

Journées de la SF2A 2026 – Programme

22-26 juin 2026 · Grenoble

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Vue d'ensemble

Salle	Lundi 22 Juin	Mardi 23 Juin	Mercredi 24 Juin	Jeudi 25 Juin	Vendredi 26 Juin
Matin 09–12	Plénière (S00)	Plénière (S00)	Plénière (S00)	Plénière (S00)	Plénière (S00)
Amphi 1	S19 IA et astrophysique - méthodes, usages et perspectives	S16 Les disques protoplanétaires à l'ère des grands instruments: quel rôle pour la communauté française?	S03 Atelier général de l'Action Thématique Physique Stellaire	S13 Commission transition environnementale: Quelle recherche en astrophysique dans un monde soutenable ?	
Amphi 2	S12 Mieux vivre ensemble : discussions sur l'eco-anxiété, la situation géopolitique, la diversité de genres et de handicaps	S10 Pour une évaluation de la recherche équitable et inclusive	S09 Atelier calcul haute performance et simulations numériques	S01 Atelier général de l'Action Thématique Exosystèmes	
Amphi 3	S04 Modeling galaxies at different scales	S14 Astrophysical foregrounds for precision cosmology	S15 Formation and evolution of large moons around giant planet	S17 Galaxy evolution in the faint Universe: insights from the era of large surveys	
Amphi 4	S02 Atelier général de l'Action Thématique PCMI	S05 Atelier général du Programme National de Planétologie	S11 Community astronomy. Where does the French astronomy community stand?	S20 Origins and impact of winds in astrophysical systems	
Amphi 5	S08 Astronomy with super-resolution: Overcoming the lambda/D limit	S06 Le ciel transitoire dans l'ère de SVOM	S18 Systèmes avancés de détection pour l'astrophysique / Advanced detection systems for astrophysics	S07 Relation Soleil Terre à l'heure du maximum solaire	
Amphi 9				S21 Gemini - Collaborations ProAm	
Soirée	Soirée Découverte — Course à pied / Chasse au trésor	Soirée d'Accueil — Hôtel de Ville de Grenoble	Soirée Grand Public — Musée de Grenoble	Soirée Cocktail — Stade des Alpes	—

Lundi 22 Juin

Matinée · 09:00–12:00 — Session plénière (S00)

10:30 Ouverture des journées · Tombola SF2A · Session plénière

10:15 – 10:45 — 10:30-11:00: Accueil Café *

10:45 – 11:10 — Résultats et perspectives de l'interférométrie double champ pour l'étude des exoplanètes

Mathias Nowak (AS HRA) [résumé PDF](#)

Mathias Nowak (LIRA, Observatoire de Paris) Résultats et perspectives de l'interférométrie double champ pour l'étude des exoplanètes La détection directe d'exoplanètes géantes par GRAVITY a démontré, ces dernières années, le fort potentiel de l'interférométrie double champ pour l'étude des systèmes planétaires jeunes. Les premières caractérisations spectroscopiques d'atmosphères planétaires ont ouvert la voie à une exploration détaillée des planètes géantes à de faibles séparations angulaires. Ces avancées ont conduit à de nombreuses découvertes : caractérisation atmosphérique de compagnons planétaires connus, confirmation directe de nouveaux compagnons à très faible séparation, ou encore détection de naines brunes révélées par astrométrie Gaia. L'extension des capacités instrumentales vers de plus grandes longueurs d'onde avec MATISSE, ainsi que l'amélioration du contraste à faibles séparations permise par le projet GRAVITY+, ont considérablement élargi le domaine d'application de l'interférométrie à fort contraste. Aujourd'hui, l'exploration de longueurs d'onde plus courtes (bandes Y, J et H) apparaît comme une étape clé, ouvrant potentiellement la perspective de la détection de planètes géantes en lumière réfléchie. Cette évolution motive la réflexion autour de la prochaine génération d'instruments interférométriques au VLTI, optimisés pour le haut contraste et la caractérisation des exoplanètes. Cette présentation fera le point sur les résultats récents et discutera les perspectives futures de l'interférométrie à double champ pour l'étude des exoplanètes.

11:10 – 11:35 —

Tombola SF2A

11:35 – 12:00 — Le Comité de liaison enseignants et astronomes (CLEA), 50 ans d'éducation à l'astronomie

Frédéric Pitout (invité) [résumé PDF](#)

La création du Comité de liaison enseignants et astronomes (Clea) est une conséquence de l'assemblée générale de l'Union astronomique internationale qui s'est tenue à Grenoble en 1976. Les journées de l'astrophysique française organisées par la SF2A à Grenoble nous offrent une occasion unique de célébrer le demi-siècle de l'association avec la communauté astronomique française. Nous proposons dans un premier temps de revenir sur le contexte de la création de l'association. Nous exposerons ensuite les actions phares comme la co-construction de ressources pédagogiques, la mise au point de maquettes, la production des Cahiers Clairaut ou l'organisation de l'école d'été annuelle. Nous élargirons enfin aux évolutions récentes qui dépassent le seul enseignement de l'astronomie et ouvrent plus généralement sur l'utilisation de l'astronomie dans l'éducation.

Après-midi · 14:00–18:00 — Sessions parallèles

AMPHI 1 — S19 : IA ET ASTROPHYSIQUE - MÉTHODES, USAGES ET PERSPECTIVES · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s19/>

13:58 – 14:00 — Introduction

14:00 – 14:20 — Unsupervised classification of the 4XMM catalogue with variational autoencoders

Dupourqué, S, Quintin, E [résumé PDF](#)

More than 20 years of imaging the sky with XMM-Newton have produced hundreds of thousands of serendipitous sources. A systematic classification of these sources is far from trivial, given their diversity in nature, distance, brightness, and exposure, leaving us with a treasure trove that has yet to be fully opened. In this work, we perform an unsupervised classification of the 4XMM catalogue using a variational autoencoder (VAE) approach applied to the EPIC spectral information of each detection. This method helps us cope with the large dynamic range and

noise levels that characterise the catalogue. We show that working with the sources in the latent space facilitates the discovery of objects of interest and reveals their dynamical evolution through latent trajectories. We further explore the use of semi-supervised clustering to enhance the efficiency of the autoencoder. Such approaches can be readily extended to the upcoming 5XMM catalogue and contribute to the identification of targets of opportunity.

14:20 – 14:40 — PISCO : A Deep Learning Method for Shear Calibration

Bonini, C. [résumé](#) [PDF](#)

The PISCO to COsmology (PISCO) project aims to develop a deep learning framework for cosmology. The first step of this project focuses on the estimation of gravitational shear from astronomical images, a key observable for weak lensing studies, probing the large-scale structure of the Universe.

We generate simulated galaxy datasets mimicking Euclid observations and use Convolutional Neural Networks (CNNs) to predict average shear components directly from images. Different training strategies, including variations in model architecture and input distributions, are explored to optimize performance.

Our results show that CNNs can reliably recover shear signals, especially when multiple galaxies are included per image, reducing the impact of intrinsic shape noise. Future work will improve model accuracy and simulation realism to enable application to real Euclid data, offering a promising alternative to traditional shear measurement methods and potentially overcoming several of their limitations, such as blending bias.

14:40 – 15:00 — Observer et simuler l'inaccessible : les étoiles à neutrons de NICER au SKA

Joanna Berteaud [résumé](#) [PDF](#)

L'astrophysique offre une fenêtre unique sur l'étude de la matière froide et dense à travers l'observation des étoiles à neutrons. Ces objets, parmi les plus compacts de l'Univers, permettent d'explorer la physique dans des conditions extrêmes autrement inaccessibles. Cependant, les modèles décrivant leur émission — notamment le traçage de rayons relativiste — sont complexes et extrêmement coûteux en temps de calcul. L'intelligence artificielle offre une voie prometteuse pour surmonter ces limites. Dans cette présentation, je détaillerai les méthodes d'apprentissage machine que je développe pour simuler l'émission des étoiles à neutrons, avec deux objectifs clés : un temps de calcul réduit et une modélisation physique réaliste. Ces approches permettront de valoriser l'héritage observationnel de NICER en rayons X, tout en préparant l'exploitation des données du futur observatoire SKA en radio.

15:00 – 15:20 — Detection and characterization of galaxies with deep-learning in radio continuum surveys, preparation to SKAO

Adam Zarka [résumé](#) [PDF](#)

The upcoming Square Kilometer Array Observatory (SKAO) will revolutionize the field of radio astronomy, particularly in the study of the Epoch of Reionization. However, its projected data flow (exceeding 700 PB/year) demands a shift toward exascale-ready pipelines. In addition, current automatic detection methods are beginning to be outpaced by the ever-increasing complexity of the data. In this Big Data era, Machine Learning (ML) stands out for efficient astronomical data processing.

During this talk, I will present our work on developing a robust and fast pipeline for radiogalaxy detection and characterization in 2D continuum images for SKAO, using precursor instruments (such as LOFAR, ASKAP, MeerKAT...) for methodological developments.

Building on the MINERVA team's success with the YOLO-inspired (You Only Look Once) regression-based method during SKA Data Challenges (SDC) 1 and 2, I will show how we generalized the method to train a new source detector model on our custom simulation pipeline. The latter was developed with the aim of simulating any deconvolved radio interferometer response for full-field observations, including point sources, but also resolved Active Galactic Nuclei (AGN) jets, star-forming galaxies, ionospheric artifacts... I will then show how we deploy our network models trained on simulations to the LOFAR Two-meter Sky Survey containing 13 million sources identified with automatic detection methods, and I will discuss how it compares to our detection performances, especially for "hard detections" like artifacts around bright sources, AGN with complex morphologies, low-SNR sources, and also in terms of computation time.

Finally, I will present the exploration of alternative self-supervised strategies, pre-training networks on target data, in order to improve recall and characterization accuracy for the faintest sources.

15:20 – 15:40 — Estimating differential pistons for the Extremely Large Telescope using focal plane imaging and a residual network

P. Janin-Potiron, M. Gray, B. Neichel, M. Dumont, J.-F. Sauvage, C. T. Heritier, P. Jouve, R. Fetick, T. Fusco [résumé](#) [PDF](#)

As the Extremely Large Telescope (ELT) approaches operational status, optimising its imaging performance is critical. A differential piston, arising from either the adaptive optics (AO) control loop, thermomechanical effects, or other sources, significantly degrades the image quality and is detrimental to the telescope's overall performance.

In a numerical simulation set-up, we propose a method for estimating the differential piston between the petals of the ELT's M4 mirror using images from a 2×2 Shack-Hartmann wavefront sensor (SH-WFS), commonly used in the ELT's tomographic AO mode. We aim to identify the limitations of this approach by evaluating its sensitivity to various observing conditions and sources of noise.

Using a deep learning model based on a ResNet architecture, we trained a neural network (NN) on simulated datasets to estimate the differential piston. We assessed the robustness of the method under various conditions, including variations in Strehl ratio, polychromaticity, and detector noise. The performance was quantified using the root mean square error (RMSE) of the estimated differential piston aberration.

This method demonstrates the ability to extract differential piston information from 2×2 SH-WFS images. Temporal averaging of frames makes the differential piston signal emerge from the turbulence-induced speckle field and leads to a significant improvement in the RMSE calculation. As expected, better seeing conditions result in improved accuracy. Polychromaticity only degrades the performance by less than 5%, compared to the monochromatic case. In a realistic scenario, detector noise is not a limiting factor, as the primary limitation rather arises from the need for sufficient speckle averaging. The network was also shown to be applicable to input images other than the 2×2 SH-WFS data.

Furthermore, we are currently exploiting multi-wavelength measurements and show that feeding multiple wavelengths simultaneously to the network enhances the capture range with minimal modifications to the baseline architecture.

15:40 – 16:00 — Class-Conditioned Consensus Loss for Multi-Expert Annotation of Low Surface Brightness structures

Renaud Vancoellie, Adeline Paiement, Pierre Alain Duc [résumé](#) [PDF](#)

Tidal structures produced by gravitational stripping during galaxy interactions are among the most direct observational tracers of hierarchical mass assembly.

Their detection is intrinsically difficult: surface brightnesses typically fall below $\mu r \sim 26\text{--}30$ mag arcsec $^{-2}$, morphologies are heterogeneous and multi-scale. Hand annotation is still the most common way datasets of such structures are created, but

at the data volumes of forthcoming surveys such as Euclid or LSST, manual expert inspection is entirely intractable, motivating the need for robust automated pipelines.

We propose a class-conditioned consensus loss that treats annotation disagreement. The expert annotations are aggregated into a per-pixel consensus score $y \in [0, 1]$, encoding the fraction of annotators in agreement. A piecewise loss function built on Focal Loss then (i) amplifies the gradient contribution of high-consensus

pixels (unanimous or near-unanimous agreement), (ii) applies standard supervision on majority-agreement regions, and (iii) leaves entirely unsupervised boundary-uncertain pixels. The decision thresholds are optimized on a held-out validation set, allowing the loss to adapt to the different annotation difficulty of each class.

The consensus loss is embedded in a modified ResNet-50 backbone whose first convolutional layer is replaced by a dual-channel, three-scale stem: the same image is processed simultaneously at its original scale and three other arcsinh scalings learned by the network during training. This provides sensitivity to both compact high-surface-brightness features and large-scale diffuse emission within a single forward pass. Images are drawn from the MATLAS survey. To address class imbalance and annotation scarcity, the training set is balanced through class-aware oversampling.

16:00 – 16:30 — *Break*

16:30 – 16:50 — **Artificial intelligence in radiative hydrodynamics for astrophysics**

Radureau, G., Busschaert, C. [résumé PDF](#)

Radiative hydrodynamics (RHD) describes the coupling between a hypersonic, hightemperature plasma and its radiation, a key process in astrophysical environments and stellar evolution. Depending on the optical regime, different models are employed: cooling functions in the optically thin limit, diffusion in the optically thick regime, and more general frameworks such as M1-gray and M1-multigroup models (Dubroca & Feugeas, 1999; Turpault, 2005), which provide a unified description across regimes. Within the POLAR project, we investigate plasma-radiation interactions in magnetic cataclysmic variables, with a particular focus on cooling instabilities, combining numerical simulations and laboratory astrophysics experiments. On the simulation side, we aim to validate and improve models of cooling instabilities by refining simplified cooling functions to better reproduce key observations (Busschaert et al., 2013; Bonnet-Bideau et al., 2015). We compare these simulations with the more general M1 framework, and mitigate its high computational cost using artificial intelligence methods for efficient closure relations and data-driven extrapolation (Radureau et al., 2025, 2026). On the experimental side, laboratory astrophysics relies on scaling laws based on dimensionless numbers such as the Boltzmann and Mihalas numbers; however, recent work has shown that more general scalings can be constructed without enforcing strict conservation of these dimensionless quantities (Tranchant et al., 2025). In this context, we explore AI-based dimensionless learning approaches (Xie et al., 2022) to approximate these generalized scaling relations. We will present an overview of these machine learning developments and the resulting physical insights within the POLAR project at the SF2A conference.

Keywords— Radiative Hydrodynamics, Artificial Intelligence, Scaling Laws

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16:50 – 17:05 — **Détection de Sursauts Radio Rapides à l'Aide d'une Approche Multi-objectifs: MUFASA**

Amblard, B., El-Bouch, S., Dalla-Mura, M., Ferrari, A., Richard, C. [résumé PDF](#)

La détection des sursauts radio rapides (FRBs) constitue un défi majeur en radioastronomie moderne, où des événements rares doivent être identifiés au milieu du bruit et des interférences radiofréquences (RFI). Ce problème s'identifie naturellement à une détection d'anomalies en ensemble ouvert, dont l'enjeu est de distinguer à la fois les anomalies (les FRBs) connues et celles qui n'ont jamais été observées du vaste ensemble de données normales (bruit et RFI), tout en maintenant un faible taux de faux positifs. Dans ce travail, nous présentons une approche neuronale qui s'appuie sur la combinaison de différents modes d'apprentissage (reconstruction du signal, apprentissages contrastif et de déviations) à travers un même extracteur de caractéristiques. En particulier,

notre objectif contrastif propre à la détection d'anomalies en ensemble ouvert encourage les échantillons normaux à former un cluster compact dans l'espace des représentations, tout en éloignant les anomalies. L'optimisation de l'ensemble est faite à l'aide de l'algorithme CR-MGDA. Celui-ci équilibre dynamiquement les contributions des différents éléments à l'optimisation des paramètres de l'extracteur de caractéristiques. Nous appliquons notre méthode, que l'on baptise MUFASA (MUlti-objective optimization for the detection of FAST radio burst as Anomalies) sur des spectrogrammes acquis par le radiotélescope NenuFAR localisé sur le site de l'Observatoire Radio de Nancy.

17:05 – 17:20 — Neural network estimation of the average density in molecular clouds and prestellar cores.

Ribeiro, Z. Hily-Blant P. [résumé PDF](#)

One of the central questions in star formation is the origin of the initial mass function (IMF), which governs stellar evolution. The IMF exhibits a peak around $0.1 M_{\odot}$, suggesting the presence of a characteristic physical scale. Since stars form within dense cores of molecular clouds, the IMF is often linked to the dense core mass function (DCMF). Observations across a variety of clouds reveal a similar peak, with an efficiency of approximately 30% between dense core mass and the resulting stellar mass. However, recent studies indicate that this peak may be influenced by observational biases, such as limited resolution and the under-detection of low-mass cores.

My thesis aims to measure the DCMF using a novel approach based on deep neural networks. Given their increasing performance and success across many areas of physics, these methods provide a promising framework to identify and characterize dense cores, particularly low-mass ones, from molecular line and dust emission integrated along the line of sight.

In a first study, we investigate several neural network architectures (CNNs, diffusion models, and conditional invertible neural networks, cINNs) to estimate the mass-weighted average density using dust emission alone. We provide a systematic benchmark of these architectures, highlighting their respective strengths and limitations in this physically degenerate context. We find that cINNs accurately reproduce both the peak and the high-mass power-law slope of the core mass function inferred from existing core catalogs, although they are difficult to train and perform poorly in diffuse regions. In contrast, U-Net and diffusion-based models recover the high-mass power-law behavior but systematically underestimate the population of dense cores, while showing better performance in low-density environments.

The ultimate goal of this work is to extend this approach toward reconstructing a physically consistent three-dimensional structure of molecular clouds by combining multiple tracers, including molecular line and dust emission, within a multimodal deep learning framework.

17:20 – 18:00 — Round Table

AMPHI 2 — S12 : MIEUX VIVRE ENSEMBLE : DISCUSSIONS SUR L'ECO-ANXIÉTÉ, LA SITUATION GÉO-POLITIQUE, LA DIVERSITÉ DE GENRES ET DE HANDICAPS · COMMUNAUTÉ

<https://journes.sf2a.eu/ateliers/s12/>

14:00 – 14:30 — Retour de la communauté de la référente handicap de la section 19 du CNRS

Damya Souami (Observatoire de Paris) — thème : Feedback from the community affected by handicap

14:30 – 15:00 — Handicap et accessibilité dans la recherche

Ludovic Petitdemange (Observatoire de Paris)

15:00 – 15:15 — Discussion générale

15:15 – 15:45 — Témoignages de membres de la communauté LGBTQIA+

Jean-François Gonzalez (CRAL, Lyon) — thème : Feedback from the LGBTQI+ community

15:45 – 16:00 — Discussion générale

16:00 – 16:40 —

— thème : Coffee break

16:45 – 17:15 — Comprendre l'éco-anxiété et en faire une alliée

Julie Delmas-Orgelet, Accompagnatrice des Organisations et des Humain.e.s pour la Transition Economie régénérative - Ecopsychologie (DDemain, Grenoble) — thème : Eco-anxiety

17:15 – 17:45 — Discussion générale**AMPHI 3 — S04 : MODELING GALAXIES AT DIFFERENT SCALES · COMMUNAUTÉ**<https://journes.sf2a.eu/ateliers/s04/>**14:00 – 14:15 — Explaining the Schmidt-Kennicutt relation: a multi-scale analytical model***Patrick Hennebelle* [résumé](#) [PDF](#)

The Schmidt-Kennicutt relation, which relates the gas column density to the star formation rate in galaxies, is a fundamental relation both regarding star and galaxy formation. Building on an analytical derivation of the star formation rate in a turbulent and self-gravitating gas (Hennebelle et al. 2024, A&A, 690, 43), I will present a model aiming at explaining the star formation rate in galaxies. The model considers turbulent energy injection, both from large scale turbulence and from supernovae, vertical equilibrium between all supports and gravity and obtain the SFR through a multi-scale analysis of the gravitationally unstable clumps. It is able to reproduce the Schmidt-Kennicutt relation and makes specific prediction regarding the dominant sources of turbulent energy injection.

14:15 – 14:30 — Does gravity drive molecular cloud assembly?*Brucy, Noé; Vázquez-Semadeni, Enrique; Colman, Tine; Fensch, Jérémy; Klessen, Ralf S.* [résumé](#) [PDF](#)

Star formation in galaxies is a complex process occurring across a vast range of scales, with molecular clouds playing a central role. However, the formation of these structures and the subsequent collapse of their gas into stars remain open questions. In particular, the role and relative importance of gravity on scales between the galactic disk scale height and prestellar cores are still debated.

In this talk, I present a case study of the mass assembly and evolution of a giant molecular cloud complex in a stratified-box numerical simulation of the interstellar medium, including photoionization and supernova driving.

By introducing tracer particles to accurately follow the forces acting on the gas during its evolution, both as it accretes onto and evolves within the clouds, we quantify the relative contributions of gas self-gravity and the gravitational potential of the stellar disk to the mass inflow.

We find that even in a highly turbulent environment, the mean motion of a small fraction of the gas is driven by gravity. However, this contribution is insufficient to significantly affect the overall mass inflow feeding the clouds.

14:30 – 14:45 — From a mass invariant in the compressible gravoturbulent ISM to the characteristic mass of the prestellar cores*Pierre Dumond, Gilles Chabrier, Jérémy Fensch, Etienne Jaupart* [résumé](#) [PDF](#)

Supersonic compressible turbulence is ubiquitous in star-forming regions. However, predicting measurable statistical properties of density fluctuations in such flows, and understanding their connection to the formation of dense structures, remains a major challenge due to the strong nonlinearities and the large range of spatial scales involved. In 1951, Chandrasekhar derived a mass time-invariant under the assumption of statistical homogeneity of the turbulent field. This invariant depends on the variance and the correlation length of the density field. Using high-resolution numerical simulations of compressible turbulence, we demonstrate that this invariant is preserved in media subject to decaying turbulence or self-gravity. We then present several applications of this invariant that provide new insights into the statistical properties of compressible turbulent flows and the formation of structures in the interstellar medium. We show that the invariant makes it possible to relate the evolution of the slope of the density power spectrum directly to the Mach number, without introducing any free parameters. This statistical quantity is essential for characterizing the initial conditions in turbulent star-forming regions. From a star formation perspective, we further show that the invariant can be used to predict the characteristic mass of prestellar cores and to explain its apparent universality across Milky Way-like star-forming environments. We also discuss how variations in this characteristic mass naturally arise in more extreme star-forming conditions, such as high-mass star-forming regions and high-redshift galaxies.

14:45 – 15:00 — Those who part the streams: a story of globular clusters and dark matter*Ferrone S.M., Di Matteo, P., Montuori, M., Ibata, R., Mastrobuono-Battisti, A., Pagnini, G.* [résumé](#) [PDF](#)

We investigate the impact of Milky Way globular clusters on stellar streams, focusing on gravitational flybys that produce gaps. A goal of the community is to use these gaps to detect dark-matter subhalos, as predicted by LCDM. As data on stellar streams improve in both quality and quantity, it becomes vital to understand baryonic

sources that can create similar features. Our study centers on the Palomar 5 stream, using collisionless N-body simulations with a Monte Carlo method to account for observational uncertainties and explore various impact scenarios. Results indicate that massive globular clusters can create observable gaps, especially in the colder regions of the stream, where low velocity dispersion increases vulnerability. We also find that an erasure process, linked to the release of epicyclic particles, can obscure gaps. I will discuss these findings, the underlying physical mechanisms, and their implications for dark matter subhalo research.

15:00 – 15:15 — Fuzzy dark matter dynamical friction and the survival of globular clusters

Adrian Szpilfidel [résumé](#) [PDF](#)

At cosmological scales, physics is well described by Λ CDM, a model which involves that 27% of the universe is composed of dark matter. The nature of this matter remains unknown so far. Although Λ CDM has been successful, it still has some difficulty matching the observations at galactic scales. One of these deficiencies relates to dynamical friction in dwarf galaxies, which is expected to have caused most of the globular clusters to fall in the central region of the galaxies. This is not observed in Fornax dwarf galaxy, for instance. A possible answer is to look for alternative cosmological models for dark matter. An exotic model called fuzzy dark matter describes dark matter as an extremely light boson particle of mass $m\chi \sim 10\text{--}22$ eV. We present a new implementation of dynamical friction in the fuzzy dark matter framework, using the galpy code to follow the orbital evolution of globular clusters over a wide range of masses and halo properties. In this scenario, dynamical friction can be strongly reduced due to stochastic heating by fuzzy dark matter density fluctuations. We explore how this effect impacts the orbital decay and long-term survival of globular clusters. We find that the largest deviations from the standard cold dark matter picture occur in dwarf galaxies, where dynamical friction can be significantly slowed down or even stalled over a Hubble time. This prevents clusters from sinking to the galactic center, in contrast with standard expectations. These results suggest that globular cluster systems provide a new way to probe fuzzy dark matter, with promising prospects for recent Euclid observations, and offer a natural explanation for the long-standing Fornax timing problem.

Keywords: dark matter, globular clusters, dwarf galaxies, galactic dynamics

15:15 – 15:30 — *Poster flash talks*

15:30 – 16:00 — *Pause*

16:00 – 16:15 — Modelling the Last Major Merger that Shaped the Milky Way

Akib, I., Hammer, F., Yang, Y [résumé](#) [PDF](#)

The formation and present-day structure of the Milky Way (MW) were profoundly influenced by its last major merger, occurring $\sim 9\text{--}10$ Gyr ago with the Gaia-Sausage-Enceladus (GSE) progenitor. We present the first hydrodynamical simulation of this event, modelling it as a 1:3-1:4 major merger using the GIZMO code, to investigate how such an encounter imprints lasting signatures on stellar dynamics and Galactic structure.

Our simulations begin 12-13 Gyr ago with gas-rich proto-MW and GSE progenitors on a parabolic orbit, and follow their interaction through merger and subsequent secular evolution. The resulting system reproduces the observed kinematic distribution of GSE debris in the energy-angular momentum (E-Lz) plane, directly linking present-day stellar orbital properties to the Galaxy's merger history. We further show that globular clusters associated with GSE can preserve orbital memory of the merger epoch, providing an additional dynamical tracer connecting accreted populations to the Galaxy's assembly.

Crucially, the merger remnant also reproduces the key structural and dynamical properties of the MW: bulge/ bar and its rotation, thin and thick discs, spiral arms, surface mass density profile, rotation curve, gas fraction, and star formation history. This level of agreement with the observed properties of the MW enables us to use the model to infer its underlying mass distribution and to trace the formation and subsequent evolution of its major components within a fully cosmological context.

Our results offer a self-consistent framework in which stellar kinematics, orbital structure, and Galactic morphology jointly encode the MW's formation history, illustrating how major mergers shape galaxy evolution over cosmic time.

16:15 – 16:30 — 100 years of Hubble's Bulges: How do bulges grow in modern high-resolution Magneto-Hydrodynamical Cosmological simulations? An insight from IllustrisTNG.

Meagher, N. Cattaneo, A. Mamon, G. [résumé](#) [PDF](#)

A century after Hubble's morphological classification of galaxies, the advent of the James Webb Space Telescope is offering an unprecedented view of galaxy structure back to within the first billion years of cosmic history [3], bringing renewed urgency to a longstanding question: how do galactic bulges form and grow? Two mechanisms have long been identified; mergers between galaxies and internal disc instabilities, yet disentangling their respective contributions remains a central challenge of extragalactic astrophysics [1, 2, 4]. Here we present a statistical study of bulge formation using the IllustrisTNG50 simulation [5], which uniquely combines a cosmologically representative volume with sufficient resolution to resolve the vertical structure of galaxies. We track the evolution of morphological indicators including the stellar bulge-to-total mass ratio, B/T , and the mean stellar surface density within the central kiloparsec Σ_1 , as a function of stellar mass M_\star , and examine how these diagnostics differ between galaxies that have undergone recent mergers and those that have not. We investigate whether mergerbuilt and disc-instability-built bulges occupy distinct regions of the $B/T - M_\star$ and $\Sigma_1 - M_\star$ parameter space, with the prospect of providing observational discriminators applicable to high-redshift galaxies where image quality is limited. We further explore the conditions under which discs become gravitationally unstable, and quantify the role of gas inflows driven by both mergers and instabilities in fuelling central star formation and supermassive black hole growth [1, 2]. Our results are discussed in the context of whether star formation enhancement saturates at high redshift, with implications for the gas infall rates that drive bulge growth in the early Universe.

16:30 – 16:45 — The Anatomy of Angular Momentum in Galactic Discs: Insights from TNG50

Pacheco-Arias, J. M., Epinat, B., Amram, P., Mercier, W. [résumé PDF](#)

Angular momentum is a fundamental property in the numerical modelling of galaxies across all scales, yet its spatial distribution within galactic discs remains poorly understood. In this talk, I present a detailed analysis of its resolved structure for the first time. Using stellar specific angular momentum maps from the TNG50 MW/M31 galaxy sample, we characterise how morphological substructures—such as rings, bars, spiral arms, and asymmetries—store and redistribute angular momentum in a cosmological context.

This approach allows us to probe scales down to ~ 500 pc, complementing traditional studies where this quantity is treated as globally integrated. We find that the dynamical properties of dark matter haloes have little impact on internal angular momentum redistribution, while gas content and stellar feedback play a dominant role in shaping the morpho-kinematic evolution of discs.

Based on these results, we propose a model for the secular evolution of stellar specific angular momentum within IllustrisTNG50 that reproduces recent observational findings (Pacheco-Arias, et al. 2026). Future work will extend this analysis to a wider range of simulations to explore the role of environment, interactions, and feedback mechanisms in driving angular momentum redistribution and, ultimately, galaxy evolution.

16:45 – 17:00 — Nuclear ring formation in barred galaxies with hydrodynamical simulations.

DEDIEU, Florian ; HALLE Anaëlle ; COMBES Françoise [résumé PDF](#)

Nuclear rings are common and remarkable structures of gas and stars, found in the circum-nuclear regions of $\sim 50\%$ of massive barred galaxies. Usually sites of strong star formation, they are believed to play an active role in secular evolution, especially in the context of starburst activity or Active Galactic Nucleus (AGN) feeding. It is now well established that the presence of nuclear rings in barred galaxies is connected to the existence of different orbit families due to the perturbed gravitational potential. However, the current proposed models still differ in the details of the precise formation process of nuclear rings, which overall remains unclear: do they actually emerge from gas accumulation due to the continuous action of gravity torques by the bar? Where do they precisely form and what is their temporal evolution? What is the contribution from viscosity? Several numerical works have explored these questions but the simulations are generally based on idealized simulations with non-self-gravitating gas and imposed barred potentials, and are thus far from realistic astrophysical conditions. Moreover, no study of nuclear ring formation in galaxies that dynamically form stellar bars with grid-based hydrodynamical simulations yet exists.

In this talk, I will provide some valuable new insight to these questions. First, I will present results about the simulation at high spatial resolution of a bar-forming galaxy that develops a nuclear ring, using the Adaptive Mesh Refinement (AMR) RAMSES code. I will address: 1) from both the theoretical and numerical sides, the main requirements for an isolated gaseous disk galaxy to form a stellar bar in a cold dark matter halo as well as a nuclear ring, alongside the main obstacles due to numerical limitations peculiar to the field of galaxy simulations, e.g. artificial fragmentation or the necessity to use sub-grid models; 2) the usual methods, via Fourier analysis and Orbital integration, to derive the properties of a bar and its impact on the stellar population; and 3) how my results

connect to the current landscape of nuclear ring-formation models, and what are the implications for future works, notably in the context of the “bars-within-bars” scenario for AGN fueling.

17:00 – 17:15 — The impact of AGN winds on the early evolution of massive galaxies

Farcy M., Hirschmann M., Occhipinti A., Somerville R. S., Choi E., Koudmani S., Naab T., Valentino F. [résumé PDF](#)

The advent of JWST is revealing a surprisingly abundant population of massive galaxies less than 2 billion years after the Big Bang, some of which are already quenched. These observations challenge standard models of galaxy formation, suggesting that both the assembly of stellar mass and the onset of quenching may occur significantly earlier and more rapidly than previously predicted. Feedback from AGN winds, powered by actively accreting supermassive black holes, is among the leading candidates for driving this evolution at early epochs. However, modelling this multi-scale process remains challenging in cosmological simulations, where AGN feedback in this regime is typically implemented as isotropic thermal energy injection. A more physically grounded treatment of AGN feedback is thus essential to assess its role at early epochs. To this end, we implemented Mistral, a physically motivated subgrid prescription for modelling AGN-driven winds within the Arepo cosmological code, informed by observations of broad absorption line winds.

Coupling this subgrid model to cosmological zoom-in simulations, I will present the new Black Dawn suite, which targets the 50 most massive galaxies at $z = 3$ from the 100 cMpc IllustrisTNG volume. Each system is resimulated with Mistral, with the standard TNG AGN feedback model, and without black holes, enabling a controlled comparison of the impact of AGN winds on early galaxy assembly and quenching. These simulations demonstrate that AGN winds can drive rapid gas depletion and compact stellar growth, and that they are required to suppress star formation efficiently enough to produce massive quiescent galaxies as early as $z = 6$. While the large-scale environment modulates the degree and persistence of quiescence, AGN winds are the dominant factor, as galaxies remain starforming in their absence. Our simulated galaxies are broadly consistent with recently discovered high-redshift quiescent and post-starburst galaxies, which supports a scenario in which AGN winds are a key ingredient in galaxy formation models to reproduce the early assembly and shutdown of massive galaxies from cosmic dawn to cosmic noon.

17:15 – 17:30 — The Simulated Infrared Dusty Extragalactic Sky (SIDES): a Semi-Empirical Simulation for Long-Wavelength Extragalactic Surveys

Matthieu Béthermin on behalf of the SIDES team [résumé PDF](#)

The Simulated Infrared Dusty Extragalactic Sky (SIDES) is a semi-empirical simulation of extragalactic surveys at long wavelengths. It is based on pre-existing dark-matter lightcones, in which halos are populated using an abundance-matching technique. We then apply a set of scaling relations to generate realistic galaxy properties, and derive broadband fluxes using empirically calibrated spectral energy distribution (SED) libraries, as well as line fluxes. SIDES also includes tools to produce simulated maps and spectral cubes. All these procedures can be performed with modest computational resources, allowing us to simulate fields as large as 117 deg^2 .

I will present some of the main successes of this simple modeling approach. By realistically simulating the impact of confusion, we reconcile the statistical properties of galaxies observed at different angular resolutions. We also reproduce the anisotropies of the cosmic infrared background (from arcsecond to degree scales) emitted by dusty galaxies tracing large-scale structures across cosmic time. Finally, SIDES is a powerful tool for preparing future instruments. I will illustrate this with the study of the confusion limit in intensity and polarization of the PRIMA far-infrared telescope, and the separation of free-free and

17:30 – 17:45 — Joining RAMSES simulations and LGRB afterglow spectroscopic observations to study high-redshift galaxies

M. Garnichey, S. D. Vergani [résumé PDF](#)

The afterglow spectroscopy of Long Gamma Rays Bursts (LGRBs) is a major tool to study the chemical properties of their host galaxies even at very high redshift. When the afterglow illuminates the galaxy as a background source, it reveals non-radiating elements present in the gas, along the line of sight, through absorption lines in the spectra. This offers unique information on the gas in, and surrounding, the GRB star forming region, as well as of the warm gas in the interstellar medium of the galaxy. Combined with typical observations integrated over the entire galaxy, from photometry or emission line spectroscopy, LGRBs bring a broad view of the physical property of its host. That makes LGRBs unique tools to better understand galaxy evolution.

I will present ongoing work comparing results of the observations of LGRB host galaxies and zoom-in hydrodynamical simulation of a representative LGRB host at redshift $z=3$, focusing in particular on neutral hydrogen, metals, and escape of Lyman-alpha and ionizing photons. The goal of my work is to physically interpret LGRB spectra, to investigate the impact of LGRBs on the progenitor environment, and test galaxy simulations. I will discuss the results of the exploration related to the absorption of neutral hydrogen and escape of Lyman-alpha and ionizing photons, and I will also present some preliminary results I obtained on metal absorption lines.

AMPHI 4 — S02 : ATELIER GÉNÉRAL DE L'ACTION THÉMATIQUE PCMI · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s02/>

14:00 – 14:02 — Introduction

14:02 – 14:42 — Dust grains properties in protoplanetary disks from multi-wavelength observations

Guidi, Greta [résumé PDF](#)

Protoplanetary disks are formed as an outcome of angular momentum conservation during the collapse of molecular cloud cores, and regulate the accretion of material onto the forming star. In the past decade, significant advances have been made in characterizing the dust and molecular gas components of disks, thanks to new observing facilities operating from optical to millimeter range, such as ALMA, VLA, VLT, JWST. These revealed a variety of structures in the dust and gas emission, in particular rings and gaps, but also spiral arms and clumps, revealing the presence of local processes that are perturbing the disk dynamics already at very early stages (~1 million years). I will discuss how our view of dust properties and evolution in disks has changed in the last few years thanks to multi-wavelength studies at unprecedented angular resolution, and how these studies have revealed more complex morphologies and mass distribution in disks than previously thought. Also, I will show how the dust emission can help us constrain the dynamical instabilities shaping the disk morphology. I will focus mainly on radio millimeter observations, and present new observations from the ALMA Large Program DiskStrat, focusing on edge-on disks and the study of disks vertical structure. I will also highlight synergies with infrared and optical studies, as well as laboratory experiments that aim to measure dust optical properties.

Acknowledgements

This project has received funding from the European Research Council (ERC) under the European Union's Horizon Europe research and innovation program (grant agreement No. 101053020, project Dust2Planets).

14:42 – 14:53 — Impact of the dust properties on the photoelectric heating efficiency of the gas, using Spitzer, Herschel and SOFIA observations of the LMC

Belloir, L., Galliano, F., Madden, S., Lebouteiller, V. [résumé PDF](#)

The Large Magellanic Cloud (LMC) provides a unique laboratory to understand the interaction between the interstellar medium (ISM) and massive star formation, in a galaxy with a low metallicity. The LMC's proximity to our Galaxy permits observation of its dusty and gaseous infrared emission at a parsecscale resolution, thereby enabling study of interstellar properties at the scale of a molecular cloud. The SOFIA Legacy Program (LMC+; supported by PCMI) [1] has observed the [CII] λ 158 μm and [OIII] λ 88 μm lines in the southern molecular ridge at a resolution of 2.5 pc. These new observations provide access to the dominant cooling lines in the neutral and ionised ISM, enabling investigation of the major heating and cooling mechanisms in the three massive star-forming regions, N158, N159 and N160. In neutral regions, the main mechanism responsible for the gas heating is the photoelectric effect. This process consists in the ejection of an electron from a dust grain after the absorption of a UV photon.

The objective of this work is to combine data acquired by the SAGE [2] survey with Spitzer (3.6 to 70 microns), the HERITAGE [3] survey with Herschel (100 to 250 microns), and new data from SOFIA, with the aim of creating maps of dust properties and constraining the efficiency of the photoelectric heating of the gas in this region. To that end, we have homogenized our multi-wavelength maps to an optimal, common resolution and pixel grid. We took particular care in the estimate of the non-Gaussianity of our uncertainties and their correlations. The spatially-resolved spectral energy distribution of each pixel was then fitted with the hierarchical Bayesian code, HerBIE [4], using the THEMIS dust model [5,6]. Two original aspects are presented in our work. The first one is that the modeling we perform allows us to compare the efficiency of the photoelectric heating to the actual mass of its carriers, and not only to their luminosity. The second one, is that, using ancillary data, we provide a phase decomposition of the [CII] luminosity. Doing so, the efficiency we estimate is less biased by the [CII] linked to other heating mechanism. Our results confirm that the photoelectric heating is dominated by the smallest grains.

In addition, the overall efficiency of the heating appears reduced, because of the lower abundance of these grains, relative to the gas, in the LMC.

References

[1] Fischer et al, A&A, 702 (2025) [2] Meixner et al, ApJ, 132 (2006) [3] Meixner et al, ApJ, 146 (2013) [4] Galliano, MNRAS, 476 (2018) [5] Jones et al, A&A, 558 (2013) [6] Jones et al, A&A, 602 (2017)

14:53 – 15:04 — 3D extinction maps of the Milky Way solar neighbourhood with Gaia GSP-Spec

Barbillon, M. ; Recio-Blanco, A. ; Palicio, P. A. ; de Laverny, P. [résumé PDF](#)

Understanding the structure of the Milky Way is a challenging study due to the mix between stars and dust distributed inhomogeneously through the halo, the disc and the bulge. The interstellar extinction caused by the dust presents along the entire line of sight (los), affects the light coming from stars, which becomes fainter and redder misrepresenting the absolute magnitude and intrinsic colours of stars. Mapping the extinction is a serious challenge in order to provide access to the distribution of this dust especially for the low Galactic latitude disc regions. In fact, high dust density areas are expected to be associated with high star formation regions. This study of extinction distribution in the Galactic disc is thus a way to demystify the spatial structure of the disc and interpret the observations.

In Barbillon et al. 2025b, we present new 2D and 3D extinction maps derived from the last DR3 of Gaia General Stellar Parametrizer from Spectroscopy (GSP-spec) spectroscopic survey including high quality astrometric parameters. It offers the advantage of deriving stellar atmospheric parameters independently of extinction. The created 2D dustmaps illustrate the full extinction distribution of the RVS catalogue in the Milky Way, while the 3D maps highlight the dust structures around the Solar neighbourhood that extends out to 2 kpc with a focus around the Local Bubble (extends out to 500 pc). Our extinction catalogue with robust and small extinction uncertainties is in good agreement with existing 2D and 3D extinction maps (c.f. Schlegel et al. 1998, Green et al. 2019, Vergely et al. 2022, Edenhofer et al. 2024, Dharmawardena et al. 2024, etc) improved by the only use of one survey that avoid the use of priors or likelihood split into the probability of the estimated extinction. The general agreement between this work and the literature is proving the reliability of this new extinction measurement in the Gaia Bp and Rp bands. Finally, the new 2D and 3D extinction maps allow us to link constraints on interstellar medium structure in the Sun vicinity (through the dust), the stellar chemistry (c.f. Poggio et al. 2022, Barbillon et al. 2025a) and the stellar density (c.f. Poggio et al. 2021, Palicio et al. 2023). It unveils the link between the Galactic distribution of dust, gas, and stars governing the chemical and dynamical evolution of the spiral arms in the Galactic ecology framework.

15:04 – 15:15 — Chemo-dynamical modeling of high-mass protostellar environments: from chemical composition to molecular emission

M. Bonfand, Y. Tu, K. H. Lam, G. Dinges, Z-Y. Li, S. W. Davis, E. Herbst, A. Belloche, B. M. Shupe, and R. T. Garrod [résumé PDF](#)

observationally than their low-mass counterparts.

I will present results from a new modeling framework designed to investigate the physical and chemical evolution of high-mass protostellar environments. The model follows the collapse of a uniform molecular cloud onto a central massive protostar through an accretion disk, using a two-dimensional hydrodynamical approach coupled with a chemical kinetic code. The resulting chemical abundances are post-processed with a radiative transfer code to generate synthetic molecular emission maps and spectra. By directly comparing these predictions with observations, we assess how the evolutionary stage and source structure—particularly disk formation and inclination— affect the emission and spatial distribution of complex organic molecules.

15:15 – 15:26 — The ortho-para chemistry of formaldehyde in protoplanetary disks

Gaillard, M., Faure, A., Hily-Blant, P., Le Gal, R. [résumé PDF](#)

The spatial distribution of the chemical reservoirs in protoplanetary disks is key to elucidate the composition of planets, especially habitable ones. However, the partitioning of the main elements among the refractory and volatile phases is still elusive. Key parameters such as the carbon-to-oxygen (C/O) elemental ratio and the ionization fraction remain poorly constrained, with the latter potentially orders of magnitude lower than in the interstellar medium. Moreover, the thermal structure of the gas is also poorly known, despite its deep influence on gas-phase chemistry. In this context, ortho-to-para ratios could provide selective and sensitive probes. Recent ALMA observations have measured the spatially resolved column density of ortho- and para-H₂CO in the

transition disk orbiting TW Hya and derived the radial profile of the ortho-to-para ratio. Yet, current disk models do not include the nuclear-spin-resolved chemistry required to interpret these observations. Our work aims to fill this gap, by combining a parametric disk physical model of TW Hya with the UGAN network, updated to include a comprehensive description of the nuclear-spin-resolved chemistry of formaldehyde (H₂CO) [1]. This new model successfully reproduces the observed column density of H₂CO to within a factor of two, as well as the measured ortho-to-para ratio which varies from ~1.5 in the outer disk to ~3 inside 90 au. In particular the low value of this ratio beyond ~90 au is well explained by our model. However, the statistical value of 3 measured below ~70 au in TW Hya and globally in the disk orbiting HD 163296 cannot be reproduced, suggesting that additional processes involving ices may be involved. Our parameter space exploration shows that the abundance of H₂CO is highly sensitive to the C/O elemental ratio and to the cosmic-ray ionization rate. Future observations of ortho- and para-H₂CO, based on well selected rotational transitions, in a large sample of disks, appear highly desirable.

Acknowledgement

This research is supported by the International Space Science Institute (ISSI) in Bern, through ISSI International Team project “Understanding Nuclear Spin Temperatures in Astronomical Environments ISSI Team 25-648”.

15:26 – 15:37 — Origin of the IMF revisited thanks to constraints on core subfragmentation and mass growth

Veyry, R and ALMA-IMF Consortium [résumé PDF](#)

The physical process by which stars inherit their mass from the properties of their parental cloud is the fundamental issue that guides all star formation studies, and it has profound implications for many areas of astrophysics. The distribution of masses of dense, gravitationally bound cores, known as the Core Mass Function (CMF), was long assumed to directly determine the distribution of stellar masses at birth, the so-called Initial Mass Function (IMF).

However, the «CMF-to-IMF» paradigm, which posits that cores are the gas mass reservoir devoted to star formation, is now being debated because these reservoirs remain poorly defined despite efforts to establish them more physically. Accurately predicting the IMF that will emerge from the fragmentation of a given cloud requires moving beyond a static, single-scale description of star formation reservoirs. Instead, we must focus on the physical processes that shape and evolve the mass function of fragments throughout the multiscale hierarchy of clouds.

We started studying two key processes that influence the CMF, which differs in low and high-mass protoclusters: core subfragmentation, the splitting of a single core into multiple fragments due to turbulence and/or gravitational instabilities, and core mass growth, the accretion of additional gas onto existing cores from their surroundings. Using the graph-theory-based analysis tool FAMILY (Thomasson+ 2024), we characterized the fragmentation cascade of the W43-MM1 protocluster over two decades, from 300 au to 15 kau.

We measured a low fragmentation level, high efficiency of gas mass transfer at smaller scales, and unbalanced mass partition between fragment siblings (Motte, Le Nestour, Veyry+ *subm*).

Based on these observationally-derived parameters, we predict that the resulting IMF will be top-heavy, like those observed in young mass clusters (e.g., Hosek et al. 2019). Meanwhile, we

also started studying the gas inflow through the protocluster and accretion rates toward cores, using N₂H+(1–0) and DCN(3–2) lines. Notably, we constrain the evolution in mass of 25 cores in

W43-MM1 and try to determine the evolution of the CMF (Veyry+ *in prep*).

By combining constraints of core subfragmentation and mass growth, we aim to move toward a predictive, time-dependent and multi-scale framework linking cloud properties to the mass function of gas reservoirs and ultimately the IMF.

15:37 – 15:46 — Flash Poster Session 1. Berat, Estève, Etchechoury, Katsis, Valeille-Manet, Zannese

15:46 – 16:16 — Pause Café

16:16 – 16:56 — Les poussières interstellaires : importance des approches expérimentales en astrophysique

Romain Basalgète. [résumé PDF](#)

Les poussières interstellaires—des microparticules solides carbonées et silicatées—jouent un rôle essentiel dans l'évolution physique et chimique du milieu interstellaire, lieu de formation des planètes et des étoiles. Ces grains influencent la propagation de la lumière, participent à l'équilibre thermique du milieu interstellaire et offrent des surfaces propices à la formation de molécules. Les observations astronomiques fournissent des informations indirectes sur les poussières à travers l'extinction, l'émission et les signatures spectroscopiques.

Les études expérimentales en laboratoire sont indispensables pour interpréter ces observations et comprendre les caractéristiques des poussières interstellaires (composition chimique, structure, distribution de taille etc...). En reproduisant dans des conditions contrôlées des processus clés—comme la formation des grains, leur irradiation, leur évolution thermique ou leur chimie de surface—l'astrophysique de laboratoire permet d'obtenir des données essentielles pour tester et contraindre les modèles, et ainsi mieux interpréter les observations.

A travers différents exemples d'études expérimentales réalisées dans le groupe d'astrophysique de laboratoire de Cornelia Jäger à l'institut Max Planck pour l'astronomie, je mettrai en évidence le rôle central des approches expérimentales dans l'étude des poussières interstellaires.

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16:56 – 17:05 — Flash Poster Session 2. Chadourne, Hoppe, Nony, Perroni, Robuschi, Saury

17:05 – 17:16 — Modeling the emission spectra of polycyclic aromatic hydrocarbons by recurrent fluorescence

Borja, D., Calvo, F., Parneix, P., Falvo, C. [résumé PDF](#)

The presence of polycyclic aromatic hydrocarbons (PAH) in the interstellar medium (ISM) was first proposed over 40 years ago, following the observation of the aromatic infrared bands (AIB) [1]. This hypothesis was later confirmed by the detection of Buckminsterfullerene C₆₀ [2] and several nitrogen-bearing PAH species [3] in the ISM. The AIBs result from a transient heating mechanism: isolated molecules absorb a UV or visible photon, reaching an excited electronic state. Nonadiabatic processes then rapidly convert this electronic energy into vibrational energy within the ground electronic state [4], allowing the molecule to relax via spontaneous emission.

Despite this general understanding, many interrogations remain about the transient heating mechanism and the structure, dynamics and stability of PAHs that play a crucial role in the ISM chemistry.

Recent experiments on the relaxation kinetics of PAH cations trapped in storage rings [5,6,7] reveal a competition between several processes: spontaneous vibrational infrared emission, dissociation, isomerization and recurrent fluorescence (RF). The latter occurs when vibrational energy is converted back into electronic energy, through a process called inverse internal conversion (IIC), putting the molecule in a low lying electronic state, from which it

can relax by fluorescence. RF is a key mechanism for stabilizing PAHs in highly ionized environments such as those found in many regions of the ISM.

In this contribution, we will present a new vibronic model of PAH relaxation by recurrent fluorescence [8] and discuss its application to various cationic PAHs. This model takes explicitly into account the vibrational levels and includes Duschinsky rotations and Herzberg-Teller effects. We will focus on our results regarding the Stokes shift and the vibrational activation of forbidden transitions, their contribution to the total RF emission in relation with experimental measurements [6], and what the consequences are for the stability of small PAH species in the environments of the ISM.

Figure 1 : Typical state-resolved RF differential RF rate constant for the D1 and D2 electronic state of naphthalene cation. The Stokes shift of the D2 state is highlighted. RF $D1 \rightarrow D0$ $D2 \rightarrow D0$ constant $D0 \rightarrow D2$ rate RF

17:16 – 17:27 — Nautilus Multi-Grain update – How grain size distribution shapes the interstellar medium

Taillard, A. ; Fuente, A. ; Navarro-Almáida, D. ; Ysard, N. ; Iqbal, W. ; Wakelam, V. ; Mechineau, A. ; Sipilä, O. [résumé](#) [PDF](#)

Abstract: Interstellar dust grains play a pivotal role in star forming regions: they allow the formation of an ice mantle at their surface, leading to a variety of molecules from the simplest one (H_2) to the most complex organic molecules (COMs). Grains vary in sizes and composition, evolving alongside the molecular cloud up to the protostellar disk. Recent observations using the James Webb Space Telescope allowed astronomers to add constraints on the grain sizes, with distribution reaching a radius already up to 0.9 microns in early star forming regions. Usually, astrochemical models consider only one grain size for the entire population, which strongly limits the surface chemistry and the overall ice composition. In this study, we present the new version of Nautilus Multi-Grain that introduces grain size distributions in the model. We updated the chemical network, added grain radius dependent mechanisms (cosmic-ray sputtering) and new grain size distributions from dust emission models (dustEM). The results show that the ice composition is highly impacted by the grain temperature and grain abundances, with each model its own particular molecular reservoir. We then compare the results of the gas-phase composition to millimeter data from the IRAM 30m GEMS Large Program (PI: A. Fuente) in molecular clouds and cold cores. In parallel, we check the solid phase predictions with data from the JWST ERS IceAge (PI: M. McClure) in the cold region of Chameleon II. The choice of dust models, and furthermore the grain abundances for each size, is very important to reproduce the various phases of the star formation, where bigger grains will act as COMs reservoirs and the smaller grains will rapidly enrich the gas-phase. Overall, introducing the grain distribution in astrochemical models highly improves the predicted abundances, both in gas and solid phase.

17:27 – 17:38 — The first chemical content of a Kreutz sungrazer comet: The exceptional apparition of C/2026 A1

Godard Palluet A., Haasler García D., Biver N., Moreno R., Bockelée-Morvan D., Crovisier J., Rivilla V. [résumé](#) [PDF](#)

Comets were formed during planet formation and later ejected beyond Pluto's orbit into the trans-Neptunian scattered disk (associated with the Kuiper Belt), or into the Oort Cloud. From these two reservoirs originate short-period comets (also called Jupiter-family comets), such as 67P/Churyumov-Gerasimenko, and long-period comets, respectively [1]. Kreutz sungrazing comets are a very special type of comet, as they are characterised by extremely close passages to the Sun (heliocentric distance $r_h < 0.01$ au), thus appearing extraordinarily bright due to the radiative outgassing. They are thought to be fragments of larger Oort cloud comets that either disintegrated under gravitational stress during a perihelion passage at very small r_h [2], or collided with a meteoric stream [3]. As fragments, sungrazers are relatively small, and their extreme declinations make them exceptionally difficult to observe from the ground. Consequently, very little is known about the origin and the chemical composition of these objects. Only three Kreutz sungrazers have been detected from the ground in the 21st century: C/2011 W3 (Lovejoy, the Great Comet of 2011), C/2024 S1 (ATLAS), and C/2026 A1 (MAPS).

Prior to this work, no spectroscopic studies have ever been performed on any of them, and so the chemical content of Kreutz sungrazers remained unknown. Observing these comets is not only challenging, but each opportunity might be unique, as each perihelion passage could be their last. Due to the extremely small r_h at perihelion, they may disintegrate under the intense tidal forces so close to the Sun, ultimately returning to dust. C/2026 A1 sungrazer has been very recently discovered in January 2026 by A. Maury, F. Signoret, G. Attard with the MAPS survey. It is the sungrazing comet we detected at its largest heliocentric distance in history ($r_h = 2.1$ au). With an orbital period estimated at ~ 1800 years, the comet reached an exceptionally small perihelion distance of 0.005 au on April 4.60, 2026. Crucially, C/2026 A1 is the 1st Kreutz sungrazer to benefit from early JWST observations providing the 1st direct constraints on the nucleus of such an object [4]. Its radius is estimated to be

0.4-0.6 km, comparable to C/2011 W3. Unfortunately, C/2026 A1 did not survive its perihelion passage, and disintegrated on April 4th.

In this presentation, I will present the observations of the C/2026 A1 Kreutz sungrazer near perihelion, conducted from April 1st to April 3rd using the IRAM 30-m telescope. Through these observations, we monitored the comet's activity by tracking the emergence of the HCN(3-2) line over the three days. This study thus reports the first spectroscopic investigation of a Kreutz sungrazer comet, offering new insights into the understanding of these peculiar and rare objects.

[1] Mumma, M. J. & Charnley, S. B. 2011, *Annual Review of Astronomy and Astrophysics*, 49, 471 [2] Fernández, J. A., Lemos, P., & Gallardo, T. 2021, *Monthly Notices of the Royal Astronomical Society*, 508, 789 [3] Guliyev, A. S. & Guliyev, R. A. 2024, *Kinematics and Physics of Celestial Bodies*, 40, 172 [4] Zhang, Q., Knight, M. M., Ye, Q. Schmidt, C. A., & Battams, K. 2026, *Research Notes of the AAS*, 10, 57

17:38 – 17:49 — Chemical impact of envelope accretion onto the nascent disk in L1527

Hugo T'KINDT, Sébastien Maret, Romane Le Gal [résumé PDF](#)

Class 0 and I sources are young protostars still embedded in their natal environment. In recent years, protostellar disks have been detected around Class 0/I protostars. Unlike protoplanetary disks, these young disks are still accreting material from a surrounding envelope. While several surveys have studied the protoplanetary disks around Class II pre-main sequence stars, only few studies have been conducted for Class 0 and I disks. The same can be said for studies focused on the chemical composition of the natal environment of Class 0 and I protostars. Its impact on the composition of protostellar and protoplanetary disks thus remains unclear. Spectral surveys at large scales targeting the envelope around young stellar objects are now necessary to link the small scales surveys to the natal environment of stars.

To start answering this question, we investigate the abundances of several molecular species in the large-scale envelope and the cavities of the borderline Class 0/I protostar IRAS 04368+2555 (L1527). The goal is to characterize the chemical composition of the natal environment of L1527, to see if there are changes when getting closer to the inner envelope, and compare the abundances with the ones at disk scales found in other studies.

In this talk, I will present the unbiased spectral survey we conducted using the NOEMA radiointerferometer and the IRAM 30m telescope. We covered almost the whole 3 mm band (from 72 GHz to 110 GHz) and observed a region of several thousand of astronomical units around the central protostar with a spatial resolution of $\sim 4''$. We calculated the abundances of more than 30 molecular species at different positions in the envelope and the cavities around L1527 using a local thermodynamical equilibrium model coupled with a Markov chain Monte Carlo algorithm. We found that the chemical composition of the envelope at 3000 au does not vary much from the one in the cavities or near the inner envelope. We compared our results with the chemical composition of protoplanetary disks and found similar abundances for the common species, which is consistent with chemical inheritance from the natal environment onto Class II disks. We also compared our results with a hot corino source, and found differences in chemical composition.

17:49 – 18:00 — Impact of variable jet bowshocks on protostellar outflows and disks

Nathan Maindon [résumé PDF](#)

While several mechanisms have been proposed to drive protostellar outflows, including magnetically driven winds and photo-evaporative flows, the role of collimated jets remains an open question. Indeed, protostellar jets often display time variability, producing a series of bowshocks with high kinetic energy as they propagate in the interstellar medium.

In this contribution, we explore how such variable jet activity may sweep up the ambient material and reshape the nearby protostellar structures, such as the envelope and the disk. Through hydrodynamical simulations, we study the interaction of jet-driven shocks in two separate scenarios: one with a hydrostatic disk, and a second with an infalling rotating envelope.

Finally, we assess the ability of variable jets to drive and sustain large-scale molecular outflows, by comparing the outputs with ALMA observations of DG Tau B, a class I protostar exhibiting such activity.

AMPHI 5 — S08 : ASTRONOMY WITH SUPER-RESOLUTION: OVERCOMING THE LAMBDA/D LIMIT · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s08/>

14:00 – 14:25 — Highlighted talk: General review of PICs*Manon Lallement***14:25 – 14:40 — Photonic lanterns for image reconstruction with FIRST-PL, a demonstration with HIP81126***Jehanne Sarrazin***14:40 – 14:55 — Characterization and on-sky testing of high-resolution photonic, AWG-based astronomical spectrographs***Jeronimo Calderon-Gomez***14:55 – 15:10 — Super-resolution as tool for detecting young protoplanets: WISPIT-2, a new PDS70 system***Guillaume Bourdarot***15:10 – 15:25 — Stellar interferometry at long baseline and short wavelength (but on bright objects): recent progress in intensity interferometry***William Guerrin***15:25 – 15:40 — Knowing your limits***Alexis Carlotti***15:40 – 15:45 — Poster pop talk***Elora Lefebvre***15:45 – 16:15 — Coffee break****16:15 – 16:40 — Highlighted talk: How blind deconvolution can push further the instrumental limits? Two examples with (I) asteroid imaging and moon detection, and (II) Betelgeuse's surface recovery from its occultation by (319) Leona***Anthony Berdeu***16:40 – 16:55 — High Order Dithering experimental validation: extending JWST small grid dithering strategies on Roman CGI***Alexis Lau***16:55 – 17:10 — Differential Piston for the ELT (petalling)***Pierre Janin Potiron***17:10 – 17:25 — Wind driven Halo over 10 years of VLT/SPHERE-IRDIS archival data***Felix Sauvourel***17:25 – 17:40 — High-precision differential astrometry for discovering exoplanets***Manon Lizzana***17:40 – 18:00 — Discussion****Soirée**

Soirée Découverte — Course à pied / Chasse au trésor

Mardi 23 Juin

Matinée · 09:00–12:00 — Session plénière (S00)

Session plénière

09:00 – 09:25 — L'émergence de la complexité chimique au cours de la formation stellaire et planétaire : premiers résultats du grand programme d'observation ALMA COMPASS

Sébastien Maret (AT PCMI) [résumé PDF](#)

L'émergence de la complexité moléculaire dans le milieu interstellaire est l'une des questions fondamentales de l'astrochimie. Des relevés spectroscopiques récents, réalisés avec les interféromètres ALMA et NOEMA, ont montré une grande complexité chimique dans les régions internes des protoétoiles de type solaire, appelées cœurs chauds. La composition chimique de ces cœurs chauds est remarquablement similaire à celle de la comète 67P, qui a été étudiée en détail par la mission Rosetta. Cela suggère que la composition chimique du système solaire pourrait être un héritage de la phase protostellaire. Cependant, cette comparaison est basée sur un petit nombre de protoétoiles.

Afin d'augmenter cette statistique, nous avons entamé un grand programme d'observation ALMA, COMPASS. Ce programme consiste à observer 11 protoétoiles proches sur une bande spectrale comprise entre 285 GHz et 315 GHz, afin de mesurer la composition chimique du gaz. Des observations complémentaires avec le JWST sont également en cours, afin de contraindre la composition chimique des glaces et obtenir ainsi un inventaire quasi exhaustif des espèces chimiques présentes dans ces objets. Dans cet exposé, je présenterai les premiers résultats de ce programme. Je discuterai également les défis que posent la réduction et l'analyse de ces grands relevés spectraux.

09:25 – 09:50 — ACES: Premiers résultats en vol

Peter Wolf (AT GRAM) [résumé non disponible](#)

09:50 – 10:15 — Actualités de l'Action Spécifique SKA-LOFAR

Cherry Ng (AS SKA-LOFAR) [résumé PDF](#)

Abstract proposé pour S00 session plénière, SF2A 2026

Auteurs : Cherry Ng-Guihéneuf, Antoine Gusdorf

L'Action Spécifique (AS) SKA-LOFAR a pour mission de soutenir les activités scientifiques et techniques de la communauté dans le domaine de la radioastronomie aux basses et moyennes fréquences, tout en favorisant les synergies avec les autres domaines de l'astrophysique. Elle accompagne également les développements et l'exploitation scientifique liés à l'Observatoire SKA (SKAO), à ses précurseurs et à ses projets pionniers. Je présenterai un panorama des activités récentes et des principaux résultats scientifiques du groupe, ainsi que les orientations futures de l'équipe, dans la perspective de l'intégration du SKA dans le paysage astrophysique national et international.

10:15 – 10:45 — Pause Café *

10:45 – 11:10 — Révéler la composition des petits corps grâce à l'astrophysique de laboratoire

Olivier Poch (PNP) [résumé PDF](#)

Comprendre l'histoire de la formation et de l'évolution du système solaire passe nécessairement par l'étude des vestiges des planétésimaux formés dans le disque protoplanétaire, les petits corps. L'observation de la lumière réfléchie par ces petits corps, collectée par les instruments de missions spatiales ou de télescopes dans les longueurs du visible à l'infrarouge moyen, permet de les classer en fonction de leurs spectres et de leurs albédos [1, 2]. Les plus sombres parmi les astéroïdes, objets trans-neptuniens et comètes sont non-différenciés, constitués d'une matrice de grains sub-micrométriques, vestige de la poussière du disque proto-planétaire [3]. Ces petits corps primitifs sombres possèdent une diversité de propriétés optiques qui restent à élucider (couleurs, bandes d'absorption ou d'émissivité, courbes de phase polarimétriques). D'autre part, la composition chimique de la matière de certains de ces objets peut être étudiée au laboratoire. De quoi est faite cette matière primitive ? En particulier, quelles sont les différentes phases porteuses des éléments légers (carbone, azote etc.) qu'elle contient ? Peut-on retracer leurs histoires depuis les environnements pré- et proto- solaires, puis le disque proto-planétaire, jusqu'à leur apport lors de l'accrétion des planètes ?

Je présenterai plusieurs activités expérimentales réalisées au laboratoire pour :

- (1) interpréter les propriétés optiques des petits corps primitifs sombres, grâce à des mesures de réflectance de la lumière sur des analogues granulaires constitués de grains sub-micrométriques de composition variée [4, 5],
- (2) analyser la composition chimique de chondrites carbonées afin d'identifier et de quantifier les phases porteuses du carbone et de l'azote, et de mesurer leur composition isotopique afin de comprendre leurs origines et évolutions [6].

J'illustrerai notamment comment la fabrication et la mesure d'analogues cométaires de granulométrie sub-micrométrique a permis d'identifier des sels d'ammonium (NH₄⁺) sur le noyau de la comète 67P/Churyumov-Gerasimenko [4], ce qui a amené quelques années plus tard à redécouvrir la présence d'ammonium dans la météorite d'Orgueil et de constater que cette molécule soluble dans l'eau représente un quart de l'azote total contenu dans cette météorite [6].

Références :

- [1] DeMeo et al., 2009. *Icarus* 202, 160–180. <https://doi.org/10.1016/j.icarus.2009.02.005>
- [2] Mahlke et al., 2022. *A&A* 665, A26. <https://doi.org/10.1051/0004-6361/202243587>
- [3] Beck et al., 2025. *Nat Astron* 9, 793–794. <https://doi.org/10.1038/s41550-025-02557-z>
- [4] Poch et al., 2020. *Science* 367. <https://doi.org/10.1126/science.aaw7462>
- [5] Sultana et al., 2023. *Icarus* 395, 115492. <https://doi.org/10.1016/j.icarus.2023.115492>
- [6] Laize-Général et al., 2024. *GCA* 387, 111–129. <https://doi.org/10.1016/j.gca.2024.10.001>

11:10 – 11:35 — Définir l'exobiologie : méthodes et structuration d'un domaine interdisciplinaire

Hervé Cottin (SFE, invité) [résumé PDF](#)

L'exobiologie est désormais un domaine de recherche bien inscrit dans le paysage scientifique. Son périmètre d'étude : l'origine de la vie sur Terre et sa recherche ailleurs dans l'Univers, se situe à la confluence de plusieurs champs fondamentaux. Mais la perception de la discipline est parfois mise à mal par des épisodes de dérives sensationnalistes médiatiques qui compromettent sa démarche, et ses contours demeurent parfois flous et mal compris au sein même de la communauté scientifique. Cette présentation visera à clarifier le cadre de l'exobiologie.

Les succès de l'exobiologie reposent et reposeront sur l'interdisciplinarité, où l'astrophysique, la géologie, la chimie et la biologie doivent dialoguer pour interpréter des données souvent fragmentaires. Pour l'interprétation de mesures présentées comme de potentielles biosignatures, la nuance scientifique doit primer sur les conclusions hâtives.

11:35 – 12:00 — Nouvelles de la Commission

Commission F&A

Après-midi · 14:00–18:00 — Sessions parallèles

AMPHI 1 — S16 : LES DISQUES PROTOPLANÉTAIRES À L'ÈRE DES GRANDS INSTRUMENTS: QUEL RÔLE POUR LA COMMUNAUTÉ FRANÇAISE? · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s16/>

14:00 – 14:05 — Introduction

14:05 – 14:30 — Romane Le Gal *Chimie des disques à l'ère des grands instruments*

14:30 – 14:42 — Probing the radial and vertical structure of an edge-on protoplanetary disk with ALMA and NOEMA

Foucher, C., Dutrey, A., Guilloteau, S., Piétu, V., Chapillon, E. [résumé PDF](#)

Understanding how complex molecules evolve and lead to the emergence of life is one of the fundamental questions in astrophysics. A key step toward answering this question is to determine where these molecules form

and how they are processed in planet-forming environments. Protoplanetary disks, dense rotating structures of gas and dust surrounding young stars, play a central role in this chemical evolution.

Edge-on disks provide a unique opportunity to directly probe the vertical structure of gas and dust, offering critical insight into molecular stratification and the physical processes governing planet formation. We analyze the disk around Tau042021 using archival ALMA observations of CO isotopologues (^{12}CO , ^{13}CO , C^{18}O), N_2H^+ , DCO^+ , H_2CO , and the continuum, combined with new NOEMA data on HCO^+ , HCN , CS , and C_2H . Using a tomographic approach together with the DiskFit radiative transfer model, we derive radial and vertical profiles of gas and dust temperature and density.

Our results reveal a vertically extended gas structure, with clear molecular stratification between a cold mid-plane and a warmer disk atmosphere. Some molecular emission traces material above the disk, possibly linked to a wind, and gas is detected beyond the dust outer radius, indicating that the gaseous component is more extended than the continuum. Overall, these observations provide constraints on the thermal structure and mass distribution of the disk.

These results highlight the power of molecular tomography in constraining the vertical structure of protoplanetary disks. At the same time, they underline the importance of combining multiple molecular tracers to capture the complexity of disk chemistry and to refine thermo-chemical models of planet-forming environments.

14:43 – 14:54 — A new and robust method to determine the abundance of ices in edge-on protoplanetary disks

Martinien L., Duchêne G., Ménard F., Stapelfeldt K., Tazaki R. [résumé PDF](#)

Ices form in the cold regions of protoplanetary disks and are involved in many processes leading to planetary formation. They can facilitate the formation of complex organic molecules and are the reservoir of volatile species, playing a key role in the chemical evolution from the molecular cloud to the protoplanets. In particular, water ice plays a crucial role in the growth of grains and in planetary formation. However, its spatial distribution in protoplanetary disks is still poorly constrained. The James Webb Space Telescope now enables the spectral study of ices with unprecedented sensitivity and angular resolution. Past studies investigated ices through the analysis of spectra. The shape, the location of the minimum position, as well as the depth of the ice bands were used to provide information about the properties and abundances of the main ice species. However, recent studies have shown that the interpretation of ice bands is more complex than it seems because the shape and location of the minimum depend on i) the inclination of the system and ii) the location within the disk from which the spectra are extracted. These dependencies stem from a balance between absorption and scattering and are due to a shift in wavelength between the absorption and scattering opacity curves. They must be taken into account in detailed radiative transfer modeling of spatially resolved infrared spectroscopy of ices. Moreover, it has been demonstrated that the ice bands reach a saturation for the main ice species (H_2O , CO_2 , CO) when the amount of ice is too high and when the inclination of the disk is too high, precluding the quantification of ice abundances from spectra only. To overcome the problem of ice band saturation for highly inclined disks, we developed a method to determine the abundance of the main ice species using JWST/NIRSpec observations of edge-on disks, without using ice spectra. This method relies on the measure of the disk thickness as a function of wavelength. Indeed, the disk thickness is proportional to the disk mass as well as to the opacity of the dust+ice mixture. Thus, we showed that outside of ice bands, the disk thickness decreases with wavelength as the opacity drops, while it increases across ice bands due to the additional ice opacity on top of the continuum opacity. We used the radiative transfer code MCFOST to build a toy model showing that the increase of disk thickness increases linearly with ice abundance, indicating that this method is not affected by saturation. Thanks to this method, it is possible to determine the ice abundances in edge-on disks by building radiative transfer models tailored to each disks, and adjust the ice abundance as a free parameter to reproduce the observed thickness. In this contribution, we applied the method to a sample of edge-on disks by building models tailored to the observations, along with their corresponding ice abundances.

Acknowledgments

This project has received funding from the European Research Council (ERC) under the European Union's Horizon Europe research and innovation program (grant agreement No. 101053020, project Dust2Planets, PI: F. Ménard).

14:54 – 15:06 — Chemical composition of inner disks with JWST

Estève, P., Tabone, B., Habart, E. [résumé PDF](#)

Despite the tremendous number of exoplanets detected, planet-forming scenarios are not yet able to fully explain the large diversity of planets. The elemental composition of planetary atmospheres is expected to give valuable

insight about their formation, since it is known to vary spatially and temporally due to physical (ex: pebble drift) and chemical (chemical reactions, sublimation) processes, like the C/O ratio. However, the chemical composition of planet-forming regions of disks is still poorly constrained, making it difficult to link exoplanetary atmospheres and planet formation history. In this context, the James Webb Space Telescope opens an unprecedented observation window on the inner disks (<10 au). The MIRI Guaranteed Time Observation of planet-forming disks MINDS (PI: Th. Henning) observed more than 50 disks, and revealed an active chemistry in these inner regions by detecting plenty of new molecules, especially hydrocarbons. I will present the surprising diversity of JWST spectra, and I will highlight important results from the MINDS collaboration, such as the link between the molecular composition of inner disks and the stellar mass (Grant et al. 2025). Detailed thermochemical modelling showed that this diversity could be explained by a variation in elemental abundances (Arabhazi et al. 2026, Estève et al. subm), and suggesting that the C/O is below 1 in T Tauri disks (Estève et al. subm). Interestingly, transport models predict a change in elemental content as the disk evolves (Mah et al. 2023, Sellek & van Dishoeck 2025), which leads to consider the leakiness of gaps as the main process behind this diversity (Tabone et al. subm). Statistical studies on larger samples and future ELT observations are needed to confirm this scenario and broaden our knowledge on disk evolution.

15:06 – 15:18 — Legacy of the GRAVITY YSO Large Program: time-variable structures in the innermost regions of protoplanetary disks

Drescher, A., Perraut, K., Berger, J.-P., Houllé, M., Bouvier, J. [résumé PDF](#)

Revealing the physical processes at play in the innermost regions of protoplanetary disks is essential for understanding the initial conditions of planet formation and disk evolution. In particular, rocky planets are thought to form within a few astronomical units of the central star. Thanks to its unprecedented sensitivity and milliarcsecond angular resolution, GRAVITY at the VLTI resolves the inner ~ 0.1 – 5 AU around nearby young stellar objects (YSOs), a region largely inaccessible to other facilities. Within the framework of the GRAVITY YSO Large Program, we surveyed nearly one hundred YSOs, including ~ 40 T Tauri stars, ~ 60 Herbig Ae/Be stars, and a few high-mass YSOs. From this survey, we are able to constrain the near-infrared emission and its potential variability through model fitting and radiative transfer modeling. Monitoring these regions over time enables us to investigate morphological variability on dynamical timescales of days to months. Such variability offers insights into the evolution of small-scale disk structures and star-disk interactions, and their potential connections to large-scale disk features. In this talk, we will present recent results on structural variability in the inner disks of young stars and discuss their implications for the dynamical processes shaping planet-forming environments. In addition, the enhanced capabilities of GRAVITY+ will enable higher-cadence monitoring, opening the possibility to probe night-to-night variability in the innermost disk regions.

15:18 – 15:30 — Numerical insights into disk accretion, eccentricity, and kinematics in the Class 0 phase

Adnan Ali Ahmad, Benoît Commerçon, Elliot Lynch, Francesco Lovascio, Sebastien Charnoz, Raphael Marschall, Alessandro Morbidelli [résumé PDF](#)

The formation and early evolution of protoplanetary disks during a gravitational collapse are governed by a wide variety of physical processes. Observations have begun probing disks in their earliest stages, and have favored the magnetically regulated disk formation scenario. Disks are also expected to exhibit ellipsoidal morphologies in the early phases, an aspect that has been widely overlooked. We aim to describe the birth and evolution of the disk while accounting for the eccentric motions of fluid parcels. Using 3D radiative magnetohydrodynamic simulations with ambipolar diffusion, we self-consistently modeled the collapse of isolated $1 M_{\odot}$ and $3 M_{\odot}$ cores and the subsequent formation of a central protostar surrounded by a disk. We find that magnetic fields and turbulence drive highly anisotropic accretion onto the disk via dense streamers. This streamer-fed accretion, occurring from the vertical and radial directions, drives vigorous internal turbulence that facilitates efficient angular momentum transport and rapid radial spreading. Crucially, the anisotropic inflow delivers material with an angular momentum deficit that continuously generates and sustains a significant disk eccentricity ($e \sim 0.1$). Our results reveal ubiquitous eccentric kinematics in Class 0 disks, with direct implications for disk evolution, planetesimal formation, and the interpretation of cosmochemical signatures in Solar System meteorites.

15:30 – 15:45 — Poster

15:45 – 16:15 — Pause

16:15 – 16:40 — Structure et dynamique des disques en lien avec la formation des planètes

Christiaens, V. [résumé PDF](#)

Dans cette présentation de revue, j'effectuerai un tour d'horizon de la science faite en France dans le domaine de la structure et la dynamique des disques en lien avec la formation des planètes. Je tisserai en particulier des liens entre les sujets de recherche actuels, les résultats récents obtenus avec ALMA, VLT et JWST, et ceux envisageables d'obtenir avec les futurs grands instruments (SKA, ALMA 2040, NOEMA, ELT, PRIMA, HWO).

16:40 – 16:52 — Modélisation de PDS 70 : de la dynamique multiplanétaire aux émissions du continuum de poussière.

Philippine Griveaud, Clément Baruteau, Elena Lega, Michiel Lambrechts, Aurélien Crida [résumé PDF](#)

Bien que les niveaux de viscosité dans les disques protoplanétaires restent très incertains, celle-ci joue un rôle crucial dans les interactions planète-disque, notamment dans les systèmes multiplanétaires. Compte tenu des suggestions récentes selon lesquelles les disques protoplanétaires pourraient être moins visqueux qu'on ne le pensait auparavant, nous testons cette hypothèse sur le célèbre système PDS 70. Bien que les contraintes directes sur les niveaux de turbulence dans ce disque restent inconnues, l'architecture planétaire du système et les caractéristiques d'émission de poussière pourraient offrir de précieuses contraintes indirectes.

À l'aide de simulations hydrodynamiques en 2D, nous constatons que la migration et les configurations d'excentricité des deux planètes de PDS 70 varient considérablement en fonction du paramètre de viscosité turbulente, α . Pour une viscosité élevée ($\alpha = 10^{-3}$), les planètes migrent rapidement vers l'intérieur, et leurs excentricités dépassent les estimations observationnelles rapportées par Trevascus et al. (2025). À l'inverse, pour une faible viscosité ($\alpha = 10^{-4}$), le sillon communs des planètes s'élargit, entraînant une migration plus lente, voire quasi-stagnante. Grâce à une exploration approfondie des paramètres, avec des masses planétaires comprises entre 2 et 8 masses joviennes, nous constatons que les excentricités observées sont mieux reproduites lorsque les deux planètes dépassent 5 masses joviennes.

Outre la dynamique multiplanétaire, nous intégrons la poussière en tant que fluide sans pression dans nos simulations hydrodynamiques. En combinant ces résultats avec des calculs de transfert radiatif réalisés à l'aide de RADMC3D, nous sommes en mesure de produire des observations synthétiques de l'émission continue de poussière de nos modèles.

En combinant les contraintes dynamiques du système planétaire avec les sousstructures de poussière et de gaz, nous cherchons à affiner les paramètres capables de reproduire le système PDS 70. À terme, ce travail vise à fournir de nouvelles contraintes théoriques sur ce système emblématique.

16:52 – 17:04 — Combining hydrodynamics, thermochemistry and radiative transfer to probe radial substructures in edge-on circumstellar disks

Wafflard-Fernandez, G., *Le Gal R.* [résumé PDF](#)

The vast majority of radial substructures have been detected in the continuum and molecular emission of circumstellar disks that are moderately inclined. In such disks and because the molecular line emission comes from a warm upper layer, we do not have a direct access to both the radial distribution and the vertical stratification of dust grains and molecules. The large program ALMA DiskStrat tackles this question by examining the radial and vertical structures of 9 edge-on disks, providing a large diversity of emission lines with high spatial and spectral resolution. I will present a new pipeline to model realistically circumstellar disks, connecting gas+dust hydrodynamic simulations with the GPU-accelerated code IDEFIX, thermochemical calculations with PRODIMO, and radiative transfer computations with RADMC3D and PRODIMO. I will then show some preliminary results of this pipeline applied to one of the edge-on disks of the DiskStrat sample, hunting down potential radial substructures in synthetic continuum and molecular emission maps.

17:05 – 18:00 — Discussion

AMPHI 2 — S10 : POUR UNE ÉVALUATION DE LA RECHERCHE ÉQUITABLE ET INCLUSIVE · SOCIÉTAL

<https://journées.sf2a.eu/ateliers/s10/>

Contact : rhita-maria.ouazzani@obspm.fr

Main language for discussions / Langue principale des échanges oraux : FRANCAIS

L'évaluation de la recherche, souvent présentée comme neutre, repose sur des critères d'excellence qui structurent les carrières et les collectifs scientifiques. Pourtant, ces normes, historiquement construites, peuvent renforcer des inégalités de genre, de classe ou de statut. Comment repenser les dispositifs d'évaluation pour qu'ils intègrent pleinement les enjeux d'inclusion et de diversité, tout en préservant la rigueur scientifique ?

Cet atelier interrogera la fausse neutralité de l'excellence académique, ses effets différenciés sur les trajectoires professionnelles, et les pistes de transformation actuellement débattues. À travers des regards historiques, politiques et sociologiques, nous explorerons les biais des critères d'évaluation et les marges de manœuvre pour construire une recherche plus juste.

Au programme :

– Des présentations invitées pour éclairer les enjeux contemporains de l'évaluation, nourries par des travaux récents et une controverse structurée, ainsi qu'une présentation sur la science ouverte. – Une table ronde : « Quels critères d'évaluation voulons-nous ? Comment concilier excellence, éthique et égalité ? », avec des intervenant-es issu-es des comités de recrutement, des instances d'égalité ou de la recherche, pour croiser les perspectives et imaginer des pratiques plus inclusives.

Contributions de la communauté :

Nous réservons également un espace pour des retours d'expérience, témoignages ou présentations d'initiatives locales proposées par les membres de la communauté. Ces contributions viendront enrichir les échanges et nourrir la réflexion collective. Comme chaque année, une large place sera laissée aux discussions avec la salle, afin de s'appropriier ensemble ces enjeux et de construire des pistes d'action concrètes.

SOC :

Rhita-Maria Ouazzani (rhita-maria.ouazzani@obspm.fr) Olivia Venot (olivia.venot@lisa.ipsl.fr) Nadège Lagarde (nadege.lagarde@u-bordeaux.fr) Eric Josselin (eric.josselin@umontpellier.fr) Patrick de Laverny (patrick.de_laverny@oca.eu)

AMPHI 3 — S14 : ASTROPHYSICAL FOREGROUNDS FOR PRECISION COSMOLOGY · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s14/>

14:00 – 14:30 — Precision modelling of the millimetre dust emission

Désert, F.-X., Sen, A., Macías-Pérez, J.F. [résumé PDF](#)

We review the dust emission properties gathered from the results obtained by the great satellites (Planck, WMAP, DIRBE, AKARI, IRAS). In intensity, the dust emission is dominant only in the far-infrared domain, becoming entangled with other emissions at millimetre wavelengths where the Cosmic Microwave Background, the Cosmic Infrared Background and other radio processes are important. We present a linear, iterative modelling approach for all components in a global fit across wavelengths and the sky. We provide conclusions on the dust temperature and emissivity.

14:30 – 14:50 — Impact of Galactic EB correlation on the calibration of CMB B-modes for future space missions

Silvia Micheli [résumé PDF](#)

The search for primordial gravitational waves imprinted in the polarization of the Cosmic Microwave Background (CMB) is a primary goal for next-generation CMB experiments. As we aim for the high sensitivity required to detect CMB primordial B modes, our ability to distinguish between cosmological signal, astrophysical foregrounds and instrumental systematics becomes crucial. Currently, in-flight polarization angle calibration for space-borne experiments often relies on the EB nulling requirement, assuming that the intrinsic cross-correlation between E and B modes is zero. Under this assumption, any observed EB signal is attributed to instrumental polarization angle miscalibration. In this contribution, I discuss how the physical complexity of Galactic dust can produce a non-zero intrinsic EB signal, which creates a direct degeneracy with the instrumental miscalibration angle if not properly modeled. We present an extension of the current state-of-the-art calibration framework for space-borne observations that incorporates a complex dust model with intrinsic EB correlations. This allows us to study the impact of such astrophysical complexity on both the estimation of the miscalibration angle and the resulting accuracy of the tensor-to-scalar ratio, r . Our goal is to determine the level of modeling required to ensure that these systematic biases remain well below the statistical uncertainties of next-generation surveys.

14:50 – 15:10 — Galactic Science with the LiteBIRD satellite: Spectral characterization of diffuse Galactic polarized emission at the angular power spectrum level

Vinzl, S., Aumont, J., Vacher, L., Génova-Santos, R.T., Adak, D., Rizzieri, A. [résumé PDF](#)

Accurate modeling of polarized Galactic emission has become a major challenge for current and next-generation Cosmic Microwave Background (CMB) B-mode experiments. Ignoring the spectral complexity of thermal dust and Galactic synchrotron emission when integrating along the line of sight and over large sky fractions inevitably leads to biases in CMB polarization analyses.

In this talk, I will review how the future LiteBIRD satellite, which will benefit from an increased number of bands and sensitivity with respect to past CMB experiments such as Planck, will exploit its broader frequency coverage to characterize the spectral properties of interstellar medium emission across the three-dimensional structure of the Milky Way. I will present a study of the polarized spectral energy distributions (SEDs) of diffuse Galactic emission and demonstrate the significant improvements LiteBIRD will achieve over Planck.

Nevertheless, the canonical description of foreground spectral behavior will reach its limits for LiteBIRD. I will show that this challenge can be addressed using moment expansion, in which modified black-body and power law SEDs are Taylor-expanded around the pivot spectral parameters, β and T . This enhanced modeling of the Galactic polarized signal enables unbiased measurements of the tensor-to-scalar ratio r , even in the presence of pessimistically complex foregrounds.

15:10 – 15:30 — *Modeling the Thermal dust with Dust Temperature Ladder Model*

15:30 – 16:00 — *Pause Café*

16:00 – 16:20 — **ML-Enhanced Foreground Removal Methods for 21-cm Experiments Preparing for the SKA Era**

Mertens, F.G. [résumé PDF](#)

Abstract: The redshifted 21-cm signal from the Cosmic Dawn and Epoch of Reionization provides a unique probe of the early Universe, but its detection is challenged by bright astrophysical foregrounds and complex instrumental systematics. As current interferometers (LOFAR, MWA, NenuFAR, HERA) reach increasing sensitivity, foreground mitigation has become the dominant limitation.

We present ML-GPR, a Bayesian framework based on Gaussian Process Regression that exploits the distinct spectral correlations of foregrounds and the cosmological signal. The method is enhanced by physically motivated priors learned from simulations using generative models, enabling robust and flexible component separation. ML-GPR now forms a core element of the LOFAR and NenuFAR analysis pipelines, contributing to the latest constraints on the 21-cm signal.

We further present recent extensions to the time domain, leveraging the partial temporal decorrelation of contaminants to improve robustness against systematics. These developments will be discussed in the context of current experiments and future SKA observations.

16:20 – 16:40 — **An improved characterisation of CMB foregrounds with map-space PE/PB spectral analysis**

Gilles Weymann-Despres, Léo Vacher, Michael E. Jones, Angela C. Taylor, Carlo Baccigalupi, A.J. Banday, Richard D.P. Grunmitt, Nicoletta Krachmalnicoff

16:40 – 17:00 — **BATMAN v Foregrounds: Dawn of Coherence**

Douspis, M., BATMAN-ANR team [résumé PDF](#)

Small-scale measurements of the cosmic microwave background (CMB) probe not only primordial anisotropies but also several extragalactic components, notably the thermal and kinetic Sunyaev–Zel’dovich (tSZ, kSZ) effects and the cosmic infrared background (CIB). The BATMAN project aims to model and exploit, within a coherent framework, both primordial and extragalactic spectra to constrain the cosmological model, the reionization epoch, and the astrophysics of large-scale structure. Extragalactic signals are typically treated as foregrounds, modeled with fixed templates while marginalizing over their amplitudes. I will show how assumptions about these template shapes can affect both cosmological and foreground parameter constraints in a joint analysis of Planck, SPT, and ACT data. Beyond their role as contaminants, these signals carry valuable cosmological information that can be used to tighten constraints on the underlying model. I will present a halo-model-based framework that provides a unified description of the tSZ, kSZ, and CIB signals, and illustrate the resulting improvements in constraints on reionization and hot gas properties from combined Planck+SPT analyses. Our ultimate goal is to enable a consistent analysis of all current CMB datasets while jointly incorporating cosmological and astrophysical information from large-scale structure

17:00 – 17:20 — A halo model approach to describe clustering and emission of the two main star-forming galaxy populations for Cosmic Infrared Background studies

Zagatti, G., Calabrese, E., Chiochetta, C., Gerbino, M., Negrello, M., Pagano, L. [résumé PDF](#)

In this talk, I introduce a semi-analytic model designed to evaluate the Cosmic Infrared Background (CIB) power spectrum across all frequency and multipole ranges. My methodology starts from the Halo Model, in order to describe the dark matter distribution in the Universe, capturing its non-linear behaviour. I further expand the Halo Model formalism to galaxies, populating dark matter halos with two distinct galaxy populations that exhibit different clustering behaviours and emissivity functions. This modeling allows to end up with a prediction of the CIB power spectrum. In the absence of a comprehensive theoretical framework for the description of both the clustering and the emission of the two galaxy populations, I aim to constrain the clustering parameters. This objective is pursued through an MCMC analysis over three dataset; Planck, SPIRE and a re-analysis of Planck data done by Lenz et al. (2019). However, my findings indicate discrepancies across different frequency and multipole ranges, highlighting either potential issues within the model or suggesting a tension among the experiments.

17:20 – 17:40 — High redshift galaxies unveiled by lensing clusters at millimetre wavelengths

Pamphile, L. [résumé PDF](#)

During the cosmic noon epoch ($z \sim 2-3$), the intense star formation activity of high-redshift galaxies enriched their interstellar medium with large amounts of cold dust. As a result, a significant fraction of their UV and optical starlight is absorbed and re-emitted at millimetre wavelengths, making their dust emission observable. Observations at these wavelengths are therefore particularly powerful: deep single-dish surveys allow the detection of dusty star-forming galaxies while simultaneously probing galaxy clusters through the Sunyaev–Zel'dovich (SZ) effect. In this context, the LPSZ project observed a sample of 38 midredshift galaxy clusters ($0.5 < z < 0.9$) at 1.2 and 2 mm with the NIKA2 camera on the IRAM 30 m telescope. As a by-product, these observations led to the detection of 260 point-like sources at 1.2 mm, supposedly located at higher redshift. Compared to the expected number counts, we find an excess by a factor of ~ 2 within 45 arcsec of the cluster centres. We quantitatively interpret this excess as the result of strong gravitational lensing induced by these massive foreground clusters with mass between 10^{14} and $10^{15} M_{\odot}$. This lensing effect magnifies background galaxies, and can produce multiple images, therefore increasing their observed flux densities. To quantify this lensing contribution and model the expected magnification bias, we constructed simulated galaxy–cluster lensing systems by combining the SIDES simulations with the Lenstool software. This approach enables us to constrain the lensing properties and the evolution of dusty star-forming high redshift galaxies at millimetre wavelengths. We complement this study with interferometric follow-up observations using NOEMA, enabling the study of dust and lensing properties of a sub sample of the detected point-like sources, in order to find the redshift of these galaxies.

17:40 – 18:00 — Model independent test of the FLRW metric and the curvature in light of DESI DR2

Cléa Millard, Benjamin L'Huillier, Marian Douspis [résumé PDF](#)

We perform a data-driven test of the FLRW metric and the flatness of the Universe, independently of any Dark Energy model, and in light of the latest DESI DR2 results. We use Pantheon+ and DES Dovekie SNIa data to reconstruct the distance modulus, dimensionless comoving distance and Hubble parameter, using an iterative smoothing algorithm. Then, combining the various reconstructions with the recent BAO measurements from DESI DR2, we perform the Ω_k diagnostic, a litmus test of the FLRW metric and the flatness of the Universe. We obtain robust results that do not depend on Dark Energy models and test some of the underlying hypotheses of the concordance model. We find that when the reconstructed Ω_k diagnostic is consistent with the FLRW metric, then the median value of $\Omega_{k,0}$ over all reconstructions that provide an improved fit relative to the flat Λ CDM model are: $\Omega_{\text{med},0} = 0.045^{+0.045}_{-0.081} \pm 0.038$ for the Pantheon+ & DESI DR2 data combination, $\Omega_{\text{med},0} = 0.095^{+0.063}_{-0.136} \pm 0.063$ for the same data but with the Pantheon+ SNIa cut at redshift $z = 1.13$, which is the maximum redshift of the DES Dovekie data, and $\Omega_{\text{med},0} = -0.102^{+0.099}_{-0.005} \pm 0.043$ for DES Dovekie & DESI DR2. The first uncertainties correspond to the spread in $\Omega_{k,0}$ over all reconstructions, followed by the median 1σ error. Our results are consistent with flatness and Planck 2018 within 3σ .

AMPHI 4 — S05 : ATELIER GÉNÉRAL DU PROGRAMME NATIONAL DE PLANÉTOLOGIE · COMMUNAUTE

<https://journes.sf2a.eu/ateliers/s05/>

14:00 – 14:04 — Bienvenue et introduction**14:04 – 14:28 — A massive primordial atmosphere on early Mars**

Sarah Joiret, Alessandro Morbidelli, Rafael de Sousa Ribeiro, Guillaume Avice, Paolo Sossi [résumé PDF](#)

Mars formed very rapidly, within the first 4 Myrs of the solar system, while the gaseous disk surrounding the Sun was still present. Geochemical analyses of noble gases on Mars indeed indicate that the planet acquired its primordial atmosphere directly from this solar gas reservoir. Subsequently, a phase of dynamical instability among the giant planets led to a bombardment of comets into the inner solar system, including Mars. However, unlike Earth, we do not detect a cometary noble gas signature in the present-day Martian atmosphere. This is surprising and suggests that the primordial Martian atmosphere, acquired from the solar gaseous disk, was sufficiently massive to dilute later cometary contributions. By quantifying the mass of cometary material efficiently retained on Mars, we place a lower bound on the mass of the primordial Martian atmosphere. To test the robustness of our conclusions, we use cometary bombardment data from two independent studies conducted within a solar system evolutionary model consistent with its current structure. Our calculations show that, even under the most conservative scenario, the minimal mass of the primordial Martian atmospheres would yield a surface pressure of no less than 2.9 bar. Such a massive nebular envelope is consistent with recent models in which atmospheric capture is strongly enhanced by the presence of heavier species on Mars - due to outgassing or redox buffering with a magma ocean. As this primordial Martian atmosphere originated from the solar gas disk, it was mainly composed of hydrogen (H₂). These results, published in Joiret et al. (2025, EPSL), have important implications for the habitability of Mars during the Noachian.

14:28 – 14:40 — Methane cloud formation and impact on the climate of Titan with the Titan Planetary Climate Model

Lucie Rosset, Audrey Chatain, Clément Petetin, Enora Moisan, Bruno de Batz de Trenquelléon, Yassin Jaziri, Nathalie Carrasco, Olwen Rering [résumé PDF](#)

The thick atmosphere of Titan, Saturn's biggest moon, is home to complex cloud activity. Due to the abundance of methane, as well as the atmospheric and surface conditions, Titan's lower atmosphere hosts a methane cycle similar to that of water on Earth, with convective methane clouds forming in the troposphere [1]. In addition to the methane cycle, stratiform hydrocarbon clouds at the poles, or HCN clouds at high altitude have also been observed [2]. In this context, climate models are great tools for understanding the mechanisms at work and further our interpretation of these observations. The focus here will be on the atmospheric portion of the methane cycle, specifically the impact of the methane distribution on the formation and structure of the clouds, and the repercussions on the climate of Titan. The Titan Planetary Climate Model (Titan LMDZ PCM [3]) is a 3D climate model that simulates Titan's climate at a global scale. It includes coupling between the various modeled physical processes, among which a microphysical model in moments for haze and clouds [4]. The model takes into account the condensation of four species (CH₄, C₂H₂, C₂H₆, HCN) in the form of ice only, and independently of each other. The abundance of methane in the model was also previously constrained by Huygens measurements, with a minimum concentration set at 1.4%. Recent reanalysis of CIRS observations show that the Huygens measurements were atypical and that the concentration of methane in the stratosphere is generally lower, around ~1%, varying seasonally by +/-0.4% [5]. We therefore decided to remove this minimum value from the model and allow methane to evolve freely. We observe that this affects the altitude of saturation of methane and thus cloud formation in the model. The vertical and seasonal distribution of methane clouds is improved. The top altitude of methane clouds increases, and the seasons and latitudes of formation are consistent with the observations. The tropospheric thermal structure is also improved with respect to the observations.

14:40 – 14:52 — A backward Monte Carlo radiative transfer model for Titan's PCM

Anthony Arfaux, Sandrine Vinatier, Vincent Eymet, Vincent Forest, Pascal Ranou, Sébastien Lebonnois, Ehouarn Millour, Bruno de Batz de Trenquelléon, Zili He and Clément Petetin [résumé PDF](#)

Titan's atmosphere has been extensively studied and modeled over the years. Global Climate Models (GCMs) successfully reproduce the main features of Titan's atmosphere, including the detached haze layer and the polar clouds [Lebonnois et al., 2012, Lora et al., 2015, de Batz de Trenquelléon et al., 2025a,c,b]. However, those models rely on simple plane-parallel radiative-transfer algorithms which fail to capture the effects of heterogeneity and sphericity, important for the extended atmosphere of Titan. To address this limitation, we are coupling htrdr-planets [https://www.meso-star.com/projects/htrdr/htrdr.html He et al., 2026], a 3D backward Monte Carlo radiative transfer model, able to account for sphericity and heterogeneity effects, with the Titan LMDZ Planetary Climate Model (PCM) [de Batz de Trenquelléon et al., 2025a,c,b]. htrdr-planets incorporates recent developments in computing science [Galtier et al., 2013, Villefranque et al., 2019], and is able to calculate the radiative budget within each PCM cell with very little approximations and relatively low computational cost. Preliminary comparisons between the original 2-stream plane-parallel model used in the Titan LMDZ PCM and htrdr-planets, indicates that important differences are expected at high altitudes and latitudes, and should affect the stratospheric circulation and the thermal structure of the atmosphere. In this presentation, we present these comparisons and we explore the first results of the coupling.

References

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14:52 – 15:04 — New Insights into Pluto's Atmospheric Radiative Balance

de Batz de Trenquelléon, B., Bertrand, T., Falco, A., Lellouch, E., Lavvas, P., Sciamma-O'Brien, E., Millour, E., Forget, F. [résumé PDF](#)

The thermal balance and cooling mechanisms of the atmosphere of Pluto have long remained a mystery. Observations of a global haze layer by the New Horizons mission [1,2], together with recent measurements from the James Webb Space Telescope [3], suggest that this haze may play a key role in shaping Pluto's unusual atmospheric temperature profile. This haze-driven regime establishes Pluto's atmosphere as a unique case within the Solar System.

Beyond the now well-established role of haze in Pluto's thermal balance [3,4], its composition and precise radiative impact remain poorly constrained. Several one-dimensional microphysical models, developed based on observations from the New Horizons mission, have attempted to characterize the properties of Pluto's aerosols. Initially, the haze was interpreted as analogous to that of Titan, dominated by purely photochemical processes [5,6]. However, more recent studies suggest that the aerosols may also include a significant fraction of organic ice [7], formed through direct condensation of major photochemical products in the cold upper atmosphere. Such a condensed component could reduce the efficiency with which haze particles regulate the atmospheric thermal balance. Current microphysical models do not account for a mixed population of both photochemical and icy haze and are not coupled to radiative transfer schemes, preventing a comprehensive assessment of the haze's impact on Pluto's atmospheric energy balance. Finally, the seasonal evolution of the haze over a Pluto year, as well as its influence on the annual variability of atmospheric temperature, remains entirely unexplored to date. Constraining the origin, evolution, and composition of Pluto's haze is therefore essential to quantify its radiative effects and to better understand the planet's atmospheric behavior and its place among hazy worlds in the Solar System.

To constrain the origin of Pluto's haze and assess its impact on the climate, we developed the Pluto Planetary Climate Model (Pluto PCM), a global climate model coupled to a microphysical scheme that describes haze and cloud formation and evolution, along with their impact on thermal balance and atmospheric dynamics (see T. Bertrand's abstract). Here we show that Pluto's haze is likely composed of a mixture of photochemical aerosols— analogous to those observed on Titan—and organic ices, reconciling observational constraints from both New Horizons and the James Webb Space Telescope (Fig. 1). We further demonstrate that this haze governs the global thermal balance and is the primary driver of atmospheric cooling. In addition, we identify a seasonal cycle in the haze, providing a first coherent explanation for the

15:04 – 15:16 — How Radiative Haze Reshapes Pluto's Atmospheric Dynamics

Tanguy Bertrand, Bruno de Batz de Trenquelléon, Aurélien Falco, Emmanuel Lellouch, Aymeric Spiga, François Forget, Ehouarn Millour [résumé](#) [PDF](#)

As one of the ten atmospheres in the Solar System, Pluto offers a remarkable natural laboratory to test our understanding of atmospheric dynamics and physics, and to investigate the diversity of possible climate regimes.

We present a new version of the 3D Pluto Planetary Climate Model (PCM) in which haze microphysics is fully coupled to radiative transfer, allowing for the first time for a selfconsistent representation of the radiative impact of photochemical and icy aerosols in Pluto's atmosphere [Bertrand et al., 2020, Falco et al., 2024, de Batz de Trenquelléon et al., 2025]. The inclusion of radiatively active haze reduces the atmospheric radiative time constant by approximately an order of magnitude compared to the gas-only configuration [de Batz de Trenquelléon et al., this issue]. This modification leads to profound changes in the simulated climate and circulation.

In the absence of haze, the general circulation in the lower atmosphere is dominated by a retrorotation. The long radiative timescale results in weak meridional temperature gradients and meridional winds. This is an angular-momentum-dominated general circulation regime, in which heating gradients imposed by insolation are efficiently erased by dynamical mixing before building significant energy for baroclinic wave formation [Forget et al., 2017, Bertrand et al., 2020].

In contrast, simulations with radiatively active haze exhibit a markedly different dynamical behavior. The shorter radiative timescale enhances radiative heating gradients and allow weak meridional temperature gradients. This leads to an enhanced baroclinic activity, associated with significantly stronger meridional shear associated with mid-latitude prograde jets.

Our results illustrate that radiative feedbacks from the haze can shift Pluto's atmosphere between fundamentally different dynamical regimes, from a quiescent, angular-momentum-controlled state to a more active, baroclinic circulation. They also place Pluto in a broader comparative context. In particular, a strong analogy can be drawn with Mars, where variations in dust loading similarly modulate the radiative timescale and control the intensity and vertical structure of baroclinic activity. Our results also provide some explanations for several observations of Pluto, in particular the atmospheric meridional heating gradient observed with ALMA [Lellouch et al., 2022] as well as the year-to-year variability in haze opacity derived from stellar occultations [see review in Meza et al., 2018].

15:16 – 15:28 — A new derivation of the 12C/13C and 14N/15N isotopic ratios in HCN in the Jupiter stratosphere revealed by ALMA

Camille Lefour, Thibault Cavalié, Raphael Moreno, Ladi Rezac, Emmanuel Lellouch, Thierry Fouchet, Vincent Hue, Paul Hartogh [résumé](#) [PDF](#)

Measuring the composition and isotopic ratios in different solar system objects is of prime interest to understand their formation (Nomura et al. 2023). In the giant planet atmospheres, these measurements should reflect the primordial composition of the solar nebula (Fletcher et al. 2014). The isotopic ratios in the giant planets are important tracers of their formation. In Jupiter and Saturn, the low ^{15}N enrichment in NH_3 indicates that the main contributor of nitrogen to the planet atmospheres was N_2 , which is expected to be less enriched in ^{15}N than NH_3 in the nebula (Fletcher et al. 2014). The $^{12}\text{C}/^{13}\text{C}$ ratios measured in hydrocarbons are also close to the solar value (Niemann et al. 1998). However, rare events can completely alter the atmospheric composition for decades, as the impacts of comet Shoemaker-Levy 9 (SL9) in the Jupiter atmosphere in July 1994 (Lellouch et al. 1996, Cavalié et al. 2023b). From shock-induced chemistry, new molecules that were previously undetected (e.g., HCN, CS...) were provided/formed in the jovian atmosphere from a recombination of the comet material and Jupiter air parcels (Zahnle et al. 1995). Intriguing isotopic ratios were measured a few years after the impacts in two of these new molecules, HCN and CS, by Matthews et al. 2002. They found an abnormally low abundance of the heavier isotopes compared to jovian values, questioning an unusual cometary composition or fractionation processes in the shocks. Using radiative transfer modelling, we derive new $^{12}\text{C}/^{13}\text{C}$ and $^{14}\text{N}/^{15}\text{N}$ isotopic ratios in Jupiter's

atmosphere 23 years after SL9, from 2017 observations of HCN, H₁₃CN, and HC₁₅N with the Atacama Large Millimeter/submillimeter Array (ALMA). In contrast to the strong depletions reported in 1998 by Matthews et al. 2002, our values are instead compatible with an enrichment in the heavier isotopes relative to the jovian bulk. We interpret these enrichments as the direct signature of the cometary contribution in HCN and/or as 23 years of chemical evolution in the jovian atmosphere.

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15:28 – 15:40 — Tracing Uranus and Neptune Formation with Disequilibrium Species

T. Briand, V. Hue, O. Mousis, T. Cavalie T. Benest Couzinou, A. Schneeberger, and M. D. Hofstadter [résumé](#) [PDF](#)

Uranus and Neptune are the most distant and least explored planets within our solar system. To this day, the formation history of these ice giants remains uncertain. A better understanding of their deep atmospheric composition helps constrain where and how both planets formed. Remote sensing techniques can only probe the atmosphere down to a few bars. Similarly, an entry probe as part of the Uranus Flagship mission may only measure the atmospheric composition down to ~10 bars. Several disequilibrium species in the deeper troposphere are quenched to the pressure levels these measurements are made. Atmospheric models are thereby needed to interpret how the measured abundances reflect the deeper atmospheric composition.

Using a pseudo-2D thermochemical & diffusion model to account for the meridional variation of several parameters of interest, we aim to take advantage of such disequilibrium species to further constrain Uranus and Neptune deep atmospheric composition. We namely investigate the impact of accounting for convection inhibition due to planetary rotation. We present a range of plausible deep oxygen abundances and carbon-to-oxygen ratio, as well as assess the impact of chemical uncertainties on such ratio. When compared against the results of a protoplanetary disk model (Mousis et al. 2024), this work provides constraints on the formation history of Uranus and Neptune and support support the need for in-situ measurements, namely with the Uranus Orbiter and Probe mission.

15:40 – 15:52 — Modeling the internal structure and evolution of giant planets from Juno to Plato: Lessons and Challenges

Guillot, T. [résumé](#) [PDF](#)

Observations from Juno have revealed that Jupiter is far more complex than initially envisioned: its central core, rather than being compact, appears diluted within the planetary envelope; observed zonal flows extend from the atmosphere deep into a significant fraction of that envelope; and convection inhibition impacts both the helium rain region and water storms in the atmosphere. Additionally, the deep atmosphere is chemically heterogeneous and may include regions stable against convection, defying standard assumptions.

Current interior models still struggle to reconcile gravitational and spectroscopic constraints, highlighting gaps in our understanding.

With Plato's launch in early 2027, we will gain the ability to precisely measure the radii, masses, and ages of giant planets in our cosmic neighborhood. The complexity of interior and evolutionary models will directly influence the derived compositions. The challenge is substantial: as demonstrated in Plato WorkPackage 116100 ("Composition and formation of gas and ice giants"), model results can differ in radius by over 1% even under simplified assumptions.

This presents an opportunity to advance comparative planetology, bridging insights from Jupiter with future Plato data.

15:52 – 16:20 — *Pause*

16:20 – 16:44 — Chemical and isotopic properties of interstellar comet 3I/ATLAS

Dominique Bockelée-Morvan [résumé](#) [PDF](#)

Comets are fingerprints of the formation of the Solar System. The passage of a bright comet-like interstellar object in the solar neighborhood has long been awaited to investigate the physical, chemical and isotopic properties of icy planetesimals in other planetary systems. The interstellar comet 3I/ATLAS was discovered on a highly hyperbolic orbit ($e = 6.1$) on July 1, 2025, as it was at 5 au from the Sun. Subsequent studies have revealed a rapid increase of its gaseous activity as it approached the Sun, making detailed investigations possible. It passed its perihelion on 29 October 2025 at 1.36 au from the Sun. Comet 3I/ATLAS was observed worldwide from numerous observatories, including both ground-based facilities and space-based instruments and space missions. In this talk, I will present the main observational results, with particular emphasis on spectroscopic results obtained in the infrared and millimeter wavelength ranges with the JWST, ALMA, and IRAM-30m telescopes, and with MAJIS/Juice. The nucleus ices of 3I/ATLAS exhibit compositional and isotopic properties that differ from those of Solar System comets, suggesting that its natal planetary system formed in a different galactic environment from our own.

16:44 – 16:56 — The dust in Sauron’s eye: Observational and experimental results on the debris disk around HR 4796

Bonduelle, M; Milli, J.; Poch, O. [résumé PDF](#)

The dust in Sauron’s eye:

Observational and experimental results on the debris disk around HR 4796

Myriam Bonduelle¹, Julien Milli¹, Olivier Poch¹

Planetary systems are formed within circumstellar disks, initially called protoplanetary and consisting of gas, ice and dust particles. With the depletion of all (or most of) the gas and dust, these protoplanetary disks evolve into debris disks, reservoirs of planetesimals, km-sized rocky and icy bodies, whose mutual collisions grind the material into small μm - or mm-sized particles. Debris disks are therefore thought to be the markers of a successful formation of planetesimals, and the dust they contain is an indicator of the composition of exoplanetary materials. The optical properties of the dust particles orbiting in a disk (scattering phase function -SPF; degree of linear polarisation -DoLP, reflectance) can be retrieved through scattered light imaging, and are linked to the physico-chemical properties of the dust particles (size, shape, composition...).

The debris disk surrounding the A type star HR4796 is a bright, narrow disk, that has been observed at multiple wavelengths in scattered light and presents several peculiarities, especially an unusually high DoLP at small scattering angles. In this work, we aim at understanding the properties of the dust particles in HR4796, by combining multi-wavelengths scattered light observations, laboratory experiments, and results from Solar System objects. We use scattered light observations of HR 4796, obtained with SPHERE/IRDIS and SPHERE/Zimpol. We forward-model those observations using a novel joint parametric approach to constrain the morphology, the SPF, and the DoLP of the disk. We then analyse these results in regard with the DoLP we measured in laboratory on a dust analogue, previous findings on HR 4796 and on some Solar System asteroids and comets. We find that the material providing the best match to these properties in the near infrared appears to be 50-100 μm large iron sulphides particles, such as pyrrhotite and troilite. Such iron sulphides are among the opaque minerals that are probable contributors to the low albedo of some Solar System small bodies (B/C/D/P-type asteroids, comets etc.).

DoLP at a 90° scattering angle for multiple λ for: DoLP as a function of the scattering angle for: x : observations of HR 4796 - observations of HR 4796 (purple and teal) + : laboratory measurements on iron sulphides - Solar System objects

From Bonduelle+26 From Bonduelle+26

The DoLP angular dependence of HR 4796 is notably different from that of Solar system comets and seems closer to that of some asteroids. Combined with the spectral reflectance in the near infrared, these result suggest 50-100 μm scatterer sizes, possibly indicating some space weathering processes on the dust particles in HR 4796.

This work is carried out in the context of the ÉPOPEE collaboration (financed by the PNP).

16:56 – 17:08 — Astrochemical Inheritance of Terrestrial Planets Water from Local Wet Silicates

Lise Boitard-Crépeau & Stefano Pantaleone, Cecilia Ceccarelli, Pierre Beck, Lydie Bonal, Piero Ugliengo [résumé PDF](#)

The delivery of water to the inner Solar System rocky planets, including Earth, remains debated, as standard models assume that they formed from dry grains. However, we showed in a recent work, that a non-negligible amount of water formed during the prestellar phase could have been retained by pebbles and planetesimals at the Earth’s orbit in enough quantities to reproduce its water content. We based this study on a kinetic approach using

quantum mechanics calculations of the binding energy of water on amorphous ice. In this work, we present new quantum calculations of the binding energy of water frozen on the surface of silicate grains, and show that it is on average about twice stronger than that on the amorphous ice. The contribution of this first layer of frozen water increases the dust temperature at which frozen water can be retained. This provides a local source of water not only for the Earth, but also for the inner rocky planets. The predictions from our model are in agreement with the available estimates of water content in terrestrial planets. This suggests that water delivery from the outer Solar System may not be required.

17:08 – 17:20 — 3D registration and fusion of remote sensing data for planetary exploration

Loïs Brun, Sylvain Douté, Adeline Paiement [résumé PDF](#)

The integration of complementary remote sensing data acquired from multiple satellite platforms represents a fundamental challenge in planetary science. Firstly, it requires precise spatial alignment as a critical preprocessing step. Secondly, the fusion of these data needs to account for heterogeneous samplings and surface coverages. This registration task is particularly demanding for extraterrestrial environments due to several inherent difficulties: the scarcity of distinctive surface features that can serve as reliable landmarks, and significant variations in the spatial coverage (referred to as acquisition footprints) between different datasets. To address these challenges, we propose a novel methodology that leverages three-dimensional topographic information derived from stereo image pairs, specifically utilizing Digital Terrain Models (DTMs). Our approach employs 3D geometric principles to achieve automatic rigid registration between DTMs, enabling hands-free accurate alignment of planetary surface data, while generating a fused geometric product of the DTMs at user-defined resolution and sampling. The performance of our method is rigorously evaluated through comparative analysis against both baseline techniques and state-of-the-art registration algorithms and fusion frameworks. This evaluation is conducted using two distinct datasets: (1) a newly developed benchmark consisting of synthetic planetary DTMs specifically designed to simulate realistic extraterrestrial terrain conditions, and (2) actual Martian topographic data acquired from orbital missions. Experimental results demonstrate that our 3D geometric registration approach achieves satisfactory alignment accuracy while exhibiting significantly enhanced robustness to common remote sensing challenges. These challenges include incomplete data coverage (missing data regions) and varying degrees of overlap between different acquisitions. The practical utility of our method is further validated through its successful application to the registration of a Martian data mosaic, showcasing its effectiveness in real-world planetary data integration scenarios. Our contributions include: (1) a robust 3D geometric registration framework specifically designed for planetary DTM alignment, (2) a customizable method to fuse the geometric information of DTMs at the resolution and sampling of choice, (3) a comprehensive benchmark dataset for evaluating planetary registration algorithms, and (4) empirical validation demonstrating superior performance in handling footprint-related challenges compared to existing methods.

17:20 – 17:32 — ZoRo : une expérience de laboratoire pour décortiquer les effets de la rotation, de l'ellipticité et des écoulements en sismologie planétaire

Nataf, H-C., Boué, P., Cardin, P. Cébron, D. [résumé PDF](#)

L'expérience ZoRo comporte un sphéroïde rempli de gaz, en rotation rapide autour de son axe de symétrie. Une modulation de la vitesse de rotation génère des écoulements en son sein. Avec un rayon équatorial $r_{eq} = 0.20\text{m}$ et un rayon polaire $r_{pol} = 0.19\text{m}$, le sphéroïde présente un aplatissement légèrement inférieur à celui de Jupiter. L'originalité de ZoRo tient à son instrumentation acoustique : 4 mini haut-parleurs et 14 microphones embarqués permettent de générer des sons et d'enregistrer la réponse acoustique du dispositif. Les modes propres de résonance sont affectés par l'aplatissement, la rotation et l'écoulement. Leur étude nous a permis de mesurer les coefficients de Ledoux (1951) et de conforter la théorie linéaire de l'écoulement de libration due à Greenspan (1968). En générant des pulses brefs, nous pouvons également étudier les réverbérations des ondes de volume qui dominent la coda et tester les méthodes de corrélation inter-stations développées en sismologie.

17:32 – 17:44 — Quel serait le champ magnétique de la Terre si elle tournait sur elle-même aussi lentement que Vénus ?

Nataf, H-C., Schaeffer, N., Noraz, Q., Brun, A.S., Strugarek, A. [résumé PDF](#)

Les lois d'échelles classiquement utilisées ne prédisent aucune différence, l'intensité B du champ magnétique ne dépendant que de la puissance convective disponible pour la dynamo. Ces mêmes lois prédisent cependant une vitesse d'écoulement U qui serait environ 6 fois plus rapide. Le jour sidéral de Vénus durant 243 jours terrestres, on en déduit que le nombre de Rossby $Ro = U/\Omega R$ serait environ 1500 fois plus grand. Ces lois d'échelle s'appuient sur des simulations numériques qui visent à satisfaire l'équilibre des forces QG-MAC attendu pour la

Terre (faible nombre de Rossby et équilibre entre les forces d'Archimède, de Lorentz et de la partie non-géostrophique de Coriolis). On peut effectivement construire un scénario QG-MAC compatible avec les mesures du champ magnétique et des écoulements pour la Terre, mais cela semble beaucoup moins faisable pour Vénus, un tel scénario prédisant que la dynamo serait générée à des échelles insensibles à la rotation. L'équilibre pertinent serait alors peut-être plus proche de celui invoqué pour le Soleil, où la force d'inertie devient comparable aux autres forces (équilibre IMAC). Dans ce régime, la dynamique n'est plus autant contrainte par la rotation. L'énergie cinétique peut excéder l'énergie magnétique, qui décroît vers les grandes échelles. Vénus pourrait ainsi générer un champ magnétique qui aurait échappé aux observations jusqu'à ce jour.

17:44 – 17:56 — The NEO Physical Observations and Properties Simulation (NEOPOPS) – an EU funded project for planetary defense

J. Bourdelle de Micas, E. Dotto, S. Ieva, P. Pravec, M. Lazzarin, S. Bagnulo, M.A. Barucci, M. Birlan, J.L. Cano, M. Devogèle, A. Farina, P. Fatka, F. Ferri, M. Fulchignoni, F. La Forgia, E. Mazzotta Epifani, M. Micheli, A. Mura, D. Perna, and M. Siciliano [résumé PDF](#)

The study of Near-Earth Objects (NEOs) provides key insights into the primordial structure of planetesimals. These bodies carry information on the compositional gradient of the solar nebula and on the processes that governed the early stages of the Solar System evolution as a function of heliocentric distance. NEOs may also have contributed to the delivery of water and organic-rich material to Earth, contributing to the emergence of life [1]. From a planetary defense perspective, these objects can pose a threat to our civilization. Terrestrial impact craters and paleontological evidence of mass extinction events attest to the catastrophic effects of past asteroid collisions with our planet (e.g. the K-Pg event which occurred approximately 65 million years ago, and is attributed to the impact of an asteroid of about 10 km in size). More recently, the Chelyabinsk meteor event in February 2013 demonstrated that even relatively small objects (less than 100 m in size) can have significant consequences for human safety and infrastructures [2]. In any potential impact scenario, mitigation measures require accurate knowledge of an object's physical properties [3], which is essential for both planning and successfully implementing appropriate response strategies.

In this context, the NEO Physical Observations and Properties Simulation (NEOPOPS) was established, building on the success of previous international research programs dedicated to the study of NEOs (NEOShield 1 and 2, and NEOROCKS). NEOPOPS is an European project funded by the European Union's Horizon Europe Programme for the period 2025-2028. Its objectives are multiple : • to efficiently organize follow-up astronomical observations of NEOs, in order to obtain high-quality data for deriving their physical properties, with priority given to the timely characterization of potentially hazardous objects; • to significantly improve statistical analyses, modeling, and numerical simulations aimed at understanding the physical nature of NEOs, with a particular focus on small-sized objects, which are of paramount importance for designing effective mitigation measures both in space and on the ground; • to foster European and international cooperation in NEO physical characterization, providing scenarios and roadmaps with the scale up the experience gained during the project to a global level;

AMPHI 5 — S06 : LE CIEL TRANSITOIRE DANS L'ÈRE DE SVOM · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s06/>

14:00 – 14:25 — Premiers résultats scientifiques de SVOM

Jesse Palmerio on behalf of Bertrand Cordier and the SVOM collaboration [résumé PDF](#)

Le lancement en juin 2024 du satellite SVOM a ouvert une nouvelle fenêtre sur les observations des sursauts gamma (GRBs) et leurs phénomènes transitoires associés, en particulier en abaissant le seuil de détection jusqu'à 4 keV et améliorant nettement la sensibilité du suivi immédiat dans le visible. Je présenterai d'abord la mission SVOM en mettant l'accent sur les choix stratégiques qui la démarquent de missions précédentes puis j'illustrerai les premiers résultats scientifiques après plus d'un an en phase d'exploitation. En particulier, je soulignerai par des exemples concrets la capacité de SVOM à explorer la diversité des populations de GRBs (les courts, les longs classiques, les ultra-longs, les mous, les haut-redshift). Je finirai par un premier bilan statistique de l'année écoulée et les perspectives d'amélioration à venir.

14:25 – 14:45 — Leveraging the diversity of GRB afterglows detected by SVOM

Pellouin, C. [résumé PDF](#)

Since its launch, the SVOM satellite has detected over 90 GRBs with its ECLAIRs instrument. While recovering standard events that were previously observed with past missions, SVOM exhibits a new population of softer events with properties resembling those of GRBs. For all those events, interpreting the afterglow emission

powered by the decelerating relativistic jet remains the most powerful way to analyse their properties (such as the jet energy and its geometry, the interstellar medium density, or particle acceleration properties) and provide an interpretation of their physical origin. I will present the diversity of afterglow properties from radio to very high energies (\sim TeV) using my model, which includes several different physical processes. I will particularly highlight the impacts of jet structures and arbitrary viewing angles, synchrotron self-Compton scattering including the Klein-Nishina regime, and self-absorption; at the forward and reverse shocks. Based on results from the studies of several different GRBs, I will show how this complete model helps shedding light on the diversity of events detected by SVOM and observed by other followup facilities (especially in radio and in the TeV range), and highlight the challenging features that such models will inevitably struggle to reproduce. I will underscore the importance of having a complete and computationally-efficient model to analyse the large number of ECLAIRs detections.

14:45 – 15:05 — Revisiting the internal shocks as a mechanism for GRB prompt emission

Charlet, A. [résumé PDF](#)

Gamma-ray bursts (GRBs) release a star's lifetime energy in seconds through an ultra relativistic jet, but the exact process behind the jet prompt emission remains unknown. In the internal shocks model, variations in the jet velocity causes the material to collide at a large distance from the source. These collisions accelerates electrons which emits this energy as gamma-rays by fast synchrotron cooling ("fast" in comparison to the dynamical time). However, observations have shown more photons at low energies than what synchrotron models can predict, pushing towards alternate explanations. In this work, we revisit the internal shock model through a full analytical derivation and careful numerical modeling. Identifying the ratio of the shells Lorentz factors as the main physical parameter, we build a spectral model that produces the expected observed flux for any input shell parameters. For a typical collision of shells with equal energy and Lorentz factor ratio of 2, the model predicts a significant spectral component at \sim 1/10th of the main spectral peak. This secondary component consistently explains the observed low-energies photon excess in GRB spectra over the range of expected jet parameters. We test the model over a few selected "single pulse" GRBs and pave the way for the analysis of more complex bursts.

15:05 – 15:25 — The impact of pair production on Gamma Ray Burst prompt emission spectra

Gnaoui, M., Daigne, F., Guépin, C. [résumé PDF](#)

Abstract : Gamma Ray Burst prompt emission is widely attributed to radiation from accelerated electrons within ultra-relativistic ejecta. Yet, the observed spectral shape is not always compatible with the most standard synchrotron prediction. The detection of high energy components (>100 MeV) in several GRBs, along with theoretical predictions of inverse Compton scattering, suggest the presence of abundant photons above the pair production threshold in the comoving frame. Under such conditions, photon-photon interactions lead to significant production of electron-positron pairs. By modelling numerically the coupled evolution of photons and leptons, we investigate the impact of secondary pairs on the emergent spectrum in the optically thin regime. We find that the emission from these pairs can drive substantial deviation from the standard synchrotron prediction in the soft gamma-ray range, including changes of both low and high energy photon indices. The recent launch of SVOM and Einstein Probe opens up new perspectives for the study of prompt low energy emission. In particular, the spectral shape above 4 keV can be precisely measured by the combination of ECLAIRs and GRM onboard SVOM. This could prove crucial in measuring these effects and improving our understanding of the prompt emission mechanisms. In rare cases, the annihilation of the secondary pairs can produce a narrow emission line above 1 MeV. We explore the physical conditions required for the emergence of this annihilation line and investigate the possibility to reproduce the MeV line reported in the BOAT GRB221009A.

15:25 – 15:50 — The Lazuli Space Telescope and its use for Cosmology

Mickael Rigault [résumé PDF](#)

Abstract Lazuli is a 3m-class space telescope founded and developed by the Schmidt Sciences as part of the Schmidt Observatory System, with a concept to launch timeline of approximately 3 years. The observatory is equipped with 3 instruments (a slicer integral field spectrograph, a multi-band camera array, and a coronagraph) and is designed to allow rapid response (<4 hours) for transients alerts' target of opportunities. In this presentation, I will review this novel facility and I will illustrate its interest by detailing a potential major cosmology science case, which focuses on using the Integral Field Spectrograph to acquire high precision and high accuracy cosmological parameters from supernova data. This presentation will be the occasion to discuss the unique opportunity offered by the Schmidt Observatory System as a whole for cosmology.

15:50 – 16:20 — Pause**16:20 – 16:40 — First scientific results from the COLIBRÍ robotic telescope and perspectives at OHP with Mistral@T193, Providence, and ELIXIR**

S. Basa et al. [résumé PDF](#)

COLIBRÍ is a 1.3-m robotic telescope equipped with a three-channel panchromatic camera, enabling simultaneous observations from the visible to the near-infrared. Designed for time-domain astronomy, it is characterized by an exceptional rapid-response capability by being able to react to transient alerts in less than 15 seconds.

Developed through a French–Mexican collaboration, COLIBRÍ has been motivated and optimized for the follow-up of the alerts from the Franco-Chinese SVOM satellite, with the goal of improving our understanding of the origin and physics of gamma-ray bursts (GRBs), as well as their applications in cosmology. Beyond this primary objective, it contributes more broadly to time-domain astrophysics, including the follow-up of fast radio bursts (FRBs), the search for optical counterparts of gravitational-wave events, and the study of a wide range of transient phenomena.

Located at the Observatorio Astronómico Nacional in the Sierra San Pedro Mártir (Mexico), COLIBRÍ has been in scientific operation since January 2025. We present its instrumental concept, on-sky performance, and first scientific results.

This contribution will also discuss the perspectives offered by current and upcoming observational facilities at the Observatoire de Haute-Provence (OHP), including Mistral mounted on the T193 telescope, Providence, the future 2.52-m telescope, and ELIXIR, a widefield survey currently under deployment.

16:40 – 17:00 — Two Years of Fast Extragalactic Transients as Seen by the Einstein Probe Mission

Turpin, D. [résumé PDF](#)

The Einstein Probe (EP), a mission led by the Chinese Academy of Sciences (CAS), is dedicated to time-domain high-energy astrophysics. It carries a wide-field lobster-eye X-ray focusing imager (WXT), which enables the detection of transient X-ray events across the sky and the monitoring of variability in known sources in the 0.5–4 keV energy range. The sensitivity and observational cadence of EP/WXT exceed those of both past and current wide-field X-ray monitoring missions.

In addition, EP is capable of rapidly characterizing newly discovered transients or outbursts using its onboard Wolter-I X-ray telescope (FXT).

Since its launch in January 2024, EP has detected 176 X-ray transients and more than 1,500 stellar flares, while issuing over 580 alerts to the scientific community through the WXT instrument. The FXT has carried out more than 1,900 Target-of-Opportunity observations, demonstrating that EP is not only a powerful discovery engine but also a versatile, interdisciplinary observatory serving the transient sky community.

In this talk, I will present EP's discoveries from its first two years of operation, with a particular emphasis on fast extragalactic X-ray transients and how our understanding of these phenomena is beginning to evolve and broaden.

17:00 – 17:20 — Almost Regular, Always Surprising: The State of QPE Research

E. Quintin, G. Miniutti, M. Giustini, R. Saxton, S. Dupourqué [résumé PDF](#)

Abstract: Quasi-Periodic Eruptions (QPEs) are among the latest members of the ever-growing family of extragalactic transient events. First identified in 2019, they are characterized by extreme bursts of thermal X-rays, lasting a few hours and repeating quasi-periodically, reaching AGN-like luminosity at their peak. The current sample consists of only 13 sources, and shows a puzzling correlation with the seemingly independent Tidal Disruption Events (TDEs). The nature of QPEs is still a mystery, although the currently favored model invokes an Extreme-Mass Ratio Inspiral (EMRI) in which a low-mass object orbits around a massive black hole, and then collides with the newly formed accretion disk of an independent TDE. If confirmed, QPEs would represent the first (and possibly only) electromagnetic counterpart to EMRIs, a key source of gravitational waves for LISA. In this talk, I will review the current state of this rapidly developing field, including recent progress in constraining the existing models. I will also discuss observational challenges and prospects for QPEs in the post-NICER era, highlighting upcoming opportunities with SVOM and Einstein Probe, as well as future missions such as NewAthena and LISA

17:20 – 17:40 — Joining RAMSES simulations and LGRB afterglow spectroscopic observations to study high-redshift galaxies

M. Garnichey, S. D. Vergani [résumé PDF](#)

The afterglow spectroscopy of Long Gamma Rays Bursts (LGRBs) is a major tool to study the chemical properties of their host galaxies even at very high redshift. When the afterglow illuminates the galaxy as a background source, it reveals non-radiating elements present in the gas, along the line of sight, through absorption lines in the spectra. This offers unique information on the gas in, and surrounding, the GRB star forming region, as well as of the warm gas in the interstellar medium of the galaxy. Combined with typical observations integrated over the entire galaxy, from photometry or emission line spectroscopy, LGRBs bring a broad view of the physical property of its host. That makes LGRBs unique tools to better understand galaxy evolution.

I will present ongoing work comparing results of the observations of LGRB host galaxies and zoom-in hydrodynamical simulation of a representative LGRB host at redshift $z=3$, focusing in particular on neutral hydrogen, metals, and escape of Lyman-alpha and ionizing photons. The goal of my work is to physically interpret LGRB spectra, to investigate the impact of LGRBs on the progenitor environment, and test galaxy simulations. I will discuss the results of the exploration related to the absorption of neutral hydrogen and escape of Lyman-alpha and ionizing photons, and I will also present some preliminary results I obtained on metal absorption lines.

17:40 – 18:00 — Very High Energy Emission from Gamma-Ray Bursts: Insights from 15 Years of H.E.S.S. Observations

Ruiz-Velasco, E., for the H.E.S.S. Collaboration [résumé PDF](#)

The detection of Gamma-Ray Bursts (GRBs) at Very High Energy (VHE, $E > 100$ GeV) was a long-awaited result that required years of dedicated observational efforts. This work presents a comprehensive re-analysis of 15 years of GRB data collected by the High-Energy Stereoscopic System (H.E.S.S.), establishing a robust set of VHE upper limits. Our analysis explores the nature of VHE emission by demonstrating that the small set of detected events from the last decade do not constitute a unique population; rather, they represent particularly luminous bursts occurring at low redshifts. By integrating H.E.S.S. limits with multi-wavelength datasets for the most significant events, we modelled afterglow emission to constrain the microphysical parameters within standard VHE emission frameworks. These findings provide a baseline for the future capabilities of the Cherenkov Telescope Array Observatory (CTAO), particularly in the context of multi-messenger synergies with the next generation of observatories and missions.

Soirée

Soirée d'Accueil — Hôtel de Ville de Grenoble

Mercredi 24 Juin

Matinée · 09:00–12:00 — Session plénière (S00)

Session plénière

09:00 – 09:25 — Se préparer pour la science de l'ELT : un instrument HARMONI recentré

Benoît Neichel (invité) [résumé PDF](#)

L'Extremely Large Telescope (ELT) progresse rapidement vers son achèvement, avec une première lumière prévue d'ici la fin de la décennie. Avec son miroir primaire de 39 mètres et ses systèmes d'optique adaptative de nouvelle génération, l'ELT ouvrira un nouveau régime observationnel en astronomie au sol, caractérisé par un gain majeur en sensibilité et en résolution angulaire. Il permettra d'aborder des questions fondamentales en astrophysique, depuis la formation des premières structures jusqu'à l'étude détaillée d'objets proches, et constituera un outil central pour la communauté astronomique pour les décennies à venir.

Afin d'exploiter pleinement ces capacités, l'ELT sera équipé d'une suite instrumentale complémentaire couvrant un large domaine de paramètres en échelle spatiale, résolution spectrale et modes d'observation.

Dans cette contribution, nous présentons tout d'abord un aperçu de l'état d'avancement de la construction de l'ELT et des principales étapes vers sa première lumière. Nous nous concentrons ensuite sur HARMONI, le spectrographe à champ intégral à haute résolution angulaire opérant dans le proche infrarouge. HARMONI a récemment fait l'objet d'une refonte visant à simplifier son architecture, renforcer sa robustesse et recentrer ses performances sur ses objectifs scientifiques prioritaires.

Nous présentons les capacités actualisées de HARMONI, modes d'observation, performances attendues et interfaces avec les systèmes d'optique adaptative de l'ELT, en soulignant ses synergies avec les autres instruments. Nous discutons ensuite les possibilités scientifiques offertes par l'instrument, notamment l'étude des populations stellaires résolues, l'évolution des galaxies à haut redshift, la physique des régions centrales galactiques, ainsi que la caractérisation d'exoplanètes et d'objets du Système solaire.

Cette présentation vise à encourager la communauté à préparer dès maintenant des programmes scientifiques ambitieux pour préparer l'arrivée de l'ELT et maximiser l'impact scientifique dès le début des opérations.

09:25 – 09:50 — Nouvelles du CNES

Philippe Laudet (invité)

09:50 – 10:15 — La physique stellaire au cœur de l'astrophysique moderne

Orlagh Creevey (AT PS) [résumé PDF](#)

Orlagh Creevey (Lagrange, OCA/UniCA/CNRS) La physique stellaire au cœur de l'astrophysique moderne La physique stellaire constitue un socle essentiel pour l'interprétation d'un large éventail de phénomènes astrophysiques. Ces dernières années, les progrès observationnels et théoriques ont mis en évidence le rôle central de la physique stellaire à l'interface avec d'autres domaines, tels que l'étude des exoplanètes, l'archéologie galactique, les populations stellaires et les grands relevés comme la mission Gaia et PLATO. Dans cet exposé, je proposerai une vue d'ensemble de ces interfaces, en mettant l'accent sur des développements récents et sur des exemples de recherches menées en France. L'objectif est d'illustrer comment la physique stellaire moderne contribue à une compréhension intégrée des étoiles, des planètes et de la Voie lactée, ainsi que de souligner quelques enjeux et perspectives actuels.

10:15 – 10:45 — Pause Café *

10:45 – 11:10 — Olivia Venot (présidente) : Bilan moral

AG SF2A

11:10 – 11:35 — Dynamique magnétisée du milieu intra-amas : synergies entre modélisation et observations futures

PRIX SF2A (Prix Meilleure Thèse) [résumé PDF](#)

Trouvé aux très grandes échelles, le milieu intra-amas est un gaz très chaud et peu dense piégé aux nœuds de la toile cosmique. La dynamique de ce fluide est vraisemblablement une clé de compréhension pour la résolution de certains problèmes ouverts de l'astrophysique moderne, comme l'origine et l'amplification des champs

magnétiques dans l'Univers pour n'en citer qu'un. Par ailleurs, de grands observatoires tels que NewAthena/X-IFU et SKA sont aujourd'hui en cours de développement et devraient permettre, à l'avenir, de caractériser avec un niveau de résolution inédit la turbulence et le magnétisme (respectivement) des amas de galaxies. Lors de cette présentation, je soulignerai tout d'abord les efforts que nous avons entrepris durant ma thèse pour modéliser de la dynamique magnétisée du milieu intra-amas. Ces efforts se sont notamment portés sur l'étude d'une instabilité magnéto-thermique et d'un possible effet dynamo pour l'amplification du champ magnétique des amas. Ensuite, je mettrai en avant les synergies possibles entre modélisation et futures observations du milieu intra-amas en rayons X et en ondes radio. Une première tentative prospective de détection de dynamique magnéto-thermique avec l'instrument X-IFU à bord de (New)Athena sera notamment présentée.

Magnetised dynamics of the intracluster medium : synergies between modelling et future observations Jean Maëï Kempf^{1,2} & François Rincon²

Found at very large scales, the intracluster medium (ICM) is a very hot and tenuous gas trapped at the nodes of the cosmic web. The dynamics of this fluid is likely key to understanding and answering some open questions of modern astrophysics, like the origin and the amplification of magnetic fields in the Universe to name but one. Besides, major observatories such as NewAthena/X-IFU and SKA are currently under way and should enable, in the future, to characterise with an unprecedented resolution turbulence and magnetism (respectively) in galaxy clusters. During this talk, I will first highlight the studies that we undertook during my PhD to model ICM magnetised dynamics. These developments focused in particular on the study of a magneto-thermal instability and of a possible dynamo effect for the amplification of cluster magnetic fields. Then, I will emphasise the possible synergies between modelling and future observations of the ICM in X-ray and radio wavelengths. A first prospective attempt to detect magneto-thermal dynamics with the X-IFU instrument flying onboard (New)Athena will be presented.

11:35 – 12:00 — Interaction vent solaire-magnétosphères planétaires: dynamique à grande échelle et processus microphysiques

PRIX SF2A (Prix Jeune Chercheuse) [résumé PDF](#)

La majeure partie de la matière visible dans l'Univers se présente sous forme de plasma, un état magnétisé, turbulent et hautement dynamique. Au sein de notre système solaire, l'interaction entre le vent solaire et les magnétosphères planétaires offre un laboratoire unique pour étudier les processus universels sous-jacents. Cette présentation retrace mon parcours de recherche, centré sur le couplage électrodynamique entre le vent solaire et divers environnements planétaires, allant de l'atmosphère non magnétisée de Vénus aux magnétosphères intrinsèques de Mercure, de la Terre et de Saturne.

Je soulignerai comment ma double approche, associant le développement instrumental à l'exploitation de données spatiales multi-missions, permet une exploration multi-échelle de la physique des plasmas. Nous aborderons des mécanismes clés tels que la turbulence, les interactions ondes-particules et le cycle de vie des ions planétaires, en allant jusqu'aux interactions complexes entre les géantes gazeuses et leurs lunes glacées.

Enfin, j'aimerais évoquer mon engagement au sein de notre communauté. Pour moi, le progrès scientifique est indissociable d'une dynamique collective, car c'est cette cohésion qui constitue le véritable moteur de la réussite de nos futures missions spatiales.

Après-midi · 14:00–18:00 — Sessions parallèles

AMPHI 1 — S03 : ATELIER GÉNÉRAL DE L'ACTION THÉMATIQUE PHYSIQUE STELLAIRE · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s03/>

14:00 – 14:05 — *Nouvelles de l'ATPS*

14:05 – 14:17 — Results (and a few surprises) from JWST imaging of Edge-On Protoplanetary Disks

François Ménard [résumé PDF](#)

By occulting direct starlight and presenting their vertical structures to direct view, edge-on protoplanetary disks are uniquely valuable systems for imaging in scattered starlight. From the optical to the mid-infrared, the wavelength dependence of the dust lane thickness provides clues about dust grain sizes and dust settling. In JWST Cycle 1 we imaged four prototype systems, finding that three of them still appeared as bipolar scattered light nebulae even at 21 microns, and that grains as large as 10 microns must still be present at the disk scattering surfaces. In JWST cycle 2, a dozen more edge-on protoplanetary disks were imaged with NIRCcam and MIRI. In

this contribution we will present a few highlights. Briefly, we find an unexpected diversity of source properties including 1) more systems that still appear as bipolar nebulae at 21 microns; 2) PAH emission extending well beyond the disk in two Ae star sources; 3) a newly recognized disk silhouette in Ophiuchus; 4) a system with unique mid-IR outflow features unseen at other wavelengths; 5) targets that transition from bipolar nebulae in the optical to PSF-dominated systems in the mid-IR; and 6) one system that is now revealed as an edge-on torus. Through these studies, we have also devised new approaches for measuring ice abundances of the main species (H₂O, CO, CO₂) in highly inclined protoplanetary disks. In strong synergy with HST, ALMA, and VLT/SPHERE, these JWST images shed new lights on several key aspects of the structure and evolution of disks and their dusty content: dust settling and radial drift, level of turbulence, disk wind and dust entrainment... Better, in combination with the on-going DISKSTRAT ALMA large Program (PI R. LeGal; Co-PI F Menard) that will study molecular gas emission in the same sample of edge-on disks, all these results will yield an unprecedented view of the 3-dimensional distribution of gas and dust in disks.

Acknowledgments

This project has received funding from the European Research Council (ERC) under the European Union's Horizon Europe research and innovation program (grant agreement No. 101053020, project Dust2Planets).

14:17 – 14:29 — Constraining the dust physics in the innermost regions of protoplanetary disks: a radiative transfer modelling approach to large VLTI interferometric surveys

Mathis Houllé [résumé PDF](#)

The innermost regions (< 1 au) of protoplanetary disks are sites of complex processes and peak dust densities, where rocky planets such as those detected via transits are formed. Stellar irradiation is intense enough to sublimate dust grains, creating an inner rim identified by hot dust emission at temperatures of 1000-1500 K, clearly detected in the near-infrared. Due to the tiny angular scales involved (< 10 milliarcseconds), only optical long-baseline interferometry has been able to resolve these regions. Large surveys with PIONIER and GRAVITY at the VLTI have provided measurements of inner rim radii, widths, and fluxes, as well as constraints on azimuthal asymmetries on a hundred of Herbig and/or T Tauri stars. In order to link these measurements to the physical nature of the dust, we are currently creating a grid of self-consistent disk models on a range of stellar luminosities, dust sizes and dust compositions with the radiative transfer code MCMax, which iteratively applies dust sublimation to compute the disk density and temperature. We will present comparisons of predictions from these models with measurements from large interferometric surveys, and discuss the constraints it provides on the dust morphology and chemistry. We will also discuss the amount of asymmetry caused by pure disk inclination effects predicted by the models, which hints at whether or not dusty local structures such as vortices have to be invoked to explain asymmetries detected by interferometry.

14:29 – 14:41 — What causes the dust's asymmetric emission in the inner parts of protoplanetary disks seen by the VLTI ?

Siméo Evelain [résumé PDF](#)

Interferometric observations conducted with the VLTI have revealed asymmetric near-infrared dust emission in the innermost regions of several protoplanetary disks, where planets are expected to form and migrate. Moreover, some of these observations show a temporal variability in the asymmetry, which can not be explained by axisymmetric disk models. We explore the hypothesis that a vortex generated by the Rossby Wave Instability (RWI) is responsible for dust trapping, and therefore for the asymmetric emission. To investigate this scenario, we carried out 2D and 3D hydrodynamical simulations with the FARGO3D code to model the inner parts of protoplanetary disks, which feature a transition between an inner strongly turbulent region and an outer weakly turbulent region. Our simulations show that this transition can trigger the formation of a dust-trapping vortex due to the RWI, whose lifetime can be significantly increased by the presence of multiple planets near the transition region. Our simulation results are post-processed with RADMC-3D dust radiative transfer calculations to compute synthetic dust emission maps in the near-infrared, and synthetic interferometric observations are then produced with the ASPRO2 tool. In this communication, we will discuss the possibility to reproduce, with our setup, the observed asymmetries in the inner regions of HD 163296 and the possible contribution of planets to account for these asymmetries.

14:41 – 14:53 — Systèmes multiples : amis ou ennemis de la formation planétaire ?

Antoine Alaguero [résumé PDF](#)

La formation planétaire se déroule majoritairement dans des environnements dynamiquement complexes, puisque la plupart des étoiles naissent au sein de systèmes multiples. En particulier, les forces de marées induites par les compagnons stellaires accélèrent les collisions entre les grains de poussière, limitant ainsi leur croissance. Cependant, ces mêmes perturbations créent naturellement des surdensités dans le disque, tels que des bras spiraux par exemple. Ces régions de forte densité sont susceptibles de devenir des sites privilégiés pour l'agrégation des grains. Ainsi, il reste difficile de savoir si les systèmes multiples favorisent ou inhibent la croissance des grains de poussière. Nous abordons ce problème à l'aide de simulations hydrodynamiques 3D de disques dans des systèmes binaires, incluant un traitement explicite de la croissance et de la fragmentation des grains. Nous traitons à la fois le cas circumstellaire et le cas circumbinaire. Nos résultats montrent que, malgré la présence de structures denses, le profil de densité des disques dans les binaires ne favorise jamais la croissance des grains par rapport à un disque isolé. En considérant en plus la cinématique de la poussière, nous démontrons que la taille maximale des grains dans les systèmes binaires est réduite d'au moins un ordre de grandeur. En étudiant les conditions de déclenchement de l'instabilité de streaming, nous montrons que cela compromet la formation des planétésimaux. Enfin, grâce à des considérations démographiques, nous posons de nouvelles contraintes sur la formation des exoplanètes détectées dans les systèmes multiples. Ce travail met en lumière la difficulté de former des planètes par accrétion de coeur dans de tels systèmes, et souligne le besoin de nouveaux éléments théoriques pour expliquer la population d'exoplanètes observée.

14:53 – 15:05 — Comparaison des propriétés de diffusion d'analogues de poussières de disques protoplanétaires

Rémi Zerna [résumé PDF](#)

Afin de mieux interpréter les images de disques protoplanétaires obtenues avec ALMA ou JWST, il est essentiel de caractériser les propriétés de diffusion des particules qui les composent. Pour contraindre leur morphologie, on peut s'appuyer sur des analogues issus du Système solaire. En effet, dans le milieu interplanétaire ou à la surface des comètes, on trouve par exemple des particules fractales [1, 2]. On peut également se baser sur les météorites chondritiques, qui contiennent une matrice (poussière fine submicronique) ainsi que des chondres et des inclusions millimétriques, formées dès les premiers millions d'années du Système solaire [3]. Il est raisonnable de penser que des objets similaires existent dans les disques que nous observons, où astéroïdes et planètes sont encore en cours de formation. Dans cette conférence, j'expliquerai notre étude des propriétés de diffusion de plusieurs analogues de ces particules, dans le but d'évaluer si leur morphologie peut produire une signature observable dans les images de disques jeunes. Une méthode non destructive, la tomographie aux rayons X, a permis de reconstruire la morphologie de chondres dans une météorite carbonée. Les analogues sont ensuite imprimés en 3D à l'échelle centimétrique avec des matériaux dont l'indice de réfraction est proche de celui des silicates astrophysiques. Leurs propriétés de diffusion sont mesurées par analogie micro-onde à l'Institut Fresnel via la plateforme MIMOSA (Mesures multi-Incidences Multi-Orientations de SER/diffraction/diffusion en chambre anéchoïque, [4]). Elles sont complétées par des simulations numériques utilisant la méthode de Discrete Dipole Approximation avec le code ADDA [5]. Pour chaque analogue, nous mesurons et calculons la fonction de phase de diffusion (SPF) ainsi que le degré de polarisation linéaire (DLP) entre 3 GHz et 18 GHz (correspondant à des paramètres de taille allant de l'unité à la dizaine). Je présenterai une comparaison de nos résultats à la théorie de Mie, montrant tout d'abord que la SPF des chondres présente un comportement proche de celui de sphères de masse équivalente. En revanche, lorsque l'élongation ou l'aplatissement de ces objets augmente, leur DLP diminue significativement, ce qu'une sphère ne permet pas de reproduire [6].

Remerciements : Ce travail a été soutenu par le projet ERC-ADG-101053020 Dust2Planets. Nous remercions également Yves Marrocchi (CRPG, Nancy) pour la tomographie aux rayons X et la morphologie des analogues.

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15:05 – 15:17 — CIRENE : une plateforme expérimentale pour l'étude des novæClotilde Busschaert [résumé PDF](#)

Les installations laser de puissance offrent une plateforme inédite pour explorer la physique stellaire en laboratoire [1]. Lors de cet exposé, nous présenterons les derniers résultats associés à la campagne CIRENE [2] réalisée sur l'installation LULI200 en Octobre 2025 et portant sur l'étude de la structure de double choc dans les novæ [3].

Les novæ jouent un rôle central dans l'évolution des systèmes binaires et sont de potentielles progéniteurs de supernovæ de type Ia [3, 4]. La physique entourant l'explosion thermonucléaire de surface est riche de phénomènes physiques complexes. En particulier, la structure de double choc lié à la collision entre des vents lents et des vents rapides est un exemple de structure hydro-radiative déclenchée par la novæ. Cette zone est enfouie dans la matière environnant la novæ et elle est trop petite pour être résolue spatialement à l'échelle astrophysique. Pourtant elle est supposée responsable de la formation de grains dans la zone froide et dense au cœur de la structure de double choc. Les résultats expérimentaux obtenus lors de la campagne seront confrontés aux simulations numériques 2D et 3D réalisées au CEA grâce au code TROLL. Les perspectives pour l'étude astrophysique du phénomène seront discutées.

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15:17 – 15:29 — Tidally driven dynamo action in convective envelopesAurélie Astoul [résumé PDF](#)

Binary systems are ubiquitous among stars, and most of (current) detected exoplanets orbit their host stars within distances comparable to or smaller than Mercury's orbit in the Solar System. Beyond their architectural and rotational influences, tidal interactions can profoundly affect the internal physical processes of tidally perturbed bodies. Using 3D magnetohydrodynamic (MHD) simulations in a spherical shell, we have recently shown that tidal flows can significantly alter both the amplitude and topology of magnetic fields in the convective envelopes of stars and giant gaseous planets. Our simulations reveal that tidal (inertial) waves non-linearly interact to generate cylindrical differential rotation (also called zonal flows)—a key ingredient for dynamo action.

This raises a critical question: what is the role of tidal flows in modifying or driving dynamo action within close stellar binaries and exoplanetary systems? While this topic remains largely unexplored, Cebbron & Hollerbach (2014) showed that a tidally driven dynamo effect can possibly emerge in fully convective spheres, triggered by the elliptical instability. In this talk, we investigate how tidal flows can amplify and possibly sustain magnetic fields in a convective shell, guided by the magneto-rotational instability that we have observed and characterized in our 3D MHD tidal flow model.

We highlight that the strength of the tidal forcing, and thus of the tidally driven zonal flow, is decisive in sustaining or not the magnetic energy. Finally, we discuss the potential occurrence of tidally driven dynamos in observed close binary stars and Hot-Jupiter systems, offering new insights into the magnetic evolution of these objects.

15:30 – 15:45 — Session poster « flash » (1/2)**15:45 – 16:15 — Pause****16:15 – 16:30 — Session poster « flash » (2/2)****16:30 – 16:42 — Transport of angular momentum and chemical elements by magnetic fields in stellar radiative zones**Laurène Jouve [résumé PDF](#)

In this talk, we will present a recent work aiming at characterising the efficiency of angular momentum and chemical element transport by magnetic fields in stably stratified radiative stellar interiors. We focus in particular on the magnetorotational instability and associated dynamo action which drives turbulence and transport. We will discuss the results of a large set of 3D MHD numerical simulations of this mechanism, showing that magnetic fields are indeed able to efficiently transport angular momentum and chemical elements in stellar radiative zones.

We propose possible scaling laws for the magnetic transport, to be reintroduced in new generation 1D stellar evolution models.

16:42 – 16:54 — Magnetic geometry of M dwarfs in the southern PLATO field

Manon Diez [résumé](#) [PDF](#)

Session S03 : Atelier général de l'Action Thématique Physique Stellaire

Title : Magnetic geometry of M dwarfs in the southern PLATO field.

Authors : *M. Diez*¹, *J. Morin*¹, *P. Petit*²

¹ Laboratoire Univers et Particules de Montpellier, Université de Montpellier, CNRS, LUPM/UMR 5299, 34095, Montpellier, France

² Institut de Recherche en Astrophysique et Planétologie, Université de Toulouse, CNRS, IRAP/UMR 5277, 14 Avenue Edouard Belin, 31400, Toulouse, France

Abstract :

M dwarfs dominate the stellar population of the Galaxy and are prime targets for exoplanet research programmes. They are also key laboratories to study dynamo-generated magnetic fields and the subsequent phenomena – starspots, flares, high-energy radiation and stellar winds – which influence the evolution of stellar angular momentum and the environments of planets.

Despite their importance, the long-term evolution of the surface magnetic fields of M dwarfs, and the possible existence of magnetic cycles, remain as yet poorly constrained. The ESA PLATO mission will provide long-duration, high-precision photometry, offering an unparalleled opportunity to study stellar variability over several years. To exploit this potential fully, it is essential to combine PLATO measurements with spectropolarimetric monitoring, as this will enable direct measurements of the surface magnetic field (field modulus, large-scale topology) and chromospheric activity.

We have therefore initiated a long-term spectropolarimetric campaign using the SPIRou nearinfrared instrument at CFHT, targeting M dwarfs in the PLATO South Field. The early M dwarf sample was selected based on activity level and rotation. It includes mainly fast and some intermediate rotators (≈ 1 day and ≈ 17 days periods respectively), probing previously unexplored regions of the mass–rotation plane.

In this contribution, we present our target selection strategy and the initial results, which include ZDI maps. Our findings provide novel constraints on the diversity and evolution of large-scale magnetic fields in low-mass stars. They also establish a physically grounded framework for interpreting PLATO photometric variability in terms of underlying magnetic activity. Furthermore, they will provide a unique boundary measurement to inform 3D wind models and assess the typical environment bathing exoplanets orbiting M dwarfs.

16:54 – 17:06 — Near-infrared spectropolarimetry of the strongly accreting T Tauri star RU Lup with SPIRou

Alexis Lavail [résumé](#) [PDF](#)

RU Lup is a strongly actively accreting classical T Tauri star, with mass accretion rates reaching up to $\sim 10^{-7} M_{\odot}/\text{yr}$ (e.g. Wendeborn et al. 2024). We present the first near-infrared spectropolarimetric study of this system using 39 observations obtained with SPIRou at CFHT across two epochs (2020 and 2021). From LSD (Least-Squares Deconvolution) profiles, we measure the longitudinal magnetic field and refine the stellar rotation period to 3.636 ± 0.001 d through Gaussian Process regression and MCMC sampling. We reconstruct the large-scale magnetic topology at the surface of RU Lup using Zeeman-Doppler Imaging for both epochs. We characterize the accretion and outflow properties through the analysis of key nearinfrared emission lines and investigate their variability via 2D Lomb-Scargle periodograms. These results provide the first constraints on the magnetic field geometry of this strongly accreting system and its connection to the accretion/ ejection processes at play.

17:06 – 17:18 — Le triplet du calcium comme indicateur chromosphérique infrarouge : étude à grande échelle, de Narval et ESPaDOnS à Gaia DR4.

Vincent Bruniquel [résumé](#) [PDF](#)

Title : The calcium triplet as an infrared chromospheric indicator: a large-scale study, from Narval/ESPaDOnS to Gaia DR4

Authors : Bruniquel Vincent 1, Meunier Nadège 1, Mignon Lucile 1

Affiliation : 1) Institut de planétologie et d'astrophysique de Grenoble, Université Grenoble Alpes

Abstract:

The magnetic and chromospheric activity of the Sun is well understood thanks to decades of continuous, high-quality observations. However, our knowledge of stellar activity in other stars remains far more limited, as obtaining such detailed and long-term measurements beyond the Sun is observationally much more challenging. The best-known chromospheric activity indicators in the visible are the Ca II H & K lines, used to derive the classical log R'HK index. Yet, obtaining this indicator still requires dedicated, ground-based spectroscopic observations of each star, making the process time-consuming and inefficient for assembling large datasets of stars observations. To overcome this, we explore the calcium infrared triplet as an alternative chromospheric activity proxy, which will be measurable directly from the time series available in the forthcoming Gaia DR4 near-infrared spectra for billions of stars. Using a sample of over 1000 high-resolution spectra of FGK stars obtained with the NARVAL and ESPaDOnS spectropolarimeters, we investigate the global correlation between the Ca II IRT as an activity indicator and the log R'HK, as well as their temporal correlations and properties (period, amplitude of variation on short or long term, etc.). Such large-scale activity diagnostics will be particularly valuable in the context of follow-up observations of PLATO targets, where stellar activity characterization is essential for interpreting photometric variability and exoplanet signals. Finally, we will present an analysis of the link between this activity indicator and stellar metallicity based on a much larger sample based on the analysis of the Gaia DR3 spectra.

17:18 – 17:30 — Détection systématique de champs magnétiques dans les cœurs de géantes rouges par l'astérosismologie

Matisse Villate [résumé](#) [PDF](#)

Systematic detection of core magnetic fields in red giants with asteroseismology

Authors: Matisse VILLATE, Sébastien DEHEUVELS, Jérôme BALLOT Laboratory: IRAP, Toulouse, France

Asteroseismology has demonstrated the need for additional mechanisms of angular momentum transport to account for the observed rotation profile in stellar interiors. One of the most promising candidate being magnetic fields in stellar cores. Recently, asteroseismic detections of magnetic fields have been obtained in the cores in red giants, offering for the first time significant insight on the structure and geometry of these fields. Up until now, only 70 out of around 20,000 red giants from the Kepler catalogue were found with detectable fields. Each of the different studies involved have worked on specific cases to detect core magnetic fields, thereby introducing significant observational biases. To improve the statistics, we need a systematic and complete process to efficiently analyse the entire Kepler catalogue.

To accomplish this goal, we have developed a method to automatically identify mixed mode oscillation frequencies in spectra and adjust them to an asymptotic expression for mixed mode frequencies taking rotation and magnetic field into account. This method involves strict statistical criteria for the detection and identification of modes, and the use of a Bayesian framework to accurately and reliably determine the distributions of seismic parameters for the rotation and magnetic field. In this talk we present the first results of this method. We discuss the relationships between magnetism, stellar mass, rotation and stellar evolution, and the link with angular momentum transport. This method will prove useful in the near future to extend the study to PLATO data.

17:30 – 17:42 — Asteroseismology of TESS Luminaries in the PLATO Era

Eva Panetier [résumé](#) [PDF](#)

E. Panetier, G. T. Hookway, E. Corsaro, S. N. Breton, R. A. García, B. Liagre, M. N. Lund, M. B. Nielsen, D. B. Palakkatharappil, L. Debacker, J. Gosmain, M. Chaumard, A. Chontos, F. Grundahl, S. Mathur, and A. R. G. Santos

The NASA Transiting Exoplanets Survey Satellite (TESS) is delivering high-precision photometry for millions of stars. The upcoming PLANetary Transits and Oscillations of stars mission (PLATO) will provide long-duration, high-precision photometry of tens of thousands of bright stars to be characterised through asteroseismology. A key innovation of PLATO is its fully automated seismic pipeline, which will, for the first time, systematically extract oscillation frequencies for such a large stellar sample. Ensuring the reliability of this pipeline requires well-characterised reference stars spanning a wide range of evolutionary stages and physical properties. In this presentation, I will focus on a subset of 32 bright main-sequence and subgiant stars from the TESS Luminaries Sample that lie within PLATO's long-duration observation fields. These nearby, bright solar-like oscillators offer a rare opportunity to probe stellar interiors with high precision and to test models of stellar structure and evolution

across key evolutionary stages. Using TESS data up to Sector 88, we extracted and validated individual oscillation mode parameters with three independent pipelines, ensuring robust seismic measurements. We therefore report precise global seismic parameters, providing strong constraints on their internal structure, evolutionary state, and fundamental properties. They should rank among the highest-quality seismic targets observed by PLATO. Our results show overall consistency with previous studies while revealing current limitations in mixed-mode identification in subgiants, highlighting the need for longer time-series observations. These stars thus serve both as astrophysically valuable laboratories and as a key reference set for PLATO, enabling early calibration and optimisation of its asteroseismic analysis and helping secure the mission's scientific return.

17:42 – 17:54 — Gravito-inertial waves in stars: Excitation and impact on the transport of angular momentum solar-type stars.

Laura Ramírez-Galeano [résumé PDF](#)

A key open question in the field of modern stellar physics is the distribution and evolution of angular momentum throughout a star's lifetime (e.g. Meibom et al. 2009, 2011, F. Gallet & J. Bouvier 2013). Observational constraints from helio- and asteroseismology (e.g. García et al. 2007) reveal discrepancies that cannot be fully explained by classical processes such as meridional circulation and shear-induced turbulence, underscoring the need for additional transport mechanisms (Charbonnel et al. 2013). Internal gravity waves (IGWs), together with magnetic fields, have emerged as promising candidates. In particular, gravito-inertial waves (GIWs) are thought to play a pivotal role in regulating angular momentum and chemical transport in stellar interiors (e.g. Schatzman 1993; Zahn et al. 1997, Charbonnel & Talon 2005, Rogers & McElwaine 2017, Mathis et al. 2017). However, several aspects of their excitation, dissipation, and the influence of rotation remain poorly understood.

In this work, we develop a new theoretical framework for GIWs, that consistently accounts for rotational effects in both their excitation and damping. We implement a rotation-dependent interface excitation prescription, together with a Coriolis-modified damping formalism that includes the impact of rotation on wave propagation. This framework is incorporated into the stellar evolution code STAREVOL, allowing us to compute evolutionary models of low-mass and solar-type stars to quantify both the excitation and dissipation of GIWs.

These results provide new insights into the role of GIWs in shaping the internal rotation profiles and chemical mixing. They pave the way for direct comparisons with spectroscopic and asteroseismic observations, and for improved predictions in the context of upcoming missions such as PLATO, ultimately advancing our understanding of internal stellar dynamics and evolution.

17:54 – 18:06 — L'atmosphère des Céphéides à travers les courbes de lumière multi-bandes et l'assombrissement centre-bord

Garance Bras [résumé PDF](#)

Les Céphéides sont parmi les étoiles pulsantes les mieux caractérisées. Leur impact sur les mesures de distance motive la nécessité de comprendre la physique de leurs atmosphères dynamiques. D'une part, la variation globale de la taille et de la température de l'atmosphère est observée grâce à la combinaison des courbes de lumière dans différentes bandes. D'autre part, les mesures d'assombrissement centrebord testent la structure spatiale de l'atmosphère. Je présenterai dans un premier temps nos récents travaux sur la construction d'un ensemble de courbes de lumière multi-bandes génériques, reposant sur une dépendance à la période de pulsation. Dans un second temps, je parlerai de nos études sur la variation de l'assombrissement centre-bord au cours de la pulsation, grâce à des données interférométriques sur deux Céphéides résolues par les interféromètres actuels. Ces deux approches offrent des contraintes complémentaires sur la structure des atmosphères pulsantes et ont un impact direct sur les mesures des distances utilisant les Céphéides, que ce soit les relations période-luminosité ou la méthode de la parallaxe de pulsation.

The atmosphere of Cepheids through multi-band light curves and limb darkening

Cepheids are among the best-characterized classes of pulsating stars. Their key role in distance determinations motivates a detailed understanding of the physics of their dynamic atmospheres. On the one hand, the global variations of the stellar radius and temperature can be constrained through the combination of light curves obtained in multiple photometric bands. On the other hand, limb-darkening measurements probe the spatial structure of the stellar atmosphere. I will first present our recent work on the construction of a set of generic multi-band light-curve templates, primarily dependent on the pulsation period. I will then discuss our studies of limb-darkening variations over the pulsation cycle, based on interferometric observations of two resolved Cepheids obtained with current facilities. These two approaches provide complementary constraints on the structure of pulsating atmospheres and have a direct impact on Cepheid-based distance measurements, including Period-Luminosity relations and the parallax-of-pulsation method.

AMPHI 2 — S09 : ATELIER CALCUL HAUTE PERFORMANCE ET SIMULATIONS NUMÉRIQUES · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s09/>

13:45 – 13:50 — Brève introduction de la session

13:50 – 14:20 — Denis Trystram (LIG): Measuring the impacts of HPC applications: For what purpose and how?

14:20 – 14:35 — LAADS, a new code to study small perturbations in astrophysical discs

Nathan Magnan, Enzo Dupont, Heloise Meheut [résumé PDF](#)

Galaxies, accretion discs and protoplanetary discs all exhibit complex structures caused by waves and instabilities. Those can be studied using numerical non-linear simulations, but these are costly and hard to interpret. Fortunately, if the amplitude of a perturbation is small, we can use a mathematical tool called linear analysis to predict its evolution.

Linear analysis is often seen as an analytical tool, but this is reductive. Indeed, analytical tools are limited to simple settings where the equations can be solved manually, whereas linear analysis is a powerful tool applicable to complex problems. Indeed, it removes the non-linear simulations' need for time-stepping, thereby allowing us to reduce the computational cost, increase the resolution, and add more physics into the model.

Our team is developing a Python software to automate linear analysis in astrophysical discs. We have already developed the core of the code (interface, solver, visualisation), as well as the first few modules (hydrodynamics, self-gravity, central object). We are now extending those modules from 2D to 3D and developing new modules for dust and MHD. Once this is done, we will make our code public.

It will have many applications: it could help estimate the resolution needed in simulations, it could help explore the interactions between waves and disc substructures, it could be connected to disc long-term-evolution models to determine when and where instabilities activate without relying on any prescription, etc.

The goal of our talk is two-fold. Firstly, we want to advertise our code to the French astronomy community. The “Journées de la SF2A” are ideal for this because we will be able to interact with people interested in all types of astrophysical discs. Secondly, we want to argue that ‘tailored’ codes like ours should play a larger role in the French “high performance computing” effort. Indeed, they are less versatile than traditional simulations, but to perform the one task they are designed for, they take half a second of CPU time instead of several thousand hours.

14:35 – 14:50 — MCMC orbital fitting using Universal Keplerian Variables

Beust, H. [résumé PDF](#)

I present here a newly realized MCMC package designed to fit orbits of exoplanets and/or companions in multiple systems, able to handle various types of data, namely relative High Contrast Image (HCI) astrometric measurements, stellar radial velocity and relative radial velocity data, and absolute astrometric data. It will eventually be included in the DIVA+ database (part of HC DC service) for free use. The code is parallelized with OPEN-MP, each walker running on a dedicated thread. It naturally works in Jacobi coordinates, allowing to fit several nested orbits simultaneously and to fit individual masses. It has the possibility to run using Universal Keplerian Variables (Danby J.M.A., 1987, *Celest. Mech.* 40, 303; Beust H., 2016, *A&A* 587, A89), a reformulation of Kepler's equation that keeps the same form irrespective of the nature of the orbit (elliptic, parabolic, hyperbolic). This formulation appears to be particularly relevant to fit long orbits that are only partially monitored on one side of the orbit only, as this is often the case for long period companions. I show that the use of standard elliptic variable leads to a long computing time mostly dedicated to finding an extended tail of the posterior distribution where the observed part corresponds to periastron. Conversely, the use of Universal Variables allows to resolve this issue much more quickly, resulting in better convergence. I show a few application examples, namely concerning the GG Tauri triple system.

14:50 – 15:20 — Development and maintenance of the RAMSES code

Colman, T. [résumé PDF](#)

In this talk, I will present ongoing work on the optimization and maintenance of the RAMSES code, a widely used community code for astrophysical simulations.

Within the context of the RAMSES SNO, we aim to bring the code up to modern software development standards. To ensure robustness, we have significantly extended the test suite and increased its coverage. To improve onboarding and developer experience, new documentation has been introduced.

On the performance side, I will present results obtained in the framework of the SPACE EuroHPC Centre of Excellence. In particular, the addition of OpenMP hybrid parallelization improves scalability on modern architectures while reducing memory requirements. The impact of these optimizations is assessed through extensive benchmarking on various EuroHPC systems, supported by newly developed benchmarking scripts designed to facilitate performance tracking for both users and developers.

Finally, I will showcase results from real-world production simulation setups, demonstrating the practical benefits of these improvements in terms of performance, scalability, and usability.

15:20 – 15:35 — Premières simulations de l'époque de Réionisation avec DYABLO

Dominique Aubert [résumé PDF](#)

Dyablo est une plateforme de simulation AMR pour l'astrophysique portée par le CEA [1] et auquel contribuent des spécialistes du calcul et de l'astrophysique provenant de multiples institutions. Basé sur l'écosystème C++ KoKKos [2,3], Dyablo peut être déployé sur architectures massivement parallèles et hybrides et est capable d'exploiter des moyens de calculs distribués soutenus par du parallélisme local en mémoire partagée, y compris des architectures GPUs.

A l'Observatoire de Strasbourg, et en collaboration étroite avec nos collègues de l'IAP et du CEA, nous contribuons à Dyablo depuis maintenant plusieurs années avec pour objectif la réalisation de simulations de l'Epoque de Réionisation cosmologique, dans la lignée de nos travaux précédents sur le sujets [4,5]. A ce titre, Dyablo inclut désormais un mode 'cosmologique' ainsi que les modules physiques indispensables à cette science de la réionisation, à savoir le transfert radiatif couplé, la formation stellaire et sa rétroaction et une thermochimie hors équilibre. Le code est actuellement déployé en production sur Jean-Zay, pour des productions scientifiques de grande ampleur. Cela concerne à la fois la formation des premières galaxies à grand z à petite échelle ou le processus de réionisation aux échelles cosmologiques.

La présentation proposée vise à faire un retour sur ces développements et faire une revue de l'état actuel de ce que nous pouvons faire et ne pas encore faire avec Dyablo. Il s'agira aussi de faire une présentation de notre expérience de développement avec des collègues d'expertise diverses sur un code d'ampleur certaine. Enfin nous développerons quelles sont nos perspectives en termes de développement et de production scientifique pour l'étude de la Réionisation avec notre nouvel outil de simulation.

[1] Delorme, M. et al., Dyablo : A simulation code for astrophysics fluids with adaptive mesh refinement in the exascale era. *Journal of Physics: Conference Series*, Volume 2997, 2025.

[2] <https://kokkos.org>

[3] Trott, C. et al. The Kokkos Ecosystem: Comprehensive Performance Portability for High Performance Computing. *Computing in Science Engineering*, 2021

[4] Ocvirk, P., et al. Lyman-alpha opacities at $z = 4-6$ require low mass, radiatively-suppressed galaxies to drive cosmic reionization *MNRAS*, 2021

15:35 – 15:50 — From Galaxy to core collapse: An overview from the theoretical astrophysics group of Cologne

Anais Pauchet [résumé PDF](#)

Abstract: Introduction: The interstellar medium (ISM) is an essential component of our galaxy, consisting of gas, dust and radiation. The ISM is the birthplace of stars and constantly evolving due to stellar feedback and chemical evolution. Method: In the Cologne theoretical astrophysics group we use the 3D magneto-hydrodynamic (MHD) adaptative mesh refinement (AMR) grid code FLASH (Fryxell et al. 2000) to simulate the ISM over a wide range of environments from au up to kpc scales. The group and its collaborators have extended the FLASH code to include several relevant processes to follow the evolution of the ISM. This includes MHD solvers (e.g. Derigs et al. 2018), non-equilibrium chemical networks to follow the evolution of several chemical species (Walch et al. 2015), self-gravity (Wünsch et al. 2018), radiation transport (Wünsch et al. 2021), a Hermite integration scheme for sink particles (Dinnbier and Walch 2020) and especially stellar feedback from massive stars (Gatto et al. 2017, Peters et al. 2017, Rathjen et al., 2021, 2024, 2025, Klepitko et al. 2023, Brugaletta et al. 2025). Results: The «Simulating the LifeCycle of molecular Clouds» (SILCC) project simulates the evolution of molecular clouds in a patch of a Milky Way-like galaxy. The simulations provide an extensive set of data focusing on different aspects of the ISM: effects

of stellar feedback, chemical evolution, magnetic fields, and metallicity. Each new generation of simulation aims to better understand observations (e.g. through the SFE and Kennicutt-Schmidt relation) by adding more physical processes. In addition to the simulations of the SILCC project, the group also studies other environments: e.g. formation of massive stars in collapsing dense cores (Zimmermann et al. 2025), evolution of HII regions and their comparison with observations (Dannhauer et al. 2025), tracing supernova remnants in simulations (Makarenko et al. 2020, 2023, 2024), formation of cores and clumps in colliding flow simulations (Weis et al. 2024), and many other topics. Conclusion: The theoretical astrophysics group of Cologne aims to improve physical models across many spatial scales to better understand the evolution of the ISM, its role in the formation of stars as well as observations of the ISM.

15:50 – 16:00 — *Présentation posters*

16:00 – 16:30 — *Pause*

16:30 – 17:00 — High-performance simulations of turbulent planetary dynamos

David Cébron [résumé PDF](#)

Understanding the dynamics of planetary interiors is essential for explaining magnetic-field generation, thermal evolution, orbital history, and observable signatures across the Solar System and exoplanets. These regions host strongly nonlinear flows driven by rotation and buoyancy, but also by tides, precession, or double-diffusive effects. They operate in extreme parameter regimes far beyond laboratory capabilities, making high-performance simulations a key tool to connect theory with observations.

In this talk, I will present recent advances in modeling turbulent planetary interiors using the XSHELLS code, a massively parallel magneto-hydrodynamic solver for spherical geometries. After introducing the physical motivations, I will describe the numerical approach and how XSHELLS allows us to reach turbulent, low-diffusivity regimes relevant to planetary conditions. I will then illustrate applications ranging from dynamos in liquid planetary layers to semi-convection driven magnetic fields in giant planets.

17:00 – 17:15 — ASTRA: an Accelerated Spectral code for TuRbulent pIAsmas

Lesur, G [résumé PDF](#)

In this contribution, I will introduce the ASTRA code, a next-generation fully spectral code designed to study the dynamics of astrophysical plasmas by utilising GPU-accelerated machines. ASTRA is based on the Kokkos and Kokkos-FFT libraries to ensure performance portability across multi-GPU machines. I will present the code's main features, limitations and scalability across the various architectures available in France.

17:15 – 17:30 — An efficient spectral Poisson solver for the nirvana-III code: the shearing-box case with vertical vacuum boundary conditions

Steven Rendon Restrepo, Oliver Gressel [résumé PDF](#)

Self-gravity (SG) is essential in astrophysical processes like molecular cloud collapse, FU Orionis outbursts, and protoplanetary disc accretion. While iterative multigrid methods on Cartesian grids require accurate boundary potential estimates, spectral methods solve the Poisson equation in Fourier space with $N \log(N)$ efficiency but assume full periodicity, causing unphysical domain repetitions. The Vico-Greengard-Ferrando (VGF) method overcomes these issues by modifying the Green's function in Fourier space to account for unbound potentials, enabling FFT-based solutions with machine accuracy at modest resolutions. However, it has not been adapted to the shearing box approximation, which demands two periodic and one vacuum boundary condition. We present VGFHybridBC, a novel full spectral method, based on the VGF method, designed to preserve both accuracy and efficiency while handling mixed periodic and vacuum boundary conditions in shearing boxes (Rendon Restrepo & Gressel, A&A, 2025, <https://doi.org/10.1051/0004-6361/202557659>)

17:30 – 17:45 — Simulating warped accretion discs with Shamrock

Lapeyre Y., Laibe G. [résumé PDF](#)

S09 Atelier calcul haute performance et simulations numériques

Simulating warped accretion discs with Shamrock Y. Lapeyre, G. Laibe

A lot of accretion discs, around multiple star systems or supermassive black holes, are not flat. Understanding their complex geometries remains essential for interpreting observational phenomena such as type-C quasi-

periodic oscillations (QPOs) and stellar-related signatures. However, limited resolution in numerical simulations previously hindered further characterization of such discs. While state-of-the-art simulations use 10 million SPH particles to reach an effective viscosity α of 0.01, a factor at least 10 in spatial resolution, meaning 1,000 in computational power, is required to allow local instabilities to grow. Over the past decade, GPUs have revolutionized supercomputing capabilities, culminating in the exascale barrier (10¹⁸ FLOPS) being broken in 2022 with the Frontier cluster. Shamrock, a new astrophysical code released in March 2025, is among the codes capable of running on such machines. In this talk, I will present recent developments in the Shamrock code regarding the magnetohydrodynamics and general relativity solvers.

17:45 – 18:00 — PIC simulations of resonant scattering–driven plasma loading in magnetar magnetospheres

Soudais A., Mahlmann, J. [résumé PDF](#)

Magnetars are highly magnetized neutron stars whose X-ray emission is thought to arise from resonant scattering in their magnetospheres. Unlike pulsars, the microphysics of magnetar magnetospheres remains largely unexplored numerically because the extreme surface magnetic field produces large separation between the relevant spatial and temporal scales. To study the kinetic aspects of these magnetospheres, global Particle-in-Cell simulations are an ideal tool; however, they require high resolutions and consequently significant computational resources. To make such simulations tractable, the usual practice is to employ rescaled parameters. Global simulations then suffer from artificially large plasma scales, eventually leading to the strong resonant scattering drag becoming unphysical. We then 1) developed a 1D simulation for which we can have a high resolution per one magnetic field line in order to probe the scale separation limits, and 2) developed a GPU-accelerated Entity version in 2D to include physical realism (pair production across field lines) at scale. In this presentation, I will describe the numerical implementation of the resonant scattering and its application to a 1D simulation. I will also report on the ongoing development of the 2D version.

AMPHI 3 — S15 : FORMATION AND EVOLUTION OF LARGE MOONS AROUND GIANT PLANET · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s15/>

13:55 – 14:00 — *Ice breaker*

14:00 – 14:20 — Galilean moons origins, insights from models and observations

Schneeberger, A., Bennacer, Y., Mousis, O. [résumé PDF](#)

Modelling the origin of Jupiter's Galilean moons remains a significant challenge. While it is widely accepted that the moons formed within a circumplanetary disk (CPD) that surrounded Jupiter during the final stages of its formation, the physical properties, evolution and composition remains unconstrained. An approach to deduce the CPD's properties and composition is by using the bulk composition of the Galilean moons as a reference to infer compositional trends within the disk. A notable example is the gradient in water content with distance from Jupiter: from the completely dry Io to a 1:1 water-to-rock ratio on Ganymede and Callisto. This gradient strongly suggests that the CPD exhibited a corresponding water abundance gradient during its formation. With the JUICE and Europa Clipper missions currently cruising to the Jovian system, the next decade will provide an unprecedented opportunity to study Europa, Ganymede, and Callisto, providing new constraints for CPD models based on improved understanding of the moons' bulk compositions. Furthermore, with new observations of the PDS 70 system, as well as eight other tentative detections of CPDs around forming planets, exoplanetary systems could offer new constraints on the evolution of CPDs. I will present a short review of the Galilean moons origins, from the CPD models and moon formation scenarios to the observational constraints from explorations with an outlook on potential constraints from forming exoplanetary systems.

14:20 – 14:40 — Orbital evolution of giant planet satellite systems: from the Solar System to exoplanets

Fayolle, S., Revol, A. [résumé PDF](#)

The present-day orbital configurations of satellite systems around giant planets result from long-term evolution processes dominated by tidal dissipation and by the capture, crossing, and disruption of orbital resonances. Reconstructing realistic evolutionary scenarios is essential to robustly link the present states of these systems to their formation and subsequent history, and to interpret constraints from interior modelling and observations.

We will provide an overview of the main mechanisms governing the orbital evolution of large moons around giant planets, with particular emphasis on the Galilean satellites and the major moons of Saturn which offer complementary archetypes. On one hand, the Galilean system is dominated by the long-lived Laplace resonance, offering the perfect example of a stable resonant chain. On the other hand, observational constraints indicate that the Saturnian system is undergoing comparatively a rapid orbital evolution that possibly results from a disruption of past resonances.

This review will be organised along the following axes:

- The role of orbital resonances (capture, stability, and disruption): in the Jovian system, present configuration of the Laplace resonance and proposed scenarios for its formation and evolution; in the Saturnian system, constraints from present-day orbits on past resonant configurations, and implications for the moons' evolution - Dynamical evolution of satellite systems under tidal dissipation: orbital migration, eccentricity and inclination evolution, orbit-rotation couplings, respective roles of dissipation within the planet and within the moons - Opening to exoplanet systems, beginning with an overview on the characterization of compact resonance systems. We will discuss the challenges posed by observational constraints and theoretical aspects, drawing from both statistical studies of exoplanet populations and well-characterized systems such as TRAPPIST-1. We will raise a question on possible connection between exoplanets, and Solar System studies.

14:40 – 15:00 — Internal dissipation and evolution of tidally heated moons around giant planets

Mathilde Kervazo and LPG collaborators [résumé PDF](#)

Tidal heating is a major driver of the thermal and orbital evolution of the Galilean satellites, where it dominates the internal energy budget and strongly couples interior dynamics to orbital forcing. Observations from Voyager program, Galileo mission and Juno mission, as well as upcoming constraints from JUICE mission and Europa Clipper, provide a unique opportunity to test models of their internal structure, differentiation, and thermo-orbital evolution.

Within the Galilean system, tidal dissipation is unevenly distributed between bodies and internal layers. Io, where dissipation is largely concentrated in a partially molten silicate mantle, acts as the primary energy sink of the Laplace resonance and plays a central role in controlling its longterm evolution. In contrast, in icy satellites such as Europa and Ganymede, dissipation may be partitioned between the silicate interior, subsurface ocean, and overlying ice shell, reflecting their differentiated structure and the presence of a global hydrosphere.

The efficiency and localization of tidal dissipation are therefore intimately linked to the internal structure inherited from formation and differentiation processes, including core formation, silicate mantle evolution, and the development of internal oceans. A key control is the rheological evolution of silicate mantles, in particular the onset and evolution of partial melting. By modifying the viscoelastic response of planetary materials, melt can strongly enhance tidal dissipation and redistribute tidal dissipation between the deep interior and outer layers.

These processes introduce non-linear feedbacks between temperature, rheology, internal structure, and tidal forcing, potentially leading to transient regimes of enhanced dissipation, variability in heat flux distribution, and long-term evolution of both the internal state and orbital configuration. In this review, I will discuss recent advances in modelling the coupled evolution of tidal dissipation, thermal state, and interior structure, and how these processes can be constrained by current and future observations (e.g., gravity, magnetic induction, surface activity, and heat flux). Broader perspectives toward tidally heated rocky exoplanets will also be addressed.

15:00 – 15:15 — Tidal dissipation in Uranus

Lainey, V. [résumé PDF](#)

Abstract: Tidal dissipation in Uranus is a key factor in understanding this system, both in terms of the planet's internal structure and the orbital evolution of its moons. Observation of the moons' orbital motion remains so far the only way to access this physical parameter. For example, the use of a consistent interval of astrometric observations has been successfully employed to determine tidal dissipation in Jupiter and Saturn. Application to the Uranus system is more difficult, however, due to the lower precision of astrometric observations. In particular, some of the older observations are relatively biased, making them difficult to use. We present here the results of an analysis based on observations beginning with the space age and restricted to the most reliable data from this system, including those from the Gaia probe. The question of older observations is also discussed.

15:15 – 15:30 — From tidal migration to exomoon survival: can close-in giant planets still host satellites?

Mario Sucerquia [résumé PDF](#)

Exomoons are expected to arise naturally during giant-planet formation, and their existence would provide key constraints on circumplanetary accretion, tidal evolution, and the long-term dynamical history of planetary systems. Yet, despite sustained observational efforts and a few tentative candidates, the exomoon population remains essentially unconstrained [1]. A central unresolved question is therefore not only how to detect exomoons, but also which classes of exoplanets are actually able to retain them over astrophysically relevant timescales. In this context, tidal evolution offers a natural framework to identify the systems in which moons should survive, migrate, or be lost.

This presentation will briefly revisit tidal migration models in which dissipation inside the planet–moon system drives a secular evolution of satellite orbits [2, 3], in some cases leading to instability, escape, or transformation into planet-like bodies known as ploonets [4]. I will then discuss the case of WASP-49Ab as an extreme test of this idea. This compact hot Saturn has recently gained renewed interest because circumplanetary material and satellite-related interpretations have been invoked in connection with its observed properties [5]. Rather than treating this possibility as an isolated peculiarity, I will frame WASP-49Ab within the broader evolutionary problem of exomoon survival under strong tidal forcing. The key question is whether a giant planet so close to its host star can still host a stable moon at all, and, if so, under what orbital conditions. Finally, I will place this discussion in a broader comparative context by contrasting compact hot giants with colder giant planets on wider orbits. While the former may be efficient at destroying or ejecting moons, the latter should offer more extended stable regions and weaker tidal forcing, making them more favourable environments for long-lived satellites and future detection. In that sense, systems such as WASP-49Ab and Kepler-167e can be viewed as complementary laboratories: one probes the tidal limit of satellite survival, while the other may represent a more favourable regime for persistence and eventual detection.

References

[1] Alex Teachey and David M. Kipping. Evidence for a large exomoon orbiting kepler-1625b. *Science Advances*, 4(10):eaav1784, 2018.

15:30 – 15:45 — HD 206893 B: an exomoon candidate revealed by high-precision astrometry

Kral Q. [résumé](#) [PDF](#)

Abstract: We report the detection of a candidate exomoon orbiting HD 206893 B, a ~ 20 Jupiter-mass companion located at wide separation from its host star. Using high-precision astrometry obtained with the VLTI/GRAVITY instrument, we monitored the orbital motion of HD 206893 B over short timescales, from days to months. Unlike previous astrometric studies of massive companions, typically based on sparse measurements spanning years, our dense temporal sampling reveals deviations from a simple Keplerian motion. These short-timescale dynamical variations can be naturally explained by the presence of a bound companion, consistent with an exomoon signal. The inferred moon would have a mass of $\sim 0.5 M_{\text{Jup}}$ and orbit at ~ 0.22 au (corresponding to a ~ 9 -month period) from HD 206893 B. While additional observations are required to confirm the nature of this candidate, this work demonstrates the potential of high-cadence, high-precision astrometry to probe a previously inaccessible dynamical regime. This approach opens a new window for the detection of exomoons, particularly around widely separated planetary-mass companions and brown dwarfs, where moons may be more massive and dynamically stable than those accessible via the transit method.

15:45 – 16:15 — *Pause café*

16:15 – 16:30 — BOREAS: A biphasic code for exploring the timing and diversity of differentiation pathways in icy moons

PINCELOUP, M., BOUFFARD, M., CHOBLET, G., LABROSSE, S., SOTIN, C. [résumé](#) [PDF](#)

Icy moons are not static layered bodies, but evolving systems whose present-day structure records a history of accretion, heating, melting, fluid migration, and freezing. Subsurface ocean formation is both a major outcome of this evolution and a key control on its subsequent trajectory, governing heat transfer between the rocky interior and the outer ice shell as well as the redistribution of salts and organic compounds relevant to habitability [1]. For the largest bodies, differentiation may also lead to metallic core formation, which is central to understanding Ganymede, the only icy moon known to possess an intrinsic magnetic field. Understanding when and how moons differentiate is therefore essential for interpreting the diversity of ocean worlds, from fully differentiated bodies such as Ganymede to less differentiated moons such as Callisto. Yet, the timing and efficiency of differentiation remain strongly dependent on poorly constrained initial conditions, including body size, ice–rock–metal–organics fractions, radiogenic inventory, orbital evolution, and the ability of melt to segregate through a compacting matrix.

Here, we present BOREAS — Biphasic flows in Ocean moons: Role in Evolution And Segregation — a new numerical code designed to model the internal differentiation of icy bodies. The code solves the coupled evolution of a deformable solid matrix and a migrating liquid phase in one-dimensional spherical geometry [2]. It allows porosity generation, melt migration, matrix compaction, latent heat exchange, and convective heat transport to evolve selfconsistently. The same formalism can be applied to two end-member differentiation problems: the upward segregation of liquid water through an ice–rock mixture, and the downward segregation of a denser metallic liquid during core formation. This flexibility makes it possible to explore both ocean formation and iron core differentiation in icy satellites within a common physical framework.

In the absence of tidal heating, first results show that ocean formation is slow on geological timescales. For chondritic radiogenic heating, internal melting typically begins after a few tens of millions of years, but complete ice–rock differentiation requires much longer timescales, from approximately 500 Myr to 1.75 Gyr depending on moon size, with smaller bodies evolving faster than larger ones. Increasing either the initial rock fraction or the radiogenic heat production accelerates differentiation by promoting earlier and faster melting. The model also predicts that migrating water can pass through warm outer-core regions before joining the hydrosphere, creating a transient leaching zone that may contribute to the delivery of soluble and organic compounds to the ocean [Fig 1].

Preliminary simulations of metallic differentiation suggest a very different regime. Without tidal heating, the segregation of metallic liquid and the formation of a metallic core occur only in the largest icy moons, and very late in their evolution after 4 Gyr. In Ganymede-sized bodies, core formation may therefore still be ongoing at the present epoch. This result opens an alternative interpretation of Ganymede's intrinsic magnetic field: rather than requiring an ancient fully formed cooling core [3], the field may be linked to the dynamics of a core still forming today. BOREAS therefore provides a new way to study internal differentiation in icy worlds, with direct relevance for the interpretation of JUICE and future ocean-world missions.

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16:30 – 16:45 — Partial Differentiation of Mimas by Tidal Heating preserves its Geologically Iner Surface

Bablin, T., Bouffard, M., Pinceloup, M., Oliveira-Amorim, D., Tobie, G., Sotin, C. [résumé PDF](#)

Mimas, Saturn's closest mid-sized moon, has orbital properties that favor even stronger tidal heating than in Enceladus, where an intense tidal dissipation drives spectacular geysers. Yet, observations made by the Cassini-Huygens mission revealed that Mimas has a heavily cratered surface, suggesting a cold and frozen interior. However, analyses of its librations [1] and periapsis drift [2] indicate that a 20–30 km thick ice shell above a subsurface ocean is needed to explain these dynamical constraints. Within the classical framework for icy moon assuming already differentiated interiors [3], the formation of such an ocean should induce global contraction and widespread fracturing of the ice shell, not observed on Mimas. An ocean without surface disruption thus challenges the standard picture of a fully differentiated interior, but could be explained if Mimas remains partially undifferentiated. In this study, we couple the 1D code BOREAS solving biphasic advection-compaction equations [4] and a code computing 1D tidal heating profiles [5], to investigate the effect of tidal heating on the differentiation of Mimas. We start from an undifferentiated interior made of an ice-rock mixture and prescribe an initial eccentricity about 3 times the current one. We show that the formation of an ocean in Mimas occurs in timescales of about 100–200 Myrs, for a current ocean beneath an ice shell 20–30 km thick and without exceeding a radius change which would imply breaking of the ice shell. These dynamics of partial differentiation by tidal heating in a few hundred millions years could change

the usual representations of Saturn's mid-sized moons interiors, and our understanding of the recent evolution of the Saturn's environment.

References

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16:45 – 17:00 — The evolution of Europa's primordial hydrosphere composition during the accretion phase

Amsler Moulanier A., Bennacer Y., Kadoya S., Sekine Y., Mousis O., Vorbürger A. [résumé PDF](#)

Europa, one of Jupiter's Galilean moons, will be intensively explored by two upcoming space missions : JUICE and Europa Clipper. The potential presence of a subsurface ocean below its ice crust raises great interest, especially regarding its potential habitability. Nevertheless, the composition of such subsurface ocean as well as its origin and evolution remain poorly constrained, particularly with respect to the volatile inventory of its hydrosphere.

The composition of Europa's subsurface ocean was likely influenced throughout time by the interactions taking place between its underlying rocky mantle and the water ocean. Such geochemical reactions impact the volatile inventory in the hydrosphere, the pH and the salinity. Moreover, it is possible that, shortly after accretion, Europa's surface temperature was hot enough to sustain an open-ocean in equilibrium with a primordial atmosphere, affecting the volatile distribution in the hydrosphere as well.

This study aims to explore how Europa's initial inventory of oceanic volatiles was affected during its early evolution by modelling the chemical evolution of its hydrosphere during accretion. It is assumed that the hydrosphere formed from the delivery of ice-rich planetesimals and solids. As Europa accumulates mass through accretion of surrounding material and bombardment by impactors, both its size and the volume of its hydrosphere increase. The surface temperature is calculated from a combination of impact heating and thermal input from the circumjovian disk (Bennacer et al. 2025). At each time step, we compute the composition of the primordial atmosphere and the evolving ocean, taking into account the water-rock interactions occurring both at the ocean-rocky mantle interface and between the rocks in suspension in the ocean and the volatile-rich water. Chemical equilibria associated with water-rock interactions are calculated using PHREEQC, while atmosphere-ocean exchange is modeled following the framework of Amsler Moulanier et al. (2025a). The transport of species throughout the water column is modelled as well, using a diffusion transport scheme.

Our results provide an overview of how Europa's accreted volatile inventory in the hydrosphere was influenced by the processes occurring during its early evolution. In particular, we highlight the key role of water-rock interactions in controlling the chemical evolution of the ocean, as well as its pH and salinity. In the context of the upcoming JUICE and Europa Clipper missions, the aim of such work is to draw the link between the formation scenario of Europa and the future measurements of volatile abundance in the exosphere, that could be indicative of its current subsurface ocean composition.

17:00 – 17:15 — New constraint on Europa's ice shell: Magnetic signature from the ocean

Florentin Daniel, Ludovic Petitdemange, Christophe Gissinger [résumé PDF](#)

Jupiter's icy moons are believed to host subsurface liquid oceans, and among them, Europa stands out as one of the most promising candidates for extraterrestrial life. Yet, the processes driving oceanic flows beneath its ice shell, as well as the factors controlling the thickness of this ice, remain incompletely understood. One especially distinctive feature of Europa is that its salty ocean is electrically conducting and thus influenced by Jupiter's time-varying magnetic field, which is believed to drive a large-scale zonal flow. In this presentation, I will examine how this magnetically induced jet affects both the heat flux and the dynamics of the convective flow within Europa's ocean. I'll first discuss how the magnetically-driven jet efficiently transports heat in stably stratified regions near the top of the ocean, and may alter the expected convective scaling laws in deeper layers. Second, by analysing the latitudinal distribution of heat flux and relating it to ice-thickness variations, I'll present some predictions that can be compared with current observations. In anticipation of the upcoming JUICE and Europa Clipper missions, improved measurement precision could help further constrain the ocean's properties and refine our model-based forecasts.

17:15 – 17:30 — Linking orbits and interiors: towards a coupled thermal-orbital model for the Galilean satellites

Fayolle Sam, Lainey Valery, Tobie Gabriel [résumé PDF](#)

Jupiter's three innermost Galilean moons Io, Europa, and Ganymede are locked in the Laplace meanmotion resonance, which both sustains tidal heating in their interiors and governs the long-term stability of the system. Subsurface oceans have been identified beneath the icy crusts of Europa and Ganymede, and suspected on Callisto, making these moons some of the best candidates for habitability in the Solar System. This, in turns, makes the long-term thermal-orbital history of the system a central question for assessing and understanding this habitability potential, and a key scientific driver of the upcoming JUICE and Europa Clipper missions.

However, the long-term history of the system is still largely unresolved. Surface geology across the moons records orbital reconfigurations (Greenberg, 2010) that likely involved periods of enhanced tidal heating due to eccentricity growth. Such eccentricity variations would be accompanied with ice shell thinning, ocean expansion, and possibly partial mantle melting (Běhounková et al., 2021). The frequency and intensity of such episodes are intrinsically tied to the resonance evolution, which remains poorly constrained beyond present-day astrometric measurements (Lainey et al., 2009).

The orbital and thermal evolutions of the systems have so far largely been studied in isolation, and truly coupled models are limited (Showman et al., 1997; Hussmann and Spohn, 2004; Bland et al., 2009). We aim to address this gap by linking an N-body integrator to interior models, allowing tidal parameters to follow the evolution of the moons' orbits and interiors. We focus on the last few hundred million years of the system's history, targeting possible periods of increased eccentricity, to place constraints on past tidal heating episodes and map plausible evolution scenarios for the Galilean system.

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17:30 – 18:00 — *Table ronde – couplage dynamique & structure interne*

AMPHI 4 — S11 : COMMUNITY ASTRONOMY. WHERE DOES THE FRENCH ASTRONOMY COMMUNITY STAND? · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s11/>

— Atelier S11 - 24 Juin

14:00 – 14:30 — The need for Mutual Stewardship and Community-based Astronomy, illustrated by the landmark example of Maunakea.

J.-G. Cuby, K. Dumaguin. CFHT

14:30 – 15:00 — Building long-lasting and authentic relationship with local and Indigenous communities – the case of the SKA Observatory

William Garnier. SKAO

15:00 – 15:30 — Expérience historique des relations territoire-habitants et astronomie du pic du Midi

Eric Delgado. OMP

15:30 – 16:00 — The Nançay Radio Observatory and the 4G cellphone coverage experiment: How citizens and science can co-exist

Jean-Mathias Griebmeier

16:00 – 16:30 — Coffee Break

16:30 – 18:00 — Discussion and breakout sessions. How the French community can contribute to the development of a community astronomy model.

AMPHI 5 — S18 : SYSTÈMES AVANCÉS DE DÉTECTION POUR L'ASTROPHYSIQUE / ADVANCED DETECTION SYSTEMS FOR ASTROPHYSICS · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s18/>

14:00 – 14:30 — Detectors for the Submillimeter and the Millimeter Domains

14:00 – 14:12 — Développement de détecteurs TES haute sensibilité pour les instruments d'observation millimétrique polarimétrique de prochaine génération

Laurent Dussopt, Michel Piat, Louis Rodriguez, Vincent Revéret, Ludovic Montier. [résumé PDF](#)

L'étude de l'Univers froid ouvre une fenêtre unique sur nos origines, qu'il s'agisse de la formation des étoiles au sein des nuages proto-stellaires ou des premières phases de l'Univers révélées par l'analyse fine du rayonnement fossile (CMB, Cosmic Microwave Background). La polarisation (modes E et B, en particulier la recherche de la signature polarisée des ondes gravitationnelles primordiales) et la spectroscopie (distorsions spectrales permettant de sonder au-delà de l'horizon actuel du CMB) constituent des outils essentiels pour explorer ces phénomènes

Les instruments d'observation opérant dans les domaines sub-millimétrique et millimétrique reposent sur différentes technologies de détecteurs, mais seuls les détecteurs bolométriques résistifs ont été déployés dans l'espace à ce jour, notamment dans les satellites Herschel et Planck. À l'aube des années 2000, une nouvelle génération de bolomètres à transition supraconductrice (Transition Edge Sensors, TES) a été proposée et a démontré sa capacité à atteindre une sensibilité ultime limitée par le bruit de photon tout en étant déployable en matrices de plusieurs milliers de détecteurs. Cette technologie s'est fortement développée aux Etats-Unis ces dernières années pour l'observation en gamme millimétrique depuis le sol dans le cadre du programme CMB-S4. Elle a été retenue pour le plan focal de la mission LiteBIRD qui requiert la fourniture par l'Europe de matrices de grandes dimensions à l'échelle du wafer avec des détecteurs bi-bandes et bi-polarisations.

Cette communication présente les activités engagées pour développer une filière française et européenne de détecteurs TES destinée aux futurs instruments d'observation polarimétrique en gamme (sub-)millimétrique et en particulier LiteBIRD. Cette filière repose sur des moyens technologiques de pointe capables de lever les verrous critiques liés à l'intégration à grande échelle, aux rendements de fabrication et à la reproductibilité nécessaires pour les grands plans focaux et les missions spatiales.

14:15 – 14:27 — Toward a millimeter-imaging spectrometer using magnetic field tunable kinetic inductance detectors

Loïc Soriano, Emile Prêle, Martino Calvo, Alessandro Monfardini et Florence Levy-Bertrand [résumé PDF](#)

Abstract We report the on going development of a millimeter-imaging spectrometer based on kinetic inductance detectors (KIDs). KIDs are a special implementation of superconducting resonators [1]. They are planar resonant circuits consisting of superconducting thin films deposited on an insulating substrate. The principle of photon detection is to monitor the resonance frequency shift, which is proportional to the incident power. The incident radiation breaks Cooper pairs, creating quasiparticles and modifying the kinetic inductance, resulting in a shift of the resonance frequency. To date, thousands of KIDs are being implemented in ground-based cameras used for millimeter-wave observations in astrophysics [2,3]. To achieve spectroscopies capabilities we tune the spectral response of KIDs using a magnetic field. Figure 1 presents the first demonstration of the optical response of the KID can be modulated under the influence of a varying magnetic field [4].

Fig.1 : Magnetic field tunable response of KID. Top: experimental setup and picture of a KID. The magnetic field is applied perpendicular to the array by superconducting coil. Bottom: Spectral response of KID exposed to different magnetic fields: frequency shift of KID as a function of the incident optical frequency. The low optical cut-off frequency corresponds to the 2Δ superconducting gap, which varies as a function of the magnetic field.

References : 1. P. K. Day et al, Nature 425, 817 (2003). 2. NIKA2 collaboration, Astronomy & Astrophysics 637, A71 (2020). 3. A. Monfardini et al, J Low Temp Phys 209, 751–757 (2022). 4. F. Levy-Bertrand et al, Applied Physics Letters 126, 042602 (2025).

14:30 – 15:00 — Innovative Detectors for Large Research Infrastructures**14:30 – 14:42 — Microcalorimeter readout of NewAthena/X-IFU prototype electronics on a cryogenic test bench**

Molin, A., Sigal, B., Beaumont, S., Mernier, F., Pajot, F. [résumé PDF](#)

NewAthena is ESA's next large class mission, to be launched in the late 2030s for observing the hot and energetic Universe in the X-ray. The X-ray Integral Field Unit (X-IFU) is one of its two instruments, it will rely on an array of 1504 Transition Edge Sensors micro calorimeters cooled to 55mK to provide high resolution (3eV design goal at 7keV) spatially resolved observations in the X-ray.

A cryogenic test bench has been developed at IRAP, with a TES readout chain that replicates the general working principles of X-IFU. Its goals are testing and validating the first prototypes of the X-IFU readout chain, and allowing the development of calibration sources for X-IFU.

In this presentation, I will introduce the working principles of the readout chain, the main results obtained with electronics from NASA/Goddard and NIST, as well as the first results obtained with prototype readout electronics, and the upcoming measurements.

14:45 – 14:57 — Compact Spectrometers for Astronomy: Coupling the Detector and the Photonic Integrated Circuit

Bonduelle, M., Mestre, N., Martin, G., Salut, R., Courjal, N., Grosa, G., Irar, M., Morand, A. [résumé PDF](#)

Compact spectrometers in the infrared are very interesting for spatial applications thanks to the reduced footprint and weight. Even for ground based applications, in particular in the near and mid IR, the small volume allows to reduce the size of the cryogenic chamber, therefore improving the energy consumption. We have been working since several years in the development of compact Fourier Transform Spectrometers, where a stationary is obtained in a single mode waveguide. In order to sample the signal, a nano-groove or nano-dot is regularly set on the surface of the waveguide (see Fig. 1). Moreover, to get the most compact device, a detector is then set on top of the waveguide, allowing to obtain a monolithic spectrometer without any relay optics. The sampling centers are set at regular spacing, ideally corresponding to the pixel pitch of the detector, which is typically 10^{-4} m. Although this will introduce some aliasing issues, the typical Nyquist window will be around 10 nm, which can be enough for applications. Besides, as the resolution is related to the total sampling length, using detectors having 2048 pixels and 10^{-4} m size, the expected resolution can be around $R = 80000$ at $\lambda = 10^{-4}$ m.

Fig.1: Principle of the Stationary Wave Integrated Fourier Transform Spectrometer (SWIFTS)

The issue here is to achieve the coupling between the commercial detector and the waveguide on the top surface. In this work, we will present two configurations that are under study. In the first configuration (Fig.2, left) we modify the detector (mechanical modification, window removal) in order to get the waveguide as close as possible to the physical pixels. In a second configuration (Fig. 2, right), we collaborate with a technological partner in order to obtain a semiconductor photo-sensitive layer over the antenna that will act as a pixel-on-chip.

15:00 – 15:15 — Quick Presentations of the Posters (1 minute per poster)**15:15 – 15:45 — Local Companies Involved in Detection****15:15 – 15:25 — eShel III et FIGU-II**

François Cochard [résumé PDF](#)

Je vous présenterai deux produits nouveaux dans la gamme des instruments de Shelyak : le spectroscopie à fibre optique eShel III, ainsi que la bonnette FIGU-II.

Ces deux instruments sont particulièrement destinés à la communauté professionnelle, et ouvre à des application nouvelles, en particulier pour des observations automatiques et/ou à distance.

15:25 – 15:35 — Innovative CMOS Image Sensors and Photonic Add-ons for Astronomy and Space Applications

Michelot J., Monsinjon P., Fertein B., Monsinjon P., Muller P., Caranhac S. [résumé PDF](#)

The French company Pyxalis has been offering off-the-shelf CMOS image sensors for several years that are well suited to astronomical applications. With strong expertise in the custom design of CMOS detectors, Pyxalis also

develops advanced and unconventional sensors capable of addressing a wide range of scientific needs, including astrometry and spectroscopy. This presentation provides an overview of the company's sensor portfolio targeting such applications.

In addition to large-format devices such as those from the GIGAPYX family, Pyxalis offers lower-resolution sensors from the HDPYX range, featuring large pixel pitches (10 μm), low dark current, and low readout noise. These characteristics ensure high detection efficiency and excellent signal-to-noise ratio. Depending on the targeted application, the presented results demonstrate that long exposure times can be achieved without the need for detector cooling.

Pyxalis also develops photonic add-ons enabling advanced functionalities, such as synchronous spectro-imaging systems capable of generating spatially resolved images with high spectral resolution. This principle has notably been implemented in the context of the AURORA AOSI project led by the European Space Agency.

Among these photonic enhancements, curved sensors are also introduced, offering opportunities for simplified optical system designs. Initial results demonstrate the feasibility of curving large-format detectors while maintaining performance.

Finally, for spaceborne applications, Pyxalis provides radiation-hardened sensors as well as devices that have undergone extensive irradiation testing, including total ionizing dose and heavy ion exposure.

15:35 – 15:45 — Les détecteurs infrarouges LYNRED au service des applications spatiales

Nicolas JAMIN, Alexandre Gaucher, Adrien Lamoure, Bruno Fiègue, Philippe Chorier [résumé PDF](#)

LYNRED s'appuie sur 30 ans d'héritage en terme de conception, test et livraison de détecteurs infrarouges spécifiques pour des applications spatiales. A ce jour, plus de 80 détecteurs modèles de vol ont été envoyés dans l'espace. Cet héritage démontre à la fois la robustesse des briques technologiques LYNRED aux environnements spatiaux mais aussi le niveau de qualité des performances électrooptiques atteintes pour ce type d'applications. Bien que la majeure partie des applications spatiales servies concernent l'observation de la Terre (e.g. Sentinel-2, MTG FCI & IRS...), les détecteurs LYNRED ont été/sont également intégrés dans des missions « Science » telles que Venus Express, Chandrayaan-2, Hayabusa-2, MIRS. Cette présentation permettra de présenter l'étendue des types de détecteurs et des briques technologiques pouvant servir les missions spatiales dans les domaines d'observation de la Terre et de la Science (dont l'astrophysique, planétologie...).

15:45 – 16:15 — Pause

16:15 – 17:00 — Detectors for the Visible and the Infrared Domains

16:15 – 16:27 — Simulation des détecteurs H4RG de HARMONI avec le cadriciel Pyxel de l'ESA+ESO

Antoine Kaszyc [résumé PDF](#)

HARMONI est un spectrographe intégral de champ dans le proche-infrarouge, qui sera installé sur l'Extremely Large Telescope. Afin de prédire le comportement de cet instrument, un « jumeau numérique » nommé HINM est développé au Centre de Recherche en Astrophysique de Lyon. HINM prend en entrée des scènes astrophysiques, et propage la lumière à travers l'atmosphère, le télescope, l'instrument, jusqu'au détecteur H4RG et reproduit la digitalisation du signal analogique.

La partie simulation de détecteur H4RG de HINM est réalisée avec Pyxel. Ce cadriciel collaboratif a pour but de standardiser la simulation des détecteurs imageurs, principalement CMOS et CCD. Cette simulation se déroule étape par étape, des photons aux électrons jusqu'aux données digitalisées, en enchaînant une séquence d'étapes modulaires. Ces étapes sont paramétrables et l'utilisateur peut même en créer de nouvelles.

Nous présenterons notre version du « pipeline H4RG », c'est à dire la liste des étapes mises en oeuvre, chacune simulant un bruit ou un comportement particulier. Des explications seront données sur les différents bruits simulés, par exemple le « Correlated Pink Noise », ou le « Inter Pixel Capacitance ». Nous insisterons sur le mode de lecture non-destructif, permettant des lectures accumulatives du détecteur, et interagissant avec certains des bruits.

Un retour d'expérience sera donné sur le développement avec Pyxel et notre collaboration active avec l'équipe en charge du projet, étant donné que cet outil se veut suffisamment générique pour s'adapter à la simulation de nombreux instruments.

16:30 – 16:39 — MCT and APD detector developments for astronomy and environmental monitoring at CEA-LETI

T. Le Goff, O. Gravrand, N. Baier, E. De Borniol, J. Rothman, F. Rochette, C. Lobre, J. Berthoz, C. Riune, L. Rubaldo
[résumé PDF](#)

CEA-LETI, in collaboration with Lynred, develops second-generation cooled infrared focal plane array (FPA) technologies for high-performance imagers, targeting defense, Earth observation from space, and astronomy. This presentation will cover past and recent MCT technology developments and associated electro-optical characterization, focusing on environmental monitoring and science applications. These past activities cover a wide range of spectral bands and applications, from Short-Wave InfraRed (SWIR) with the ALFA detector, a 2Kx2K focal plane array designed for the detection of low flux in astronomy, to Very Long Wave InfraRed (VLWIR, 15 μ m cutoff) detectors for Earth observation in the Meteo Third Generation (MTG) satellites. Recent efforts on P/N photodiode process flow optimization address process-induced defect reduction, high stability for high flux applications, low dark current, and low persistence across the entire SWIR to VLWIR spectral range. These technological developments are jointly supported by state-of-the-art electrooptical characterization means and expertise, enabling a deeper understanding of detector performance and guiding the optimization of infrared imaging technologies for demanding applications. Moreover, CEA-LETI has been at the forefront of the development of MCT eAPDs for adaptive optics, with the RAPID detector installed on the PIONIER VLTi instrument in Paranal. Today, the APD technology development targets single-element photodiodes for free-space communication, LIDAR, or quantum optics, supporting the creation of the startup Moons Photonics.

16:40 – 16:49 — Caractérisation des détecteurs APD IBEX au CEA pour les futurs instruments d'astronomie infrarouge très bas bruit

Jean Le Graët, Vincent Affatato, Marion Baumann, Olivier Boulade, Cyrille Delisle, Christian Ketchazo, Frederic Lemmel, Vincent Moreau, Thibault Pichon, François Visticot. [résumé PDF](#)

La prochaine généra.on d'instruments d'astronomie dans le proche infrarouge exige des détecteurs dont le bruit de lecture effec.f est inférieur à 1 e⁻. Dans ce?e op.que, l'ESA et Leonardo UK développent le détecteur IBEX : une matrice HgCdTe à photodiodes à avalanche de 2kx2k pixels, lue sur 16 voies et présentant une longueur d'onde de coupure de 2,5 μ m en mode avalanche. L'ESA et le Département d'Astrophysique du CEA ont ini.é un programme de caractérisa.on, s'appuyant sur l'exper.se et les bancs de tests du CEA, précédemment éprouvés sur d'autres détecteurs comme le détecteur ALFA de la caméra CAGIRE. Nous présentons ici les résultats de la première caractérisa.on d'un détecteur IBEX au CEA. Ce?e étude porte notamment sur le courant d'obscurité, le bruit de lecture effec.f et l'efficacité quan.que en fonc.on de la polarisa.on d'avalanche. Ces travaux sont complétés par une analyse de la non-linéarité, du crosstalk et de la persistance, dans des condi.ons représenta.ves de l'astronomie infrarouge à bas flux.

16:50 – 17:02 — Geant4 Modeling of X-ray Induced Charge Clouds for High-Precision Sub-pixel PSF measurement in HgCdTe based infrared detectors.

Nolane Delille, Thibault Pichon, Nicolas Baier, Clémentine Durnez, Olivier Gravrand [résumé PDF](#)

Geant4 Modeling of X-ray Induced Charge Clouds for High-Precision Sub-pixel PSF measurement in HgCdTe based infrared detectors. N. Delille^{1,2*}, T. Pichon¹, N. Baier³, C. Durnez², and O. Gravrand³ ¹University Paris-Saclay, University Paris-Cité, CEA, CNRS, AIM, 91191 Gif-sur-Yvette, France ²Centre national d'études spatiales (CNES), 18 avenue Edouard Belin - 31401 Toulouse Cedex 9 ³University Grenoble Alpes – CEA LETI, 17 Avenue des martyrs 38054 Grenoble, France *nolane.delille@cea.fr Abstract In the context of dark matter studies via weak gravitational lensing and galaxy distortion measurements, modern space-borne astrophysics missions demand unprecedented performance from infrared (IR) detectors in under sampled imaging. This necessitates a rigorous understanding of the Point Spread Function (PSF) at the intra-pixel scale. However, traditional optical characterization techniques like spot scans or CSIG (Continuously Self Imaging Grating) are experimentally difficult to implement at cryogenic temperatures and processing the data resulting from these measurements is not straightforward. This study focuses on HgCdTe photo-detectors with a cutoff wavelength of 2.1 μ m, with 15 μ m pixels based on P+/N photo-diodes. These detectors exhibit excellent noise performance, with dark currents of the order of a few electrons/pixel/s and read noise of approximately 20 electrons. We therefore propose an innovative method to measure the spatial response of infrared detectors using X-ray photons. This approach overcomes the constraints associated with classical optics by bypassing its diffraction and cryogenic-coupling constraints. The interaction of X-ray photons with the semiconductor generates a high number of carriers in a spatially localized volume, forming a charge cloud. The characteristics of this cloud directly relate to the measurement precision as well as the choice of the X-ray source. Consequently, simulation and theoretical

calculations were made in order to determine the shape, dimensions and orientation of such a cloud and the impact of its various experimental parameters, such as the X-ray photons energy, the different materials used in the detector and its fixture, the various de-excitation effects such as fluorescence or auger electrons. We also simulated the individual electron cloud produced by the impact of a single X-ray. All those simulations were made using Geant4, a Monte-Carlo based simulation tool developed by CERN. This work will focus on those simulations, specifically that of the interaction between X-ray photons and the infrared detector.

17:05 – 18:00 — *Signal Conditioning and the Environment of Sensors*

17:05 – 17:17 — **Calibration of pixel's grid location of a CMOS silicon matricial detector based on Young's fringes for space-based high accuracy astrometry**

Hugo Rousset, Manon Lizzana, Sébastien Soler, Fabrice Pancher, Jean Baptiste Le Bouquin, Julien Michelot, Logi Olgeirsson, Fabien Malbet [résumé](#) [PDF](#)

The field of astronomical science is highly challenging for instrumentation, requiring a comprehensive knowledge of the acquisition chain systematics from the optics to the focal plane. In the context of exoplanet detection, a proposal was made for the Theia space-borne mission at ESA's M8 call for missions (Malbet, 2024), as well as an hosted payload on the future NASA's HWO. The purpose of this proposal is to detect Earth-like planets at distances of up to 10 parsecs using the star's astrometric signal.

In order to detect this signal, the centroid of the star must be measured at sub-microarcsecond precision. The preliminary error budget, in conjunction with other calibrations (typically optical distortion), necessitates a pixel position knowledge requirement on the focal plane geometry of down to $5e-5$ pix for the HWO telescope and $5e-6$ pix for the Theia mission.

Since 2012, researchers in the US and France have been working on a calibration method based on the projection of scrolling Young's fringes on a matricial detector (Crouzier, 2016; Shao, 2023). This method is used to measure the geometrical shift of the pixel's peak response with regard to a perfect grid at pixel pitch period. This is achieved by measuring the dephasing of the signal between the pixels and subsequently fitting physical parameters to the measurements.

The present study involves the simulation of the aforementioned calibration method and sensitivities to instrumentation instabilities, with the objective of deducing the calibration unit requirements (i.e. laser power, mechanical stability, electronic and photon noise). Subsequently, the positional coordinates of the initial pixel were determined through the utilisation of a dedicated testbed that was derived from the work of (Crouzier, 2016). The detector utilised in this study is a Grenoble French CMOS silicon matrix manufactured by the compagny Pyxalis.

17:20 – 17:29 — **Comparison of intrapixel measurement techniques using a SWIR format TV detector**

Mouzali S., Ketchazo C., Rodriguez M. E., De Borniol E., Baumann M., Baier N., Delisle C., LeGoff T., Pichon T., Soria M., Provost L., Ronayette S., Gravrand O., and Boulade O. [résumé](#) [PDF](#)

Mouzali S. a, Ketchazo C.a, Rodriguez M. E.b, De Borniol E.b, Baumann M.a, Baier N.b, Delisle C.a, LeGoff T.b, Pichon T.a, Soria M.b, Provost L.a, Ronayette S.a, Gravrand O.b, and Boulade O.a

a. Université Paris-Saclay, CEA, CNRS, AIM, F-91191 Gif-sur-Yvette, France

b. CEA-LETI, 17 av des Martyrs, 38054 Grenoble, France

The Intrapixel sensitivity defines the variation of the pixel signal with the position of the incoming flux within the pixel surface. In the past, this feature was considered negligible in the system error budget. This assumption can no longer be made with the development of undersampled instruments and the current science objectives which target to sense extremely weak effects involved in gravitational shearing, precise astrometry and exoplanets detection. Therefore, the intrapixel response has to be evaluated during the detector characterization phase.

At CEA-IRFU, a test bench called "Intrapix" has been specifically designed for this measurement by means of the determination of the MTF at frequencies well beyond the Nyquist frequency of the detector [1]. Two detectors issued from the ASTEROID and ALFA [2] programs were characterized. These detectors are SWIR sensitive photodiodes with a $15\ \mu\text{m}$ pixel pitch and Source Follower per Detector ROIC architecture. The measured results are in accordance with the predictions and consistent with the diode technologies.

The ongoing activity aims to compare different intrapixel measurement techniques using the ASTEROID detector, which has already been tested with the « Intrapix » bench. The idea consists in taking advantage of the spot scan technique developed by the CEA-LETI at $1.55\ \mu\text{m}$ in order to estimate the response delivered by each of the two

techniques. The first results will be presented, taking into account the spot scan test bench characterization in terms of stability.

[1] Pichon, Thibault, et al. « Quantix and Intrapix : test benches dedicated to quantum efficiency measurement and intra-pixel response of detectors from VIS to LWIR », Proc. SPIE 12191, XRay, Optical, and Infrared Detectors for Astronomy X, 121912I (29 August 2022); <https://doi.org/10.1117/12.2630232>

[2] Gravrand, Olivier, et al. « Fabrication and characterization of a high performance NIR 2kx2k MCT array at CEA and Lynred for astronomy applications. » Infrared Technology and Applications XLVIII. Vol. 12107. SPIE, 2022.

17:30 – 17:42 — MILENE: Development of the interferometric test bench for mid infrared photonic integrated circuits characterisation

Louis Gemmerlé, Manon Lallement, Jean-Philippe Berger, Guillermo Martin, Pierre Labeye, Laurence Gluck, Stéphane Curaba [résumé PDF](#)

Nulling interferometry allows us to benefit from the high angular resolution provided by current ground-based (or future space-based) interferometric facilities, as well as the capability to observe exoplanets with higher planet-to-star flux ratio through coherent cancellation of the flux from the star. The LIFE space mission is an instrument aiming to perform this method within a wavelength range of 4 μm to 18 μm , and no detector has for now been demonstrated for its specifications. This space mission has a ground-based precursor, NOTT for the VLTI, working in the L' band. Using photonic integrated circuits (PIC) for the aperture recombination function has the potential to considerably simplify the instrument and enhance its performances: it allows the instrument to gain in compactness and thermo-mechanical stability compared to bulk optics and provides intrinsic self-alignment, enhancing the nulling performance.

To explore the ability of the different PIC technologies to provide strong performances in this context, with the support of LabEx FOCUS we have built a dedicated four-beam interferometric bench called MILENE (Mid Infrared Lab Equipment for Nulling Experimentations). This bench can also be used to test detector technologies in a precision interferometry context and evaluate their suitability for nulling in broadband light conditions. The chosen design of this characterisation device is composed of an association of Michelson's interferometers, dividing the flux of a unique source into four beams. The architecture of the bench permits the consideration of an upgrade to eight interferometric channels, opening the way to the characterisation of up-to-eight-telescope recombination PICs in the context of an extended VLTI facility or at the CHARA array. The coaxial aspect of this architecture provides identical pupils for all the beams, so a more uniform injection efficiency among the inputs of the nulling PIC. The uniformity of the injection is also heightened by the development of a telecentric injection system. Moreover, in order to achieve deep null values (10^{-3} goal null value across the L-band), a stringent precision in controlling the phase, intensity and polarisation of each individual beam is required. We present the error budget established to evaluate these constraints, the characterisation of various control elements used on the bench and preliminary results obtained with a nulling PIC developed at CEA-Leti using the SiGe platform.

17:45 – 17:57 — Anti-Reflective Technologies for Silicon and Alumina Lenses in CMB Experiments

Kalemi B., Catalano A. [résumé PDF](#)

Next generation experiments at millimeter wavelength require larger optical elements to increase sensitivity and to enable the illumination of 10k-pixels detector arrays, resulting in wider fields of view and larger mapping speed. Conventional plastic lenses are no longer viable due to their high absorption losses, making low-loss materials such as silicon and alumina necessary. However, their high refractive index (~ 3) leads to significant reflection losses, thus requiring the development of effective anti-reflective (AR) solutions.

In our research, we investigate two AR techniques specifically tailored for these materials. For silicon lenses, we implement a subwavelength surface structuring approach, which involves machining nanostructured patterns directly onto the lens surface using a customized milling machine. These structures are optimized through electromagnetic simulations to minimize reflectivity across the targeted frequency band. The nanostructures are fabricated in-house, and the resulting lenses are experimentally characterized using a Martin-Puplett interferometer coupled to a dilution cryostat hosting Kinetic Inductance Detectors operating at 100 mK.

For alumina, where machining is not feasible due to the material's hardness, we adopt an alternative AR solution based on the deposition of a dielectric coating layer with an intermediate refractive index. The coating parameters, such as thickness and refractive index, are optimized via simulations, and the layer is deposited using a custom-built vacuum system.

Both approaches demonstrate robust, efficient, and reproducible performance, reducing reflection by about a factor of three and showing strong potential for integration into next generation CMB experiments.

Soirée

Soirée Grand Public — Musée de Grenoble

Jeudi 25 Juin

Matinée · 09:00–12:00 — Session plénière (S00)

Session plénière

09:00 – 09:25 — Nouvelles de l'INSU AA

Céline Reylé (invitée)

09:25 – 09:50 — (09:30-09:45)

Photo de groupe

09:50 – 10:15 — Pause Café * (09:45-10:15)

10:15 – 10:45 — CNAP – AA

SESSION CARRIERE

Après-midi · 14:00–18:00 — Sessions parallèles

AMPHI 1 — S13 : COMMISSION TRANSITION ENVIRONNEMENTALE: QUELLE RECHERCHE EN ASTROPHYSIQUE DANS UN MONDE SOUTENABLE ? · SOCIÉTAL

<https://journées.sf2a.eu/ateliers/s13/>

14:45 – 15:05 — Sustainability and Astronomy: Current Estimate on the Environmental Impact of ELT's MOSAIC

Rafa Nadhil, Cyril Pannetier, Nazim Ali Bharmal, Alondra Solá, Kacem El Hadi, Myriam Rodriguez, Hermine Schnetler, Clarysse Picard [résumé PDF](#)

Sustainability and Astronomy: Current Estimate on the Environmental Impact of ELT's MOSAIC Rafa Nadhil¹, Cyril Pannetier¹, Nazim Ali Bharmal², Alondra Solá¹, Kacem El Hadi³, Myriam Rodriguez¹, Hermine Schnetler¹, Clarysse Picard⁴ ¹UNIDIA, Observatoire de Paris - PSL, CNRS, Meudon, France ²Centre for Advanced Instrumentation, Department of Physics, Durham University, Durham, UK ³Aix Marseille Université, Laboratoire d'Astrophysique de Marseille, CNRS, CNES, Marseille, France ⁴Observatoire de Paris, Université PSL, CNRS, Paris, France MOSAIC is a multi-object and multi-integral field spectrograph for the Extremely Large Telescope, which is currently in its preliminary design phase (Phase B2). A first estimation of its carbon footprint had been done in 2024, presenting the order of magnitude of the CO₂eq emission. However, the scope of the analysis excludes some of the important parts of the project, such as the AITV phase, cooling system, and electronics. We perform further environmental impact estimation using Life Cycle Analysis (LCA) in accordance with the ESA LCA guideline, covering all project phases from the preliminary design to the instrument's end-of-life and ensuring inclusion of other environmental impact categories, in addition to carbon emissions. This followup study aims to provide the astrophysics community with reliable environmental impact figures of our project, identify «hotspots», build strategies on reducing the environmental footprint, and pave the way for an applicable methodology for future astronomical instruments.

15:05 – 15:25 — Evaluating the carbon footprint of research projects prior to their submission

Alexandre Santerne, Héroïse Méheut [résumé PDF](#)

There is a growing practice in academic research to evaluate the carbon footprint of the institutes and projects (e.g. Blanchard et al. PLOS Climate 2022). This is very important to monitor the climate impact of our activities and adopt a strategy to mitigate these emissions. However, these carbon footprint are used to be estimated a posteriori, hence once the carbon is emitted. (e.g. Berné et al. ERL 2022, Gokus et al. PNAS Nexus 2024)) In this talk, I will present an experiment that was organised over the entire astronomical community in France, to evaluate the carbon footprint of research projects, before they are submitted to funding agency. Nearly 200 projects were submitted and used a simple carbon calculator to help defining the project. I will present the methodology and results of this experiment and discuss the various options that are considered to include carbon footprint as part of the evaluation criteria in future calls.

15:25 – 15:45 — L'effet rebond – un point aveugle des efforts de réduction

Patrick Hennebelle [résumé PDF](#)

Depuis plusieurs années à présent, la communauté de recherche s'est mobilisée pour quantifier son empreinte environnementale et a tenté de mettre en œuvre des réductions de ses émissions de gaz à effet de serre. Cet effort louable se heurte néanmoins à des barrières complexes. L'une d'entre-elles est particulièrement redoutable, voire insidieuse, il s'agit de l'effet de rebond, également connu sous l'appellation « Paradoxe de Jevons ». Le paradoxe, constaté empiriquement dès le 19^{ème} siècle, se manifeste par l'augmentation de la consommation d'une ressource lorsqu'un gain d'efficacité de la consommation de ladite ressource est réalisé. Concrètement cela signifie qu'une réduction « apparente » à l'échelle, par exemple d'un laboratoire, ne garantit absolument pas que l'effort consenti se traduise par une réduction effective des émissions. Au cours de l'exposé, je ferai un bref tour d'horizon de la littérature, y compris d'articles de recherche qui ont cherché à quantifier les effets rebonds dans différents contextes. Je distinguerai les différents types d'effets rebonds, directs, indirects et macro-économiques et je donnerai plusieurs exemples. Je discuterai concrètement du cas de nos laboratoires.

15:45 – 16:05 — Quelles limites à la recherche en astrophysique à l'échelle des chercheurs ?

Cantalloube, F. [résumé PDF](#)

La physique fondamentale fait face à de nombreuses limites intrinsèques comme la vitesse de la lumière, le zéro absolu, ou encore le principe d'incertitude de Heisenberg. En parallèle, les ressources en matières premières, nécessaire à l'exercice de nos métiers de recherche en astrophysique, comme l'énergie, l'eau, ou les métaux sont aussi en quantité et en capacité d'extraction limitées, souvent rassemblées sous le terme de limites planétaires.

AMPHI 2 — S01 : ATELIER GÉNÉRAL DE L'ACTION THÉMATIQUE EXOSYSTÈMES · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s01/>

14:00 – 14:05 — Nouvelles de l'AT

14:05 – 14:25 — The reflex instability in protoplanetary discs

Clément Baruteau, Nathan Magnan, Aurélien Crida, Jean-François Gonzalez, Philippine Griveaud, Elena Lega, Frédéric Masset, Héloïse Méheut [résumé PDF](#)

Theoretical studies of protoplanetary discs have a long history, with many works on what instabilities may grow, and how they impact disc evolution and planet formation. By running long-term hydrodynamical simulations of disc-planet interactions, we have recently (and quite unexpectedly!) uncovered what seems to be yet another instability in non-axisymmetric discs. It is a linear instability that takes the form of a growing $m=1$ mode arising from the reflex motion of the star around the barycentre of the star-disc-planet system, and for this reason we refer to this instability as the reflex instability. It is found with a variety of grid-based codes as well as in smoothed particle hydrodynamics codes, and it is likely relevant to astrophysical discs other than protoplanetary discs. In this communication I will tell you all we currently know and understand about the reflex instability.

14:25 – 14:40 — Accretion on the PDS 70 planets: a burst-like behavior?

D. Demars, Y. Zhou, Y. Aoyama, L. Biddle, B. Bowler, M. Bryan, N. Calvet, S. Haffert, Y. Hasegawa, J. Hashimoto, G.-D. Marleau, A. Sanghi, S. Takasao, T. Thanathibodee, T. Uyama, K. Wagner and Y. Wu [résumé PDF](#)

Giant planets acquire their mass by gas accretion from their natal protoplanetary disk. While some of the gas reaches the planet directly, most of it is channeled through a circumplanetary disk. While the exact process by which the disk is accreted onto the planet is still up to debate, accretion is expected to produce strong emission lines (H α , Paschen Beta, ...) and UV excess. The details of accretion, and interactions with the circumplanetary disk, are expected to dictate the initial energy budget of the planet, and the formation of exomoons.

Only two systems are known to bear accreting planets (3-10 M $_{\text{Jup}}$) within a protoplanetary disk: the PDS 70 b and c planets, and the WISPIT 2 b planet. Their very close separation (0.1-0.3") and faint emission lines prevent their study besides low-resolution H α observations. This implies that the interpretation of the emission lines flux from snapshot observations is mostly model-dependent. Instead, planetary-mass companions, wide-orbit (1-2") and higher-mass counterparts (10-20 M $_{\text{Jup}}$), have been used as proxies to test the mass-limits of various accretion scenarios in the case of self-evolving systems.

Recent studies have shown that magnetospheric accretion (the accretion process for stars) extends down to brown dwarfs and planetary-mass companions (10-20 M $_{\text{Jup}}$), hinting at a common process on a wide range of mass. Magnetospheric accretion occurs when the planet's magnetic field is sufficient to truncate the surrounding disk and lift up material in accretion columns that crash down at the planetary surface. In this scenario, the UV excess is produced at the accretion shock, while the emission lines are produced both at the shock and within the

funnel itself. The variability of the emission lines is therefore a combination of both stochastic variability, and that induced by rotational modulation. Still, it is still unclear whether this behavior extends past the deuterium-burning limit or if the protoplanetary disk environment strongly influences accretion processes.

We present HST/WFC3 UVIS2 observations of the PDS 70 system with the F656N narrow-band filter (H α). Observations span 2 independent years: 6 epochs in 2020, and 6 epochs from early 2024 to early 2025. We find a burst-like behavior of the H α line, hinting at drastic changes of the accretion rate on various timescales as low as a day. We compute their occurrence rate, and interpret this variability in the context of various accretion scenarios and in comparison to wide-orbit companions behavior.

14:40 – 14:55 — A colored view and dust properties along the beta Pictoris’s cat-tail

Nicolás Godoy, E. Choquet, E. Serabyn, I. Rebollido, C. Danielski, A. Boccaletti, A.M. Lagrange, P.O. Lagage, M. E. Ressler [résumé PDF](#)

Submission 2:

S01

Authors: Nicolás Godoy, E. Choquet, E. Serabyn, I. Rebollido, C. Danielski, A. Boccaletti, A.M. Lagrange, P.O. Lagage, M. E. Ressler

Title: A colored view and dust properties along the beta Pictoris’s cat-tail

Abstract: Recent observations with JWST/MIRI have demonstrated an unprecedented capability not only for the atmospheric characterization of directly imaged exoplanets, but also for revealing the fine structure of circumstellar disks. In the beta Pictoris system, the discovery of new mid-infrared structures has opened a unique window into disk morphology and dynamics. Among these, the so-called “cat-tail” feature stands out as one of the most remarkable structures, raising new questions about the complexity of this planetary system. In this work, we present an extended analysis based on new coronagraphic observations obtained with the F1065C and F1140C filters, combined with archival data at F1550C and F2300C. We model the cat-tail structure to extract its flux and spatial distribution across all bandpasses. These measurements are then used to investigate its mid-infrared colors and to constrain the dust composition, grain-size distribution, and temperature along the structure. We present our first results on the dust properties of the cat-tail and discuss their implications for the origin and evolution of this feature.

14:55 – 15:10 — A brown dwarf responsible for the late inwards migration of GJ 436 b?

Desgrange, C., Matthews, E., Mara, A., Flasseur, O., Mignon, L., Palma-Bifani, P., Rajpoot, B., Bourrier, V., Delfosse, X. [résumé PDF](#)

In the context of the study of the formation and evolution of planetary systems, the question of exoplanet migration mechanisms is crucial. On the one hand, theoretical models show that exoplanets can migrate inwards through interactions with the disk during the first million years of the system. On the other hand, there are systems in which we know that the migration has to happen gigayears later. The planetary system GJ436 is an archetypal example: it hosts a Neptune-mass planet named GJ436b. This exoplanet orbits its host star in 2.6 days with a misaligned, eccentric orbit. Due to its proximity to its host star, its atmosphere is strongly escaping. However, the system is old, between 4 and 8 Gyr. As a result, the atmosphere of GJ436b should have migrated recently, via the mechanism of high-eccentric migration (HEM). This mechanism implies the presence of an additional companion, GJ436c. We obtained VLT/SPHERE data revealing a promising brown dwarf candidate for GJ436c. Our GJ436c candidate should be confirmed in the coming year thanks to our new accepted SPHERE observations. In my talk, I will present our brown dwarf candidate GJ436c, which is about 25MJup, its orbital and atmospheric properties, and also its consistency with Gaia complementary information. All in all, the system GJ436 is currently the most ideal system to constrain the HEM scenario observationally. It will enable a better understanding of the dynamical evolution of exoplanets orbiting close to the stars, including those located in the so-called “hot Neptune desert” (see Figure). Our pilot study paves the way for a larger high-contrast imaging program in the future, to trace back the dynamical evolution of other exoplanets located in the “hot Neptune desert”. In practice, we would search for outer companions in those systems and assess whether late-migration could also have happened, based on deep observational constraints (and new companion detections) using VLT/ERIS or ELT/METIS, coupled to HEM simulations.

Figure: Dots represent the radius of exoplanets as a function of their orbital period. The triangle emphasizes a region often called the “hot Neptune desert”, where exoplanets should not be, because they should have lost their atmosphere.

15:10 – 15:25 — Binary tidal evolution as a sculptor of circumbinary planet architectures

Mario Sucerquia, Nicolás Cuello, Gaspard Duchêne [résumé PDF](#)

Circumbinary planets are expected to form within circumbinary discs and to migrate inward until they approach the disc inner cavity, close to the dynamical stability boundary imposed by the central binary [1, 2]. Yet the observed population does not cluster at strict marginal stability. Instead, known circumbinary planets typically orbit at a small but significant offset from the critical radius, suggesting that present-day circumbinary architectures may preserve the imprint of post-formation evolution rather than reflecting a purely primordial disc-truncation configuration [3]. Previous tidal studies have shown that direct star–planet tides are generally too weak to produce significant planetary migration in circumbinary systems [4]. In this context, a natural and still little explored possibility is that the binaries themselves are not static hosts: if they shrink and circularise through long-term tidal dissipation, the circumbinary stability boundary should retreat with time, potentially widening the planet–stability gap even when the planets themselves remain nearly unchanged.

This presentation will explore this idea from a population-level dynamical perspective, motivated by the observed distribution of circumbinary planets relative to the critical stability limit. I will show that, over a broad region of parameter space, surviving planets can remain nearly quasi-fossilised in semimajor axis and eccentricity while the stability boundary moves inward as the binary evolves. In this regime, the final offset from marginal stability is produced mainly by binary tidal evolution rather than by additional post-disc planetary migration. I will further discuss how this mechanism depends strongly on the binary mass ratio: unequal-mass binaries preferentially preserve long-lived survivors, whereas near-equal-mass systems become much more efficient at destabilising planets through ejections and collisions. These results suggest that the present-day architecture of circumbinary planets may encode a fossil record of binary tidal evolution, and that the observed circumbinary population may reflect not only formation and migration, but also the long-term secular evolution of their host binaries.

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15:25 – 15:40 — Inférence et optimisation des stratégies multi-époques en imagerie directe d'exoplanètes : simulations HARMONI et extension bayésienne de K-Stacker

Ould-Elhkim, M., Le Coroller, H., Beust, H., Nowak, M., Carlotti, A., Vigan, A., Choquet, E. [résumé PDF](#)

La détection d'exoplanètes en imagerie directe reste aujourd'hui limitée par le bruit de speckle et par la difficulté à exploiter efficacement les observations multi-époques. Les approches modernes de traitement du signal et d'inférence statistique offrent de nouvelles perspectives pour extraire des signaux planétaires faibles dans des régimes dominés par le bruit corrélé. Dans ce travail, nous développons une approche complète allant de la simulation instrumentale à l'inférence orbitale, appliquée au cas de l'instrument HARMONI sur l'ELT. Nous produisons des simulations réalistes multi-époques, incluant des effets instrumentaux et astrophysiques, puis nous comparons différentes méthodes de réduction de données haute-contraste, incluant PCA-ASDI (VIP), PACO-ASDI et une approche originale de WPCA appliquée aux cartes de flux, s'inscrivant dans le cadre des méthodes de réduction de dimension et d'apprentissage statistique. Nous introduisons en parallèle une extension bayésienne de K-Stacker basée sur un échantillonnage MCMC, rendue possible par un changement de variables orbitales non singulier. Cette approche permet d'accéder à la distribution a posteriori complète des paramètres orbitaux et photométriques, et d'explorer les dégénérescences du problème, ouvrant la voie à une inférence robuste dans des contextes faiblement contraints. En combinant ces développements, nous étudions systématiquement l'impact des stratégies d'observation sur les performances de détection : durée minimale d'observation par époque (rotation ADI), espacement temporel optimal entre les époques, et gain en rapport signal-à-bruit en fonction du nombre d'époques et du mouvement orbital. Cette analyse met en évidence le rôle central de la modélisation statistique dans l'optimisation conjointe des observations et du traitement des données. Ce travail propose ainsi un cadre unifié combinant simulation, traitement avancé du signal et inférence bayésienne pour préparer l'exploitation des instruments de nouvelle génération (ELT/HARMONI) et des futures missions d'imagerie directe.

15:40 – 15:55 — Accelerating atmospheric characterization with Optimal Estimation

Palma-Bifani, P., Charnay, B., Leconte, J. [résumé PDF](#)

Exoplanet science is transitioning from an era of discovery toward the indepth spectroscopic characterization of distant climates and formation histories. However, as data sophistication grows, traditional modeling faces bottlenecks in the form of parameter degeneracies and enormous computational costs. To address this, I introduce Optex, a high-performance retrieval tool that adapts Earth-science inversion techniques, specifically the Optimal Estimation algorithm (Rodgers 2000), for directly-imaged exoplanetary atmospheres. Integrated with the Exo_k library (Leconte 2021), Optex achieves superior computational speed and vertical resolution compared to traditional sampling, while providing a rigorous framework for uncertainty quantification and bias mitigation. I will demonstrate Optex's unique ability to resolve complex structures by presenting results for the T-dwarf W1935, where JWST observations revealed unexpected methane emission from auroral heating. Finally, I will highlight Optex's scalability to multidimensional modeling, offering a high-performance pathway to move beyond static 1D atmospheric descriptions.

15:55 – 16:10 — 2026 : La communauté HALO fait son bilan

Lucie Leboulleux, Yassin Jaziri, Elodie Choquet, Mickaël Bonnefoy, Julia Seidel, Frantz Martinache, Lucile Mignon [résumé PDF](#)

Formée en 2023, HALO (Habitability And Life on Other Worlds) fédère la communauté française impliquée dans l'étude des exoplanètes, de leurs atmosphères et de leur habitabilité. Elle regroupe actuellement 45 chercheur·se·s et ingénieur·e·s issu·e·s de l'astrophysique, de la planétologie, des sciences de l'atmosphère et de l'instrumentation spatiale. Elle s'appuie sur une richesse interdisciplinaire et sur une implication forte et convnue dans les grandes infrastructures sol et espace des vingt dernières années, qui constituent aujourd'hui le socle scientifique et technique indispensable à la préparation des missions spatiales de nouvelle génération HWO (Habitable Worlds Observatory) et LIFE (Large Interferometer For Exoplanets).

Début 2026, un mini-comité est mis en place au sein de HALO pour faire un bilan de ces 3 premières années et réfléchir à une prospective des activités à venir. Ce sera présenté à l'atelier Exosystèmes de la SF2A vise à introduire la communauté française HALO et à partager ce travail de bilan et de vision prospective.

16:10 – 16:30 — Pause**16:30 – 16:45 — Une nouvelle caméra pour le spectrographe SOPHIE à l'OHP : de nouvelles possibilités par l'extension du domaine de longueur d'onde**

I. Boisse et l'équipe scientifique SOPHIE-red [résumé PDF](#)

Le spectrographe SOPHIE est monté au télescope de 1.93m à l'Observatoire de Haute-Provence depuis l'été 2006 et apporte des résultats scientifiques de premier plan. Pour ses 20 ans, une nouvelle caméra est en cours d'installation depuis fin Mars 2026. Nous souhaitons donner des nouvelles des performances de cette nouvelle caméra qui va permettre d'obtenir un meilleur signal sur bruit sur tout le domaine spectral de SOPHIE (385-690nm) grâce à un meilleur rendement quantique. Et surtout, grâce à un format plus grand que l'ancienne caméra, elle permet de mesurer un plus grand nombre d'ordres spectraux et d'étendre le domaine de longueur d'onde, particulièrement vers le proche infra-rouge. Il sera présenté les différents défis liés à cette extension (calibration en longueur d'onde, correction des telluriques) et les nouveaux programmes scientifiques envisagés.

16:45 – 17:00 — Reduction of photochemical networks : application to sulfur chemistry for 3D atmospheric models

R. Veillet, E. Hébrard, H. Baskett, M. Zamyatina, N. Mayne [résumé PDF](#)

Astrophysics Group, University of Exeter, EX4 4QL Exeter, UK

Abstract

The detection of SO₂ in four different exoplanet atmospheres (WASP-39 b, WASP-107 b, HAT-P-26 b, GJ 3470 b) by the James Webb Space Telescope (Tsai et al., 2023; Dyrek et al., 2024; Beatty et al., 2024; Gressier et al., 2025) has proven the importance of sulfur chemistry in current models to better understand exoplanets and prepare future missions like ARIEL. More specifically, photochemistry has been identified as the key process responsible for oxidizing H₂S to SO₂, and is essential to explain the abundances inferred from these observations. Such processes are currently modeled in the literature using detailed chemical networks in one-dimensional models,

but other applications such as in retrievals or GCMs require a fast, reduced network. In this talk, we will discuss the reduction of detailed chemical networks for exoplanet atmospheres subject to photochemistry. We'll use results from graph theory to discuss the different approaches that can be used to construct a graph from this chemical network, analyze the chemical pathways and identify key reactions and intermediates that connect the targeted species. We'll discuss how this methodology can be applied to construct a reduced chemical network from 1D simulations with FRECKLL (AlRefaie et al., 2024), and compare it to more black box approaches that have been used previously in the literature such as Genetic Algorithms (Lira-Barria et al., 2024). We'll use both of these approaches to reduce a detailed C/H/O/N/S kinetic network that has been built and validated on experimental data in a previous work (Veillet et al., 2026), apply it to the case study of sulfur chemistry on WASP-39 b and WASP-107 b, and discuss the utility of these tools for chemical analysis, 3D modeling and on-the-fly reduction in retrievals.

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 Veillet, R., Venot, O., Sirjean, B., et al. 2026, *A&A*

17:00 – 17:15 — ESPRESSO characterizes the small transiting exoplanet population with extreme precision radial velocities

Hobson, M. J., and the ESPRESSO GTO consortium [résumé PDF](#)

Abstract: The most common planets in the Galaxy are super-Earths and sub-Neptunes. These planets, with masses and radii between those of Earth and Neptune, are intriguing as we do not find such planets in the Solar System, raising the question of what their likely compositions are. Likewise, they are the most promising candidates for habitability. However, due to their small size and low mass, they are also the hardest planets to detect and characterize, requiring the best possible facilities.

The ESPRESSO spectrograph at the Very Large Telescope in Chile is the leading instrument for the characterization of the lowest-mass planets with extreme precision radial velocity (EPRV), thanks to its exquisite 10 cm/s instrumental RV precision and the large collection area of the VLT, which enables the acquisition of high signal-to-noise spectra even for fainter host stars. Between 2018 and 2023, the ESPRESSO consortium followed up some 50 stars hosting small transiting planet candidates from K2 and TESS, as part of the ESPRESSO Guaranteed Time Observations (GTO).

In this contribution, we will give a global overview of the 54 planets in 23 systems confirmed by this program, which range from super-Mercuries through super-Earths and water worlds to sub-Neptunes. These planets represent a significant addition to the precisely-characterized small planet population. We will highlight emerging trends in the overall population, such as: - an insolation-dependent mass threshold between rocky and volatile rich planets; - the clear emergence of a group of high-mass rocky «stripped core» planets at high insolation; - an increasing planet mass with higher stellar metallicity. We also compare planet masses to typical protoplanetary disks, finding these planets must form either early in the disk's lifetime, with high formation efficiency, or preferentially in massive disks. Finally, we will discuss the lessons learned from this program in terms of observing and analysis strategies. In the context of the upcoming PLATO mission, this is vital knowledge for the follow-up of the Earth-sized planet candidates that are PLATO's principal objective.

17:15 – 17:30 — Modeling, interpretation and preparation of JWST observations of the temperate super-Earth LHS 1140 b

P. Dupont, M. Turbet, et al. (TBC) [résumé PDF](#)

Since the start of JWST operations in mid-2022, a major goal of the exoplanet community has been to determine whether rocky planets orbiting M-dwarf stars can retain atmospheres. More than one thousand hours of observing time have already been devoted to this question, including the 500-hour DDT Rocky Worlds program. So far, the overall results have been largely negative: aside from a few still-debated exceptions (e.g. August et al. 2025), most well-observed rocky planets show no evidence for atmospheres (Kreidberg & Stevenson 2025). This is notably the case for TRAPPIST-1 b, for which extensive observation programs (multi-wavelength eclipses, phase curves, and transmission spectroscopy) concluded the absence of atmosphere (Gillon et al. 2025, Maurel et al. 2025). An empirical framework known as the cosmic shoreline (Zahnle & Catling 2017) suggests that more massive and less irradiated planets are more likely to retain atmospheres. In this context, the super-Earth LHS 1140 b stands out as the prime target, with a mass of about five Earth masses and an insolation of ~0.4 times that

of Earth – i.e., well within the habitable zone of its host star. Initially thought to be a mini-Neptune due to its low density, early JWST transmission spectroscopy has ruled out the presence of an H₂/He envelope (Cadieux et al. 2024, Damiano et al. 2024). LHS 1140 b is therefore currently one of the most promising rocky planet candidates to host volatiles, possibly including water, and a secondary atmosphere. Several large JWST observing programs are now dedicated to this planet, including multiple transit spectroscopy observations with NIRISS and NIRSpec (partly completed and partly forthcoming), as well as an ambitious secondary eclipse program with MIRI within the DDT Rocky Worlds program. In support to these observations, we have performed numerical simulations using the 3D climate model Generic PCM, coupled with the 3D radiative transfer code Pytmosph3R, to generate realistic transmission and emission spectra. These models account in particular for the effects of water and CO₂ clouds expected for the range of possible compositions and insolation of LHS1140b. We compare our simulations with merged, existing JWST datasets and provide predictions for upcoming observations, with the aim of determining whether LHS1140b possesses an atmosphere and if so, what it is made of. We will present the results of our work.

17:30 – 17:45 — Vertical wind shears of KELT-20b unveiled with MAROON-X

Valentin De Lia, Vivien Parmentier, Julia V. Seidel [résumé PDF](#)

The golden era of exoplanet characterization has just started with the increasing number of exoplanet observations, and the design of accurate data analysis methods. In particular, High-Resolution Spectroscopy (HRS) has recently demonstrated that it is a powerful tool to investigate not only the chemical composition, but also the dynamical structure of exoplanets. We recently achieved one of the highest signal-to-noise ratio (S/N) observation ever obtained for an exoplanet, with the MAROON-X spectrograph located at the 8-meter-class Gemini telescope, enabling an in-depth study of the Ultra-Hot Jupiter KELT-20b.

Our observations allowed us to directly measure the vertical wind shear of KELT-20b with unprecedented precision. In order to do that, we used 9 different chemical species that act as numerous probes of the different layers of the atmosphere. We found that the standard contribution method used to determine the layers probed by each detected species was strongly biased when applied to cross-correlation HRS. We therefore developed a more robust method to estimate which layers were actually probed by the data, enabling the precise measurement of the wind gradient in KELT-20b. Due to the high quality of our observation, we could further split the iron contribution into weak and strong lines and confirm the vertical wind gradient both with multi-species and single-species measurements.

We measured that the wind speed decreases with altitude, ranging from 12 km/s at 1e-3 bar to 6 km/s at 1e-6 bar. This decreasing trend with altitude challenges current hydrodynamical Global Circulation Models (GCMs), which predict the opposite. We interpret this by the presence of magnetic drag that dampens the low pressures more importantly, since they are highly ionized parts of the atmosphere. Using both GCMs with active magnetic drag and energy balance models from Koll & Komacek 2018, we find that our data are compatible with magnetically driven circulation, provided that the atmospheric magnetic field is at most a few Gauss. By using multiple species on one planet we come to the same conclusion to a recent population-level study targeting one species in multiple planets, cross-validating our results

17:45 – 18:00 — Towards Doppler Eclipse Mapping of Hot Jupiters

Vincent Yariv [résumé PDF](#)

In the last decade, ground-based high-resolution spectroscopy (HRS) has emerged as a powerful method to characterise exoplanet atmospheres. With tens of instruments worldwide, HRS has produced detections on many targets, revealing these planet's thermal, compositional and dynamical structure. As HRS science continues to mature, novel strategies will be key to fully and robustly extracting the 3-dimensional information encoded in these rich datasets. Eclipses, where the planet is progressively hidden/revealed from behind its star, could provide a unique solution for obtaining spatially resolved dayside spectra. While it has been successfully applied at low spectral resolutions to map temperatures on several HJs, eclipse mapping has yet to be attempted with HRS.

We present results from the first observational campaign to perform high resolution eclipse mapping on the ultra-hot Jupiter (UHJ) WASP-33b. With 8 eclipses observed using SPIRou, we are detecting the planet's CO emission as it is being occulted for the first time. While our signal is not yet strong enough to recover meaningful spatial information, it highlights both the potential of stacking multiple eclipses, as well as challenges for data processing with short time-series. Based on the SPIRou data and initial results from an ongoing study with IGRINS-2 observations, we present future prospects for eclipse mapping at high-resolution with the ELT.

AMPHI 3 — S17 : GALAXY EVOLUTION IN THE FAINT UNIVERSE: INSIGHTS FROM THE ERA OF LARGE SURVEYS · COMMUNAUTÉ<https://journées.sf2a.eu/ateliers/s17/>**14:00 – 14:15 — The history of our Milky Way disc using the Gaia mission and post-processed simulations***Barbillon, M., Recio-Blanco, A., Tepper-García, T., Joss Bland-Hawthorn, J. [résumé PDF](#)*

Understanding the formation and evolution of galaxies remains one of the central challenges in Galactic archaeology (Bland-Hawthorn & Gerhard 2016). The ability to map the kinematic and chemical properties of stars has revealed that the different components of the Milky Way (bulge, disc, and halo) are key to unravelling Galactic evolution. Present-day disc galaxies often exhibit distinct thin and thick discs. However, the formation mechanisms of these two components and the timing of their emergence remain open questions. Disc of galaxies serve as laboratories for studying star formation, resonance-driven migration, as well as secular evolution and external perturbations. Nevertheless, their detailed structure and the nature of the stellar populations tracing them, particularly in the Milky Way, are still actively debated.

To investigate the influence of the cosmic environment that has shaped the Milky Way's history, I am using chemo-dynamic parameters from the most recent data release of the Gaia mission, which provide new chemical diagnostics for tracing the duration of spiral arms (Barbillon et al. 2025a). Our understanding of the chemical evolution of the disc has evolved from a simplistic 1D radial view to a more comprehensive 2D perspective that combines radial and azimuthal trends with small-scale variations. I have also investigated the distribution of interstellar dust in the Milky Way by constructing new 3D dustmaps based on the Gaia Bp and Rp bands, as well as on the chemophysical parametrisation of stellar spectra from the General Stellar Parametriser from Spectroscopy (GSP-Spec) module. This catalogue has the advantage of deriving stellar atmospheric parameters independently of extinction. One goal was to recover the spiral arm signatures in the interstellar medium and to reveal the intricate connections between the Galactic distributions of dust, gas, and stars (Barbillon et al. 2025b).

Furthermore, by taking advantage of the NEXUS idealised galaxy simulations (Tepper-García et al. 2021) and the NewHorizon cosmological zoom-in simulations (Dubois et al. 2021), I have studied in detail the evolution of Milky Way-like galaxies to better interpret observational data. In both simulations, we recovered spiral arm signatures across stellar populations of different ages, from the oldest to the youngest age bins. From a kinematic perspective, stars within spiral arms exhibit a lower velocity dispersion than those outside the arms. These differences are more pronounced for older populations and are also observed in Gaia data when comparing old and young stellar samples from our first paper (Barbillon et al 2025a). Similar trends have also been highlighted in other types of simulations (Ardévol et al. 2025). Both observations and simulations thus question the age of the stellar populations best suited for studying spiral arms (Barbillon et al., in prep.). Combining different stellar populations, various tracers (such as gas and dust), and simulations will bring a new perspective to the analysis of the Galactic disc and provide a better understanding of the processes that have shaped it.

14:15 – 14:35 — Can stellar streams retain signatures of early major mergers?*Guillaume, C. [résumé PDF](#)*

Stellar streams in the Milky Way commonly exhibit morphological distortions indicative of external dynamical perturbations. Numerical studies have shown that such signatures can arise from a wide range of mechanisms, including encounters with dark matter subhaloes and baryonic structures such as the Galactic bar or giant molecular clouds, leading to significant degeneracies in the interpretation of observed stream perturbations.

In the context of hierarchical galaxy formation, the Milky Way is known to have experienced a major merger approximately 10 Gyr ago. The impact of such an event on stellar streams remains unexplored and may add an additional layer of complexity to their interpretation. A key question is whether streams formed prior to a major merger could survive the event and retain observable signatures, potentially allowing stellar streams to trace the early assembly history of the Galaxy.

In this talk, I will first present an N-body simulation of a Milky Way-type galaxy experiencing a major merger and show how such an event can perturb stellar streams and generate long-lived signatures in terms of morphology, asymmetry, and energy-angular momentum. This experiment demonstrates that these merger-induced features in stellar streams can survive for several gigayears, well beyond the merger epoch itself. I will then generalize these conclusions to other merger configurations and discuss how comparisons with observed Milky Way streams can be used to constrain or exclude past merger scenarios.

14:35 – 14:55 — Unlocking the low surface brightness Universe with Euclid: performance, validation, and early science

J.-C. Cuillandre (CEA Paris-Saclay) [résumé PDF](#)

The study of low surface brightness (LSB) structures has long been limited by instrumental systematics, background stability, and the difficulty of preserving diffuse emission through data processing. This presentation provides a quantitative assessment of the LSB performance of Euclid based on end-to-end analyses, showing that its optical design, stable space-based conditions, and controlled systematics deliver unprecedented sensitivity to extended faint emission in the optical and near-infrared. Through methodologies developed for the first Euclid science results (2024), using Early Release Observations, Euclid achieves surface brightness limits and spatial uniformity beyond previous wide surveys, while preserving the fidelity of diffuse structures across large angular scales. We detail how this performance is measured, validated, and translated into robust detection limits for Galactic cirrus, stellar haloes, tidal features, intracluster light, and ultra-diffuse galaxies. With its Wide survey (2024–2029), Euclid enables, for the first time, homogeneous and statistically robust measurements of faint structures across cosmological volumes.

By J.-C. Cuillandre (CEA Paris-Saclay / AIM)

SF2A 2026, S17, “Galaxy evolution in the faint Universe: insights from the era of large surveys”

14:55 – 15:15 — Exploring the LSB Universe in the Euclid Era : Advances and Challenges

Duc, P.-A. [résumé PDF](#)

I will address how the unique capabilities of the Euclid mission - mainly a large field of view combined with a great image quality - are exploited to study the low surface brightness structures and objects around galaxies in the nearby Universe. The Euclid surveys appear to be a game changer for many topics, including the census of faint dwarf galaxies and tidal debris, together with their globular cluster populations. However, this also presents challenges in terms of exploiting the large set of data provided by the mission. For example, there is a need to adapt existing tools and pipelines, or even develop new ones, many of which use ad hoc training and artificial intelligence. Other surveys, such as LSST, will soon benefit from these efforts.

15:15 – 15:35 — Exploring new realms : small and giant ultra-diffuse galaxies

Boissier S., Bournaud E., Junais [résumé PDF](#)

Since about 10 years, astronomers re-discovered the low surface brightness (LSB) realm of galaxies. Van Dokkum et al. (2015) coined the term Ultra Diffuse Galaxies (UDGs) describing very LSB galaxies, larger than usual dwarfs and found in large number in clusters (Koda et al. 2015). Low surface brightness galaxies are also found with sizes much larger than usual galaxies, with « monster » galaxies such as Malin 1 (Galaz et al. 2015, Boissier et al. 2016 and references within), the Giant LSB galaxies (GLSBs).

Recent HI discoveries show that giant gas-rich galaxies exist without being seen (O’Neil et al 2024; Shu et al., 2026). The SKAO area will bring us many more GLSBs, but should also allow us to detect gaz in many UDGs, helping us to understand their nature and evolution, by confronting them to models of their evolution (e.g. predictions of the models of Junais et al. 2022 for Virgo diffuse and ultra-diffuse galaxies).

I will present some recent results concerning these two families of LSB galaxies, including the possible discovery of a star forming UDG in the Virgo Cluster, how candidate UDGs can turn out to be GLSBs once their redshift is determined, and models fitting the photo-metric properties of UDGs in Virgo, that do predict gas masses that will be tested with SKA observations.

Large ongoing sky surveys (e.g. Euclid, LSST) and future projects will clearly open a new observational window on galaxy evolution.

15:35 – 15:55 — Dwarf Galaxies: Insights from the Most Compact to the Most Diffuse Systems

Grishin K. [résumé PDF](#)

Galaxy clusters are the largest gravitationally bound structures in the Universe. Although numerical simulations provide detailed predictions of their assembly and evolution over cosmic time, observational confirmation of these models remains limited. The galaxy populations of nearby clusters are dominated by dwarf stellar systems, whose origin, however, is still not fully understood.

Over the past five years, we have assembled an extensive spectroscopic dataset using MMT/Binospec, including more than 250 dwarf early-type galaxies and dozens of dwarf post-starburst systems across three massive nearby clusters: Coma ($D = 99$ Mpc), Abell 2147 ($D = 165$ Mpc), and Abell 168 ($D = 193$ Mpc). These observations are complemented by re-reduced archival spectroscopic data for the Virgo Cluster ($D = 16.5$ Mpc), obtained from the Keck, Gemini, and VLT public archives. In addition, we have incorporated reprocessed deep optical imaging from Subaru/HSC and CFHT/MegaCam, optimized for low-surface-brightness detection through improved sky background subtraction, which allowed us to trace outer parts of dwarf galaxies, which can have features of such processes as recent tidal interactions and ram-pressure stripping.

Together, these spectroscopic and photometric datasets, further enriched by ongoing large-scale surveys such as DESI, enable us to place strong statistical constraints on the evolutionary pathways of different dwarf galaxy subclasses. These include compact ellipticals (cEs), for which new DESI-based samples emphasize the key role of preprocessing within infalling groups; classical dwarf ellipticals (dEs), where our long-slit spectroscopy reveals a significant fraction of kinematically decoupled cores and counter-rotating components, indicative of past mergers; and, finally, ultra-diffuse galaxies (UDGs), whose younger progenitors, post-starburst dwarfs, highlight ram-pressure stripping as a dominant evolutionary mechanism.

15:55 – 16:10 — *Break*

16:10 – 16:25 — **A Euclid perspective on Globular Clusters**

Euclid Collaboration et al. [résumé PDF](#)

Extragalactic globular clusters (EGCs) are powerful tracers of the assembly history of galaxies. GCs have been shown to reveal low-surface brightness features, such as streams and the intra-cluster medium. This has particularly been demonstrated in the Andromeda and Centaurus A galaxies for streams, and in the Fornax and Virgo clusters for intra-cluster light. However, studying EGCs in the local universe (within <100 Mpc) has historically been limited by the difficulty of distinguishing them from other sources, such as stars and galaxies, and by the lack of homogeneity in existing datasets.

In this presentation, I will showcase our work (Euclid Collaboration: Voggel et al., 2024) on forecasting the detectability of globular clusters (GCs) across the entire Euclid survey. Our estimates suggest that the galaxies within Euclid's survey footprint host almost one million GCs, approximately 350,000 of which should be detectable in the VIS band. Furthermore, we demonstrate that EGCs can be spatially resolved in the Early Release Observations (ERO) Fornax dataset compared to pure point sources. Our analysis of both simulated and ERO data highlights Euclid's potential to set a new standard for Local Universe EGC studies. Euclid is set to increase the number of GCs accessible through high-resolution imaging by an order of magnitude.

Euclid is unique in enabling systematic studies of EGCs in the outskirts of large galaxies where low-surface brightness feature as well as the intra-cluster medium are located. With a complete GC catalogue a systematic understanding of how low-surface brightness features correlate with the position of GCs are within reach. Many of the EGCs detected will also be spatially resolved and have infrared colours in a single photometric system, enabling new large-scale studies of their structural properties and spectral energy distributions, which will help in using them for tracing galaxy assembly. Finally, I will provide an overview of what can be expected for GCs within the Euclid data in future releases.

16:25 – 16:40 — **Breaking degeneracies in the formation of LSB dwarf galaxies with globular cluster systems**

T. Saifollahi, Euclid SWG Local Universe, Euclid Consortium [résumé PDF](#)

Low-surface-brightness (LSB) dwarf galaxies are highly sensitive to the baryonic processes involved in galaxy formation and evolution, and several formation models have been proposed to explain their origin. Such models include episodic supernova feedback, and gravitational tidal interactions with their surrounding galaxies. However, the structural properties of these galaxies alone are often insufficient to distinguish between competing baryonic scenarios due to degeneracies among formation models.

In this talk, I show that globular cluster (GC) systems of LSB dwarf galaxies offer a powerful way to break these degeneracies. I demonstrate that by presenting our recent studies of dwarf galaxies in nearby galaxy clusters in the Local Universe, where we combined GC abundance and spatial distributions with galaxy structural parameters and stellar mass to study their formation pathways. I also outline a forward-looking strategy that combines state-of-the-art cosmological simulations with star cluster formation and evolution models to quantify the impact of baryonic processes on dwarf galaxies and their GC systems. This approach aims to establish GCs as

robust probes of baryonic physics and to provide a framework for exploiting current and upcoming wide-field surveys (e.g., Euclid, Roman) to systematically test galaxy formation models.

16:40 – 17:00 — Intracluster light in the Euclid and JWST era

Amaël Ellien [résumé PDF](#)

The intracluster light (ICL) of galaxy clusters, a low surface brightness (LSB) glow emanating from free floating stars not bound to any galaxy in particular, is receiving an increasing amount of attention from the scientific community. The origin and quantity of these stars, as well as the physical mechanisms behind their current dynamical state hold critical information about the past history of galaxy clusters, and provide new diagnostics about their evolution. The pace of observations is accelerating with a new generation of instrumentation (e.g. JWST, Euclid, Vera Rubin, Roman Observatories) that will provide broad-band optical and/or near-infrared colors for almost all galaxy clusters in the observable Universe over at least the last 10 billion years of history. Notably, the ESA Euclid space telescope will survey 15000 deg of the extragalactic sky, a mission primarily designed to improve the figure of merit of cosmological probes but which shows an astounding potential for LSB studies as demonstrated by the Early Release Observations of the Perseus, Fornax, A2390 and A2764 clusters. In parallel, the JWST provides an order of magnitude improvement in sensitivity in the IR and represents a vivid jump in our efforts toward probing galaxy clusters and the distant Universe, as shown by the first JWST release of SMACS J0723.37323 at $z=0.39$. The combination of these pristine and complementary datasets will allow us to reach deeper layers of galaxy cluster sciences, in terms of redshift, of photometric depths and of statistics. Though, these advancements are also unveiling unprecedented contamination by faint foreground Galactic Cirrus, imposing new methodological challenges to reach the extragalactic signal of interest.

17:00 – 17:15 — Paving the way to the Fornax ICL analysis with Euclid data

Mathias Urbano & the Nottingham IntraCluster Light group [résumé PDF](#)

The first data release of the Euclid space telescope mission will cover a large portion of the sky. It will include new observations of the Fornax Wall structures (especially the Fornax Cluster and the Dorado Group) in a unique combination of coverage, depth, and resolution, enabling the study not only of their diffuse components but also of their globular cluster (GC) counterparts. However, these wide fields (spanning multiple Euclid observations) require adaptations of image processing methods (especially, but not exclusively, on star subtraction) in order to extract precise photometric measurements of the diffuse components. The work presented will review the data preparation efforts and the first results of this study.

17:15 – 17:30 — Untangling XUV galaxies from GLSB galaxies

Bernaud E., Boissier S., Junais [résumé PDF](#)

XUV galaxies are a class of galaxies presenting low surface brightness (LSB) extended components identified through their extended UV emission, tracing star formation in the outermost regions. Recent studies have confirmed a strong interest in this type of galaxies, including the detection of a XUV galaxy at intermediate redshift (0.67, Pandey et al 2026) highlighting their relevance beyond the local Universe.

A possible link between XUV galaxies and Giant LSB (GLSB) galaxies was discussed for Malin-1 and UGC1382 (Boissier et al. 2008, Hagen et al 2016). Since GLSB galaxies are generally defined as such in the optical, deep optical data of XUV galaxies are needed to investigate further this link.

In this presentation, I will present recent results (Bernaud et al. 2025, Bernaud et al. 2026 in preparation) revealing a diversity among XUV when observed in the optical, from XUV galaxies presenting similar properties to GLSB (Malin-1 like), to Malin-1 opposites, with a focus on the role of the environment on their formation and evolution.

In this context, upcoming large and deep surveys such as LSST will provide opportunities to study a large number of XUV galaxies and their optical counterpart across a range of environments.

17:30 – 17:45 — HAGRPS: an H-alpha narrow-band imaging survey of galaxy groups in the Local Supercluster

Mangola, E.S. [résumé PDF](#)

Abstract: I will introduce HAGRPS, an H-alpha narrow-band imaging survey of galaxy groups in the Local Supercluster, which is a large observing program carried out with the VLT Survey Telescope (VST). H-alpha imaging data are gathered to study the role of the environment on galaxy evolution. Indeed, H-alpha observations

reveal the ionized hydrogen emission, which is a direct tracer of recent star formation, and are a powerful probe in the identification of perturbing mechanisms such as ram pressure stripping, tidal interactions, and starvation in dense regions. Since these perturbing mechanisms acting on galaxies are expected to vary with the halo mass, observations must cover a wide range of environments, from massive clusters down to groups of $M_{\text{halo}} \sim 10^{13} M_{\odot}$. This survey has been designed to extend previous narrow-band imaging studies of massive clusters down to intermediate mass groups. I will present the scientific objectives of the survey and describe the development of an ad-hoc data reduction pipeline especially tailored for the reduction and calibration of the narrow band H-alpha imaging data and optimized for the detection of faint low surface brightness extended features such as those produced by the interaction of galaxies with the hostile surrounding environment. I will also show the first results of the survey through the analysis of representative galaxies.

17:45 – 18:00 — Probing protocluster assembly through cold molecular gas at $z = 4.3$ with ALMA

Torti, A. [résumé PDF](#)

How the environment impacts galaxy evolution remains a fundamental question at early cosmic times, when the first massive structures were rapidly assembling. In the Λ CDM paradigm, cluster formation occurs through hierarchical assembly along cosmic filaments. These processes are expected to leave imprints that trace the history of galaxy formation. However, directly observing the fuel for this assembly, the cold molecular gas, remains a challenge.

Here, I present deep ALMA Band 1 observations of the CO(2–1) emission line in the massive protocluster SPT2349-56 at $z = 4.3$. This system is the most extreme star-forming overdensity known, only ~ 1.4 Gyr after the Big Bang. It hosts nearly 30 spectroscopically confirmed gas-rich galaxies within a compact region. While previous studies focused on high-excitation tracers, these new Band 1 data provide a more precise view of the cold molecular gas reservoir and how dense environments impact its availability.

We detect CO(2–1) emission in 14 out of the 29 confirmed members, at $S/N > 3$, and provide stringent limits on the remaining sources. In parallel, we conduct a blind line search to identify additional low-excitation gas-rich emitters that may have been missed by high-excitation surveys. Using a conversion factor of $\alpha = 0.8$, we derive molecular gas masses ranging from 1.22×10^8 to $9.33 \times 10^8 M_{\odot}$. These measurements are consistent with previous estimates, showing a mean agreement within 0.07 dex while providing more robust constraints on each member. Through comparison with existing FIR continuum, [CII], [CI], and high-J CO line data, the CO(2–1) analysis allows us to determine gas fractions, depletion timescales, and excitation conditions for individual galaxies.

This work provides key constraints on the regulation of gas supply mechanisms and star formation in star-forming galaxies residing in extreme environments at early cosmic times. This dataset serves as a benchmark for future studies of molecular gas in overdense regions.

AMPHI 4 — S20 : ORIGINS AND IMPACT OF WINDS IN ASTROPHYSICAL SYSTEMS · COMMUNAUTÉ

<https://journes.sf2a.eu/ateliers/s20/>

14:00 – 14:05 (5') — Introduction from SOC

14:05 – 14:28 (20' + 3') — Formation of large-scale galactic winds

Dubois, Y. — thème : Feedback in galaxies [résumé PDF](#)

The formation of galactic winds, driven by feedback processes associated with supernova explosions and active galactic nuclei, remains a central problem in astrophysics that has been actively debated for several decades. Despite significant progress, the physical mechanisms responsible for launching and sustaining these outflows are still not fully understood or well constrained.

These winds play a key role in galaxy evolution by regulating their gas content and star formation activity. They can operate through different channels: either by efficiently expelling gas out of the gravitational potential, or by suppressing gas accretion, thereby limiting the supply of fresh material.

In this presentation, I will provide a theoretical perspective on this problem, with a focus on recent advances from numerical simulations. I will discuss the main driving mechanisms, as well as the different approaches currently being explored by the community to model and constrain this phenomenon.

14:28 – 14:41 (10' + 3') — First Look at Spatially Resolved H₂ and AGN Feedback in BCGs with JWST/MRSC.Riesco, P.Salomé, P.Guillard [résumé PDF](#)

Brightest Cluster Galaxies (BCGs) inhabit the deepest gravitational potential wells in the Universe and host extreme interstellar and circumgalactic environments, making them unique laboratories for studying the interaction between the interstellar medium (ISM) and active galactic nucleus (AGN) feedback. Approximately 15-20% of these systems are classified as cool-core clusters. These are characterized by short cooling times that would suggest enormous star formation rates (SFR); however, such high SFRs are not observed. This implies that an external source, likely the AGN, is responsible for preventing this runaway cooling. In addition to this, cool-core BCGs present extended, multiphase filamentary structures whose molecular component remains poorly understood. These filaments appear largely unique to these systems and are morphologically correlated with radio jets and outflows. Consequently, cool-core BCGs offer a new window into the ways AGN interact with and regulate their host galaxies via winds and radio jets. Mid-infrared observations with Spitzer revealed exceptionally strong rotational H₂ emission in several nearby BCGs—far exceeding that observed in normal star-forming galaxies, but lacked the spatial resolution needed to investigate its origin. JWST now enables these molecular filaments to be directly resolved. In this talk, I present the first JWST/MIRI Medium Resolution Spectroscopy (MRS) IFU observations of warm molecular hydrogen and Polycyclic Aromatic Hydrocarbons (PAHs) in a sample of cool-core BCGs characterized by radio jets and outflows. These data provide unprecedented spatially resolved maps of H₂ emission, allowing the distribution, excitation, and kinematics of the warm molecular gas to be explored for the first time. Combined with PAH analysis, these observations allow us to distinguish between the different ionization mechanisms responsible for the emission in various regions of the BCGs. This work opens a new window onto AGN feedback in extreme environments and reveals filamentary molecular structures that were previously inaccessible to observation. It provides new insights into the mechanics of AGN feedback in extreme environments.

14:41 – 14:46 (5') — High-z Gamma Ray Burst (GRB) host galaxies and metal poor local analogs as laboratories to probe gas kinematics and chemical enrichment.Abril-Melgarejo, V., Vergani, S. [résumé PDF](#)

Dwarf metal poor galaxies undergoing starburst episodes share physical properties with galaxies at higher redshifts. These systems are considered analogs of galaxies at the cosmic noon and in the era of reionization (EoR) in terms of size, stellar mass, SFR, metallicity, morphology and dynamics. They are the nearest laboratories to explore in detail chemical enrichment processes and the turbulent kinematics of the gas powered by the intensive star formation.

On the other hand, high-z galaxies are very difficult to study in detail since low mass star forming galaxies are very faint. Gamma ray bursts (GRB) are energetic events originated by the death of massive stars or the collision of black holes or neutron stars. The radiation released and shocks due to fast moving gas, ionize the interstellar medium (ISM) around producing a temporary (from hours to few days) bright source of light known as the afterglow. GRBs offer a unique opportunity to study the ISM of high star-forming galaxies in the far universe, but being transient events need a fast response to trigger the observations.

In this talk, I present a study on the chemical content and the kinematics of the ISM (stellar winds/outflows in SF regions), in both local high-z analogs and GRB host galaxies at $2 < z < 6$, derived from the analysis of spectroscopic observations of the UV and optical rest-frames. Regarding the local high-z analogs, I will describe the determination of neutral and ionized gas chemical abundances of a sample of 45 galaxies from the CLASSY (COS Legacy Archive Spectroscopic Survey), and co-spatial apertures of KCWI, MUSE and SDSS optical spectra. The GRB sample is composed of 44 GRBs, detected by satellites of fast response (Swift, Einstein probe, Fermi and SVOM) and with follow-up observations of the afterglow and later observations of the most luminous host galaxies by VLT X-shooter, VLT-UVES and JWST. I compare HI column densities, gas abundances for different ions sampling different elements (N, O, S, P, Ni, C, Fe, Zn and Si) and the kinematics structure by measuring gas outflows along the line of sight in both the neutral and ionized gas phases.

This is a pioneering study to characterize high-z GRB host galaxies, which also provides a careful comparison of its metal content and ISM structure with local high-z analogs. Whether local analogs are good representative of high-z systems remains a topic of debate; however, GRBs provide a unique opportunity to bridge the gap between the local and distant universe.

14:46 – 14:51 (5') — Warm molecular gas and mechanically coupled feedback in low-power radio ellipticalsShaunak Mishra, Pierre Guillard, Philippe Salomé, Mathieu Langer [résumé PDF](#)

SF2A 2026 – S20: Origins and impact of winds in astrophysical systems

Warm molecular gas and mechanically coupled feedback in low-power radio ellipticals

Shaunak Mishra, Pierre Guillard, Philippe Salomé, Mathieu Langer

Institut d'Astrophysique de Paris, Sorbonne Université, CNRS, 98 bis boulevard Arago, 75014 Paris, France

Observatoire de Paris, PSL University, 61 avenue de l'Observatoire, 75014 Paris, France

shaunak.mishra@obspm.fr

Context. Low-power radio AGNs in early-type galaxies provide an important laboratory for testing how mechanical feedback couples to the interstellar medium outside the regime of classical powerful radio galaxies. The dusty ellipticals identified by Kaneda et al. (2008), which show bright rotational H₂ emission and little evidence for recent star formation, are particularly well suited to this question.

Aims. We investigated whether the warm molecular gas observed in two representative Kaneda galaxies, NGC 708 and NGC 4589, can be powered by turbulence alone or instead requires additional AGN-related heating channels, and whether their low star-formation activity remains robust once AGN contamination is accounted for.

Methods. We combined NOEMA CO(2–1) cubes with IRAM 30m/APEX spectra to derive cold-gas masses and CO kinematics. Using the Spitzer H₂ rotational-line measurements from Kaneda et al. (2008), we estimated warm-H₂ luminosities and cooling rates. We compared the warm-H₂ cooling budget with turbulent dissipation inferred from the CO line widths, estimated the available AGN mechanical power from LOFAR DR3 144 MHz data, assessed the plausibility of cosmic-ray heating, and used X-CIGALE to refine the star-formation rates and AGN contribution.

Results. We found that the warm-H₂ cooling times are short, implying the need for continuous heating. The turbulence inferred from the observed CO kinematics does not robustly account for the full warm-H₂ budget, while cosmic-ray heating requires extreme ionization rates. By contrast, the AGN mechanical power inferred from the radio data could supply the observed warm-H₂ luminosity at only a few per cent coupling, favouring a picture of mechanically coupled feedback through shocks and unresolved dissipation. Preliminary X-CIGALE constraints on the SFR and AGN contribution will also be presented.

Conclusions. These systems suggest that even low-power AGNs can couple efficiently to the ISM and maintain luminous warm molecular gas without requiring strong ongoing star formation. They therefore provide a useful bridge between local low-power feedback and the broader question of how AGN-driven winds regulate galaxy evolution.

14:51 – 15:14 (20' + 3') — AGN winds and outflows: From the accretion disc to kpc scalesPorquet, D. — thème : Winds in AGNs [résumé PDF](#)

I will provide an overview of the current observational and theoretical understanding of winds and outflows from active galactic nuclei (AGN), detectable across the electromagnetic spectrum from X-ray to sub-millimetre wavelengths. They are multi-phase and multi-scale, ranging from ultra-fast, highly ionised outflows from the AGN disc to molecular outflows at kpc scales. Playing a crucial role in feedback processes, they shape galaxy evolution and regulate black hole growth.

15:14 – 15:27 (10' + 3') — AGN winds shaping massive galaxies from cosmic dawn to high noonFarcy M., Hirschmann M., Somerville R. S., Choi E., Koudmani S., Naab T. [résumé PDF](#)

When actively accreting matter, supermassive black holes (SMBHs) in active galactic nuclei (AGN) can launch powerful winds, driving high-velocity outflows that can extend to galactic scales. These broad-line and nuclear winds are powered by radiatively efficient accretion processes, which occur on small scales typically unresolved in large-scale cosmological simulations. To account for this limitation, AGN feedback has traditionally been modelled using subgrid prescriptions, and, in the radiatively efficient regime of SMBHs, most often as continuous thermal energy injection. However, it remains uncertain whether such models can reliably reproduce large-scale gaseous outflows as observed out to redshift $z = 7.5$. As an alternative approach, we developed Mistral, a physically motivated subgrid prescription for modelling AGN-driven winds in the Arepo cosmological code,

informed by observations of broad absorption line winds. Mistral is designed to capture the impact of AGN winds on SMBH and galaxy evolution, by modelling the transfer of mass, momentum and energy into the surrounding interstellar and circumgalactic medium.

I will first review the Mistral framework and demonstrate how different AGN feedback implementations affect black hole growth, wind properties, and the evolution of the host galaxy. This comparison will illustrate that Mistral provides a physically motivated approach to modelling AGN winds, and a predictive tool for interpreting the high-redshift galaxy and quasar population now accessible with JWST. Extending this analysis, I will then present results from the Black Dawn suite of cosmological zoom-in simulations, focusing on the 50 most massive galaxies at $z = 3$ selected from the 100 cMpc IllustrisTNG volume. Each system is resimulated using Mistral, the standard TNG AGN feedback model, and without black holes, enabling a controlled study of AGN wind effects on galaxy assembly, star formation, and gas distribution. The simulations reveal that AGN winds drive large-scale outflows whose impact is modulated by the surrounding gas environment. Depending on the interplay between outflow strength and gas supply, these winds can rapidly deplete fuel for star formation. By regulating star formation and shaping the circumgalactic medium, AGN winds produce massive galaxies broadly consistent with JWST-observed quiescent and post-starburst systems, emphasizing their role as key regulators of the baryon cycle from cosmic dawn to high noon.

15:27 – 15:40 (10' + 3') — Particle acceleration at Ultra-fast Outflows of Active Galactic Nuclei

Le Nagat Neher, Cristofari, Peretti, Zech [résumé PDF](#)

SF2A Abstract, S20: Origins and impact of winds in astrophysical systems

Ultra Fast Outflows (UFOs) are sub-relativistic dense winds launched from Active Galactic Nuclei with wide aperture angle, at which strong shocks are expected to form, typically with Mach number such that $M \gg 1$. At these shocks, particle energisation through diffusive shock acceleration (DSA) should lead to the copious production of gamma rays and neutrinos through the interaction of accelerated charged particles and the surrounding circumnuclear medium. We model this particle acceleration through DSA at UFO shocks and estimate the associated highenergy gamma-ray and neutrino fluxes, and investigate the prospects for detection with current and next generation gamma-ray and neutrino observatories. For a selected list of nearby UFOs, we identified the best candidates for detection with next generation gamma-ray observatories such as CTAO, and discuss the potential for detection with neutrino observatories such as KM3NeT.

15:40 – 15:45 (5') — Large-scale collimation properties of outflows launched from Keplerian accretion discs

Jannaud, T., Ferreira, J. and Zanni, C. [résumé PDF](#)

1DAMTP, University of Cambridge, CMS, Wilberforce Road, Cambridge CB3 0WA, UK

2Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France

3INAF - Osservatorio Astrofisico di Torino, Strada Osservatorio 20, Pino Torinese 10025, Italy

ABSTRACT

It is generally accepted that the launching of fast collimated outflows requires a large-scale magnetic field threading a central object (black hole or star) and/or its surrounding accretion disc. However, the collimation mechanism far from the central object has not yet been fully understood. In Jannaud, Zanni, and Ferreira (2023), we investigated a mechanism in which the inner jet is self-collimated due to a dominant hoop stress. We performed numerical simulations in which a jet-emitting disc (JED) spans the entire lower computational boundary. These were the first simulations of their kind to demonstrate the steady recollimation shocks predicted by steady-state analytical studies.

However, the large radial extent of the JED prevented a complete study of the connection between the accelerating and asymptotic electric circuits, as well as the influence of the outer medium. In Jannaud, Ferreira, and Zanni (2026), we perform a set of axisymmetric, ideal, non-relativistic magnetohydrodynamic (MHD) outflow simulations. In these simulations, only the innermost disc region launches an outflow. And, only the innermost part of the outflow appears as a self-collimated jet.

Outflows of finite radial extent also produce steady recollimation shocks at large distances from the central object. Standing recollimation shocks are therefore not an artifact of selfsimilarity, but a generic feature of outflows emitted from magnetized Keplerian accretion discs. They may produce observable signatures in both AGN and protostellar outflows, such as stationary emission knots, a decrease in the rotation rate, or changes in

polarization. For protostellar outflows, we recover the need for an outer MHD wind to provide the pressure required to confine the inner jet.

15:45 – 16:05 (20') — *Break*

16:05 – 16:28 (20' + 3') — Winds in X-ray Binaries

Parra, M., Diez, C. — thème : Winds in binaries [résumé PDF](#)

In X-ray Binaries, which provide some of the most accessible signatures of extreme accretion in our Universe, winds remain as one of the most glaring gaps in our understanding of accretion-ejection structures. Depending on their theoretical prescription, they may completely transform the accretion flow, modify the cycles and duration of outbursts, influence the long-term evolution of binary systems, and release energy and mass into the interstellar medium. We will thus introduce both disk winds and stellar winds in X-ray Binaries, from their observational landscape to relevant wind launching mechanisms, and finally recent developments following the advent of high-resolution X-ray spectroscopy.

16:28 – 16:41 (10' + 3') — Magnetic winds in resistive compact binary discs

Marc Van den Bossche, Geoffroy Lesur & Guillaume Dubus [résumé PDF](#)

Dwarf Novæ and low-mass X-ray binaries are eruptive binary systems comprised of a Roche-lobe overflowing solar-type star and an accreting compact object. Their recurrence time can be explained by a low-accreting phase, the quiescence, during which the angular momentum transport parameter is inferred to be $\alpha \approx 0.01$ by the Disc Instability Model. Non-magnetics mechanisms, such as spiral wave transport, only achieve angular momentum transport an order of magnitude too low, at best, because these discs are so thin in quiescence. During this phase, the Magneto-rotational Instability is known to be suppressed by the increased resistivity of the little ionised plasma. Studying these thin magnetised discs is a numerical challenge because of the wide separation in scales requiring to be resolved. Thanks to the GPU-accelerated code *Idefix*, I produce global 3D MHD simulations of very thin disc ($H/R = 0.01$) for the first time. I explore the possibility that an MHD wind arises and increases accretion in low magnetic Reynolds number ($R_m \approx 100$) and realistic plasma parameter ($\beta \approx 1000$) regimes. We observe that the MRI is only quenched in the resistive disc bulk but survives in the disc atmosphere. This drives strong accretion and wind launching. I quantify the efficiency of the arising wind and measure its global effect on the disc. I explore the effect of the initial disc magnetisation and compare the the accretion/ejection regime with and without resistivity.

16:41 – 16:54 (10' + 3') — The stellar wind and accretion disk emission anti-correlation in Cygnus X-1: insights from multi-wavelengths observations

M. Brigitte, P. Hadrava, B. Kubátová, M. Cabezas, J. Svoboda, M. Šlechta, M. Skarka, K. Alabarta, O. Maryeva, D. M. Russell, and M. C. Baglio [résumé PDF](#)

First discovered in 1964, the High-mass X-ray binary Cygnus X-1 contains a 21.2 solar-mass black hole and a 40.6 solar-mass (B0 or O9.7 lab-type) star - also known as HDE 226868. For over 60 years, the system has been widely studied in X-rays and optical wavelengths. I will present the results obtained from the optical monitoring of the binary using the 2m-Perek telescope located in Ondrejov in the Czech Republic, simultaneously with X-ray observations. The optical data were analysed using the method of Fourier Disentangling which separates the different spectral components of a multiple system (in our case the stellar atmosphere from the circumstellar matter). The variable profiles of hydrogen and helium lines are used to study the structure and kinematics of the stellar atmosphere and the circumstellar matter in the system. This method enables a new perspective on the strong correlation between the X-ray emission from the accretion disk and the optical/UV emission from the stellar wind.

16:54 – 16:59 (5') — Winds from Post-AGB binaries

Ferreira, J., Van Winckel, H., Kluska, J., de Prins, T., Verhamme, O. [résumé PDF](#)

Post-AGB stars are descendants of low-to-intermediate mass main sequence stars. Binaries among these post-AGB objects display a nearinfrared excess, indicating the presence of a circumbinary disc of gas and dust in Keplerian rotation. As the Galactic post-AGB systems are located at typical distances of one to several kiloparsecs, the angular sizes of the circumbinary discs are small, and high spatial resolution techniques are needed to resolve them.

The luminous evolved post-AGB primary has a dim unevolved stellar mass companion. Winds with speeds up to 150 km/s or more, emitted from the companion's circumstellar accretion disc, have been detected for about 35 objects in H α absorption lines. As the companion moves in front of the primary, the geometrical cone of the wind gradually enters the line of sight, absorbing the post-AGB light. This allows to make a full tomography of the wind during the orbital period (of 100 to 2500 days), which is a unique opportunity in astrophysics.

Synthetic spectral-time series of the H α line have been computed using magnetohydrodynamical (MHD) accretion-ejection models. It turns out that many of the observational properties are well reproduced by a cold MHD model. However, systematic mismatches remain such as an overestimated rotation and underestimated post-AGB circumbinary disc lifetime. How to alleviate these issues will be briefly addressed.

16:59 – 17:22 (20' + 3') — Origins and impact of winds in young stars

S. Cabrit — thème : Winds in YSOs [résumé PDF](#)

In this talk, I will review our current knowledge of winds from young stars, and their feedback on star, disk, and planet formation. Observed «wind» signatures include both fast and highly-collimated ionized «jets» and slower rotating molecular outflows surrounding the jets. I will highlight recent results from JWST, ALMA, and numerical simulations that shed new light on their origins and impact.

17:22 – 17:35 (10' + 3') — MHD winds in protoplanetary discs undergoing a stellar flyby: the case of AS 205

Castro Martínez, E. M., Cuello, N., Price, D. J., Kurtovic, N. T., Vioque, M., Lesur, G., Wafflard-Fernandez, G., Alaguero, A., Delorme, P. [résumé PDF](#)

Recent surveys of young stellar regions have shown that magnetically driven winds (MHD winds) are ubiquitous among Class II objects. Population-level studies have revealed correlations between accretion and outflow processes, suggesting a common physical origin of winds across young stellar systems. However, protoplanetary discs are often subject to perturbations, such as planets, close companions, and stellar flybys, which can significantly affect the structure of the disc and potentially impact the properties of MHD winds. An example of this is AS 205 N, a highly perturbed disc undergoing a flyby involving the AS 205 S spectroscopic binary. Some studies have reported signatures of winds and a jet originating from AS 205 N. However, it remains unclear whether the ongoing flyby may contaminate these signals and thus bias their interpretation, or physically alter the accretion-ejection processes, potentially making the system unrepresentative from a population perspective. In this work, we investigate how external perturbations influence the structure and efficiency of MHD winds. We focus on the case of AS 205, by first constraining the orbital parameters of the flyby and initial disc properties inferred from the gas morphology using hydrodynamical simulations with the code Phantom. These results were used to initialise three-dimensional global magnetohydrodynamic simulations with the code Idefix. We analyse the properties of the winds arising from the disc under the influence of the flyby, and contrast them with observations of the system. The results of this investigation improve our understanding of the impact of external perturbers on the structure and observational signatures of MHD winds, and help assess whether flybys may bias their interpretation in observed systems. This preliminary work will constitute the foundation for a more general framework to interpret observational signatures of MHD winds in perturbed environments, as well as the underlying physical processes governing them.

17:35 – 17:48 (10' + 3') — Chemical and kinematic stratification of the HL Tau outflow seen by ALMA and JWST

T. Nony, F. Bacciotti, C. Dougados, G. Navarro, B. Nisini, P. Kavanagh, A. Banzatti, S. Cabrit, L. Podio, J. Ferreira [résumé PDF](#)

Investigating the evolution of protostellar systems is crucial for understanding the formation of stars and planets. HL Tau, a Class I/II star with a mass of 2.1 M $_{\text{sun}}$, stands out as a benchmark system, as it offers a unique opportunity to trace the origin of a prominent bipolar outflow associated with a well-studied ringed disk.

Our studies of HL Tau using ALMA at 1.3 mm and JWST (1.6 – 26 μm) reveal a clear chemical and kinematic stratification in the HL Tau outflow, organized into three main nested components. The innermost component is the atomic jet, detected at radial velocities of about 160 km/s in numerous infrared transitions of [Fe II] and other species. It displays a knobby structure indicative of a possible temporal variability in the ejection of a few years. Surrounding the jet, H $_2$ lines trace a wide-angle outflow, with velocities of 45 km/s and a complex arc-like substructure. The rovibrotional transitions of CO($n=1-0$) at 4.7 μm appear as an external cocoon around the H $_2$, co-spatial with the cooler gas emission in the rotational transitions of CO($J=2-1$). Our ALMA study of the CO($J=2-1$)

Slow in HL Tau shows that it is itself structured into discrete nested, layered shells with velocity decreasing with distance from the axis, from 20 to 2 km/s. Comparison with theoretical models show that this distribution is compatible with the CO(J=2-1) flow being a wide, inhomogeneous magnetized wind launched from an extended region of the disk, possibly up to 90 au from the star.

These findings pave the way for a detailed comparison with MHD models of disk, jets and wind systems, to shed light on the physical mechanisms driving the formation of young stars

17:48 – 17:53 (5') — Impact of variable jet bowshocks on protostellar outflows and disks

Nathan Maindon [résumé PDF](#)

While several mechanisms have been proposed to drive protostellar outflows, including magnetically driven winds and photo-evaporative flows, the role of collimated jets remains an open question. Indeed, protostellar jets often display time variability, producing a series of bowshocks with high kinetic energy as they propagate in the interstellar medium.

In this contribution, we explore how such variable jet activity may sweep up the ambient material and reshape the nearby protostellar structures, such as the envelope and the disk. Through hydrodynamical simulations, we study the interaction of jet-driven shocks in two separate scenarios: one with a hydrostatic disk, and a second with an infalling rotating envelope.

Finally, we assess the ability of variable jets to drive and sustain large-scale molecular outflows, by comparing the outputs with ALMA observations of DG Tau B, a class I protostar exhibiting such activity.

17:53 – 17:58 (5') — Transport des poussières dans les disques protoplanétaires

Zjawiony, M. [résumé PDF](#)

Les disques protoplanétaires se forment autour des étoiles jeunes. Ils sont le lieu de formation des systèmes planétaires. Observationnellement, nous savons que les disques sont peuplés de poussières de différentes tailles, allant de quelques dixièmes de microns à quelques millimètres. Au cours de cette présentation, je discuterai des simulations numériques de disques que j'ai pu réaliser avec le code IDEFIX. Je présenterai des simulations MHD globales dans lesquelles je fais évoluer simultanément des poussières de 10 tailles différentes, du nanomètre jusqu'au millimètre. En particulier, j'insisterai sur la formation de structures gazeuses en anneaux liées aux vents magnétiques. De plus, je présenterai l'export des plus petits grains par les vents ainsi que la sédimentation et la dérive radiale des grains plus gros (au-delà de 1 micron).

AMPHI 5 — S07 : RELATION SOLEIL TERRE À L'HEURE DU MAXIMUM SOLAIRE · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s07/>

14:00 – 14:30 — Can active regions in the solar atmosphere explain the high solar wind variability?

Poirier, N. [résumé PDF](#)

Active regions in the solar atmosphere are known as being the birthplace of highly energetic events like flares and coronal mass ejections (CMEs). Although active regions are mostly made of magnetically confined plasma, they are also suspected to influence the solar wind, a continuous stream of charged particles originating from the solar atmosphere. The solar wind properties are fundamental in space weather predictions at Earth, and yet have a high variability that remains to be explained. The slow and dense solar wind is the most variable of all, a property which is likely associated to its various sources down to the lower solar atmosphere. In particular, part of the slow solar wind is suspected to take sources in the vicinity of active regions, where interchange magnetic reconnection between closed and open magnetic fields provides a channel for matter and energy exchange. This mechanism remains poorly understood, and yet could explain why slow solar winds have a similar composition in heavy ions as active regions. In this contribution I will give an overview of recent observations and novel numerical models that can help better understanding the solar wind sources. For such purpose one needs to follow a global and multi-physics approach that goes from the lower solar atmosphere all the way up to the corona and heliosphere.

14:30 – 15:00 — Improving solar wind models for space weather: time-dependency and fast solar wind for coronal models

Brun S., Perri B., Ausseresse M. [résumé PDF](#)

The Sun reached the peak of its activity in cycle 25, making space weather predictions increasingly challenging as small-scale structures on its surface evolve rapidly. In our work, we aim to better understand the solar corona so that we will better predict the solar wind, and this within an operational timing. To do so, we have two main focuses using our magneto-hydrodynamic code Wind Predict: improve the simulation itself or improve its post-processing. On one hand, we aim to incorporate time-dependency within the boundary conditions at the solar surface. This will allow the solar wind predictions to update in sync with magnetograms every two hours, or even more frequently thanks to an interpolation between them. To achieve this, we are basing our study on the work of Lionello et al., 2023. Our goal is to create a test case where the time evolution is known. Once we have established this time evolution in Wind Predict, we will test the configuration with discontinuous maps. On the other hand, we want to focus on a more operational aspect: we will use the coupling of heliospheric models with Wind Predict, which together form a complete forecasting model. To achieve this, we will automatically correct our Wind Predict solution using empirical formulae to improve especially the description of the fast solar wind. We successfully created a functioning test case. We now have the time evolution of the physical parameters (magnetic field, velocity, pressure, density, etc.) for a Sun with differential rotation. Furthermore, our model is now able to update the solar wind solution along with magnetograms. Eventually, we found the best method of interpolation of the surface magnetic field, we only need its implementation for time-dependency in Wind Predict. For the second approach, we began by correcting the wind speed, as a test to determine the best method. The first correction is made using empirical formulae developed by Wang, Sheeley and Arge and the second one uses Réville et al., 2023 results. After implementing the corrections, we found that we could indeed reproduce both fast and slow wind, and we extended the routine to correct the other physical parameters. After a comparison to a more physical version of Wind Predict which includes heating by Alfvén waves (WP-AW), we are currently doing some tests to find our own WP-adapted empirical correction. To conclude, we have seen that there are ways to improve predictions with low computational costs. Moreover, introducing time-dependency in Wind Predict would be beneficial, as it allows the integration of data from both Earth and Solar Orbiter (far-side observations). In the future, we also plan to test our improved coupling with an heliospheric model by comparing it to existing forecasts.

15:00 – 15:30 — Analysis of the solar energetic particle event GLE76

Manon Jarry, Athanasios Papaioannou, Diana Morosan, Nasrin Talebpour, Alexis Rouillard, Eleni Lavasa, George Vasalos, Bernd Heber [résumé PDF](#)

Abstract : Solar energetic particles (SEPs) are accelerated during eruptive solar events and can reach energies of several hundred MeV or higher. Their acceleration is commonly associated with solar flares and coronal mass ejections (CMEs), however, the dominant mechanisms and the location of the acceleration regions remain open questions. The most energetic SEP events can produce relativistic particles detectable at ground level by neutron monitors, known as Ground Level Enhancements (GLEs). These events form the high-energy end of the SEP spectrum and provide strong constraints on particle acceleration processes.

GLE76 occurred in November 2024. In this work, we present a detailed analysis of this event, combining in situ particle measurements with remote observations of the associated solar activity. The event is associated with a fast CME and a far-side solar flare. We reconstruct the three-dimensional evolution of the CME-driven shock and examine its expansion in relation to particle acceleration regions and magnetic connectivity to multiple spacecraft distributed around the Sun, including STEREO-A, Solar Orbiter, and near-Earth observers. We further investigate the locations, timing, and temporal evolution of the different solar components and of the shock, as well as the associated type II radio burst as a signature of particle acceleration.

15:30 – 16:30 — *Pause*

16:30 – 17:00 — ATISE Wind: Auroral Thermosphere Ionosphere Spectrometer Experiment – Wind measurement

Reboud S. Barthélemy M. [résumé PDF](#)

Solar activity poses a critical threat to terrestrial and orbiting infrastructure, yet a lack of high-resolution dynamic data in the upper atmosphere hinders accurate mitigation. To bridge this gap, the ATISE Wind project introduces a static interferometer designed to measure thermospheric and ionospheric winds with better temporal resolution than previous wind measurement instruments. Unlike traditional Fabry Perot devices constrained by mechanical optical path differences scanning (often exceeding one minute), the ATISE Wind instrument utilizes a Fizeau-based architecture. Eliminating moving parts enables direct interferogram measurements in just a few seconds. Successfully demonstrated during a 2026 ground-based campaign in Skibotn, the system proved its potential for near-future high efficiency even under low sky brightness conditions ($\rightarrow 15$ kR). Exposure time down to 1s could be

used to determine such wind speeds for the red (630 nm) and green lines (557 nm). Future developments will focus on real-time velocity retrieval to ensure robust monitoring of winds from both ground and space, as well as developing a design with the lowest possible sensitivity to environmental conditions.

17:00 – 17:30 — Coupling modeling and optical observations to reconstruct the precipitating particle fluxes and the ionosphere dynamics: new observations and uses of RGB images

Barthelemy, M. ; Cessateur, G. ; Lamy, H.; Reboud, S. ; Robert, E. et al. [résumé PDF](#)

Optical observations of the aurora from space and from the ground give key information for auroral physics studies. They however often need to be coupled with simulations to give their quintessence. In our works, we use imagery, spectroscopy and polarimetry instruments to observe the auroras and combine these observations with a 1D kinetic code of the ionosphere thermosphere named Transsolo to get both the precipitation particles characteristics and the dynamics. Recent developments allow to get the full synthetic spectra of the aurora both in the FUV (120-200 nm) and in the visible (380-900 nm). By running the code at different locations on a grid it is then possible to map the precipitation using different parameters of the particle distributions, especially the total flux, the mean energy of the distribution(s) and their widths. By integrating over RGB filters bandpass, it is also possible to use RGB images to reconstruct these precipitating characteristics. This last activity being done in the frame of the ISSI ARCTICS group. In this presentation, we will review these optical developments and their potential applications for auroral physics.

17:30 – 18:00 — Solar data and space weather products at MEDOC

Éric Buchlin, Barbara Perri, Stéphane Caminade, Susanna Parenti, Frédéric Auchère, Salim Hachemaoui, Khalil Ashkar, Martine Chane-Yook, Dominica Leung [résumé PDF](#)

MEDOC (Multi-Experiment Data and Operation Centre), initially created as a European data and operation centre for the SoHO mission, has grown with data from other solar physics space missions, from STEREO to SDO, and now Solar Orbiter. In addition to observational data, MEDOC also provides datasets derived from observations (maps, catalogues...), tools for data analysis and interpretation, and numerical simulation results. Some of the derived data products can be useful for space weather applications and are made available in the ESA space weather portal.

AMPHI 9 — S21 : GEMINI - COLLABORATIONS PROAM · COMMUNAUTÉ

<https://journées.sf2a.eu/ateliers/s21/>

14:00 – 14:20 — Remise du prix Gemini et présentation

14:20 – 14:40 — The Geminid Campaign – A Practice Run for the LUMIO Mission

Anthony Charles Cook, Detlef Koschny, Elisa Maria Alessi, Maria Teresa Artese [résumé PDF](#)

The ESA CubeSat LUMIO mission, due to launch in 2028, will be monitoring the far side of the Moon from the L2 Lagrange point, for lunar impact flashes (LIFs). As part of ciWzen science outreach, the LUMIO team will be asking amateur astronomers to video earthshine on the near side so that impact rates on the near and far side can be compared, and for a few LIFS on the edge of the Moon, to study these from different viewing angles. As a test run, amateur astronomers were asked to participate in the lunar Geminid campaign which ran from Dec 12-14 2025. 27 observers took part, just under sixty hours of observations of earthshine were made, of which approximately ten hours of this observing overlapped. Approximately twenty candidate LIFs were detected for which we have high certainty and one event was witnessed by six observers simultaneously. A second campaign was conducted during the Artemis-II mission to see if Earth-based observers could confirm candidate LIFs that the astronauts saw visually. A third campaign for the Lyrids will take place from Apr 21-23rd 2026.

Acknowledgement: E.M.A. and M.T.A. were supported by the Italian Space Agency through the agreement n. 2024-6-HH.0, CUP n. F43C23000340001, entitled "Supporto scientifico alla missione LUMIO".

14:40 – 15:00 — Le programme Binaires Astrométriques Spectroscopiques Eclipsantes (BASE)

Halbwachs, J.-L., Midavaine, T., Kiefer, F., Coliac, J.-F., Corp, L., Creevey, O., Debackère, A., Destrieux, F., Famaey, B., Guillout, P., Hamsch, F.-J., Lebreton, Y., Mazeh, T., Merle, T., Mollier, T., Salomon, J.-B., Wullaert, P. [résumé PDF](#)

Jean-Louis Halbwachs, Thierry Midavaine, et Flavien Kiefer, Jean-Francois Coliac, Laurent Corp, Orlagh Creevey, André Debackère, Florian Destriez, Benoît Famaey, Patrick Guillout, Franz-Josef Hamsch, Yveline Lebreton, Tsevi Maze, Thibault Merle, Thomas Mollier, Jean-Baptiste Salomon, Patrick Wullaert

BASE est un programme proposant aux amateurs de découvrir des éclipses entre composantes de binaires astrométriques de la DR3 de Gaia qui sont également suivies comme binaires spectroscopiques à deux spectres par un groupe d'astronomes professionnels. Depuis le début de l'année 2026, des observations ont été programmées afin de détecter 2 nouvelles binaires à éclipses (BE), et de poursuivre les observations des éclipses d'une BE détectée l'an dernier.

15:00 – 15:20 — L'observation des phénomènes mutuels des satellites de Jupiter en 2026-2027

Arlot, J.E., Midavaine, T [résumé PDF](#)

Résumé : L'astrométrie des objets du système solaire nécessite des observations régulières car leurs mouvements sont rapides et les modèles dynamiques ont besoin d'un échantillonnage de données sur de longs intervalles de temps. La période de 2026-2027 est favorable aux occultations et éclipses mutuels des satellites de Jupiter et nous lançons une campagne d'observation commune Am/Pro. L'environnement scientifique et technique a évolué et nous nous intéresserons particulièrement aux phénomènes impliquant les petits satellites intérieurs de Jupiter qui n'ont pas été suffisamment observés par les sondes spatiales et qui nécessitent une surveillance depuis le sol. Un atelier technique pour les observateurs suivra les journées.

15:20 – 15:40 — New Detections of Binary Asteroids with Stellar Occultation (GaiaMoons)

Raphaël Lallemand, Josselin Desmars, Bruno Sicardy, Ziyu Liu, Paolo Tanga, Luana Liberato, Benoît Carry, Yucel Kiliç and the co-authors [résumé PDF](#)

Binary and multiple systems are a common outcome of small-body evolution in the Solar System. A fraction of small binaries among near-Earth asteroids (NEAs), small diameter ($D < 10$ km) and Main-Belt asteroids (MBAs) was estimated at 15% [1][2]. They represent a key population for understanding the formation and evolution of small bodies in the Solar System [3]. Nowadays, despite significant progress, the study of binary asteroids remains affected by strong observational biases and intrinsic limitations: Radar observations only target a few nearby near-Earth asteroids, adaptive optics are restricted to the largest and closest systems, and lightcurve inversion works best for tightly bound binaries with favorable viewing angles. In this context, GaiaMoons is a project that aims to identify binary candidates using Gaia astrometric data and validating asteroid companions through stellar occultation observations for a sample of 361 objects [4]. Stellar occultation is a ground-based method that yields highly precise astrometric positions (to mas levels) at the epoch of the event and allows the determination of key physical parameters of the system such as size (km level), shape, orientation, and relative component geometry [5] [6]. Between October 2023 and January 2026 where a total of 165 stellar occultation observations have been performed for 101 different objects with the help of the amateur community in France and abroad. Out of 165 observations, 76 led at least to one positive observation. Among them, 33 with at least 2 positives for 24 objects that have undergone unprecedented occultation observation campaigns. For the vast majority of these objects, unique physical and astrometric constraints, as they had never been observed through stellar occultations before [7]. Among them, 2000 SW₁₄₃ in particular, has been observed in August 2025 and presents strong binary features (Fig. 1). This talk will focus on the main results of these campaigns and their implication in the small binaries population sample thanks to Pro/Am collaborations.

15:40 – 16:00 — Flash Talk Posters

16:00 – 16:20 — PAUSE CAFE – DISCUSSIONS POSTERS

16:20 – 16:40 — The 2SPOT Consortium: A Pro–Am Facility for Spectroscopic Follow-up in Astronomy

Lionel Mulato, Stéphane Charbonnel, Olivier Garde, Pascal Le Dû, and Thomas Petit [résumé PDF](#)

1Southern Spectroscopic Project Observatory Team (2SPOT), 45, Chemin du Lac

38690 Châbons, France

April 2026

1 Abstract

We present the 2SPOT consortium¹, established in 2019 by five amateur astronomers, which operates two remotely controlled telescopes in Chile dedicated to spectroscopy: a 0.3-m Ritchey–Chrétien telescope equipped with a medium-resolution eShel spectrograph (R ~10,000) and a 0.3-m f/4 Newtonian telescope equipped with a low-resolution Alpy 600 spectrograph (R ~600). We contribute to various pro-am collaboration programs by providing spectroscopic observations of a range of astrophysical objects. These include poorly studied southern Be stars, rapid-response observations of novae and transients, and the confirmation of planetary nebula candidates from amateur and professional surveys. Since 2022, we have been involved in a long-term project aimed at identifying new Galactic symbiotic systems using Gaia DR3 data. This collaboration has enabled significant knowledge exchange and allowed us to develop independent research activities under professional supervision, including two studies focused on the search for new Galactic Wolf–Rayet stars and planetary nebulae using Gaia DR3 data.

16:40 – 17:00 — Le projet AIP-NP (découvertes de Nébuleuses Planétaires par IA)

Dominique Daniel (AIP) [résumé](#) [PDF](#)

Probablement en compagnie de Djaffar Ould Abdelslam (Prof à l'UHA), je présenterai l'avancement du projet AIP-NP (découvertes de Nébuleuses Planétaires grâce à l'IA) que j'ai présenté lors de l'atelier Gemini de Marseille en 2024. La partie IA est maintenant développée en collaboration avec CentraleMed (CentraleDigitalLab - Anne-Laure Mealier) et l'UHA (Université Haute Alsace). Je présenterai également le sous-projet de création d'une survey «AIP» en OIII qui devrait pallier l'absence de telle survey disponible.

17:00 – 17:20 — RAPAS 2026

Thierry Midavaine [résumé](#) [PDF](#)

RAPAS 2026 (Réseau Amateurs Professionnels pour les Alertes Scientifiques)

17:20 – 17:40 — The RAPAS Data Processing and Archival System

Pier-Francesco Rocci, Renaud Savalle [résumé](#) [PDF](#)

We have developed a web-driven data reduction photometric pipeline and a Virtual Observatory compatible archive retrieval system for observations performed by the members of the RAPAS (Réseau Amateurs Professionnels pour les Alertes Scientifiques) program, a project which has been funded by the Gemini ProAm effort at Paris Observatory. RAPAS is a network of observers dedicated to the follow-up of transients, each equipped with a different telescopes and cameras, but using the same set of Gaia-compatible filters to facilitate comparison of results. RAPAS Photometry Pipeline (RPP), is a Streamlit/FastAPI application for homogeneous reduction of RAPAS FITS image observations. After users have uploaded the image and set the analysis parameters, the pipeline performs header and WCS checks, optional Astrometry.net plate solving, and astrometry refinement through the stdpipe library. Then the pipeline automatically iterates through several steps: sources detection, aperture and PSF photometry with Astropy and Photutils, Gaia-based zero-point calibration, and catalog enrichment via GAIA, SIMBAD, SkyBoT, VSX, Milliquas, and Astro-Colibri. Results are managed through a Python stack using SQLAlchemy, and SQLite. All along the pipeline, general statistics, log messages, and plots provide the user with real-time information about the status of the pipeline. The RAPAS Archive, implemented with the DaCHS backend, provides SIAP2 and TAP/ADQL services allowing to query the collected dataset. Those IVOA compliant services can be used by Aladin, TOPCAT, and our PADC ObsTAP portal which allows easy discovery and visualization. We conclude by examining other ProAm (professional-amateur) collaborations and discussing how this framework and its methodologies could be adapted to facilitate the upload, processing, and archiving of their astronomical datasets. This approach would enable enhanced data mining opportunities for the broader astronomical community.

17:40 – 18:00 — TABLE RONDE – DISCUSSIONS SUR ETAT DES PROJETS

Soirée

Soirée Cocktail — Stade des Alpes

Vendredi 26 Juin

Matinée · 09:00–12:00 — Session plénière (S00)

Session plénière · Assemblée générale de la SF2A

09:00 – 09:25 — Exo-atmosphères en mouvement: nuages, vents et transport chimique vu par le JWST et les grands observatoires au sol

Vivien Parmentier (AT EXOS) [résumé PDF](#)

Les atmosphères d'exoplanètes sont en mouvement perpétuel. Les vents transportent la chaleur, les nuages et les espèces chimiques entre les régions chaudes et les régions froides. Cela change la composition chimique et donc notre interprétation des spectres observés. Ces dernières années, l'amélioration du nombre et de la précision des observations avec le JWST et avec les nouveaux instruments sur les télescopes au sol, tels qu'ESPRESSO et CRILES+ ont permis de mesurer directement les vents dans les atmosphères d'exoplanètes et de comprendre plus en profondeur le rôle joué par les processus de transport. Je discuterais à la fois les observations récentes et les implications pour l'interprétation des futures observations avec l'ELT.

Exo-atmospheres in motion: Wind, cloud and chemistry unveiled with JWST and groundbased observatories. Vivien Parmentier, Observatoire de la côte d'azur Presentation in French, slides in english

Exoplanet atmospheres are always in motion. Winds transport heat, clouds and chemical species, impacting the local composition and our interpretation of exoplanet spectra. I will show how the extreme precision provided by JWST and new ground-based instruments such as ESPRESSO, allow the direct measurements of transport processes on exoplanet atmospheres, how this improves our understanding of atmospheric dynamics and escape processes in hot giant planets and discuss the implication for future ELT observations of cooler objects.

09:25 – 09:50 — Présentation de l'IAU

Daniel Hestroffer & Athena Coustenis

09:50 – 10:15 — Avenir du numérique : scénarios manquants et bifurcations

Florence Maraninchi (Com. TE) [résumé PDF](#)

Le numérique dans son ensemble a déjà des impacts socioenvironnementaux très conséquents, et en croissance. Par ailleurs le numérique est toujours présenté dans le discours public comme faisant nécessairement partie de la solution. On parle de transitions numérique et écologique (ou énergétique) couplées. La recherche en informatique et l'ingénierie du numérique suivent essentiellement deux branches : - Les approches dites Green-ICT consistent à réduire les impacts environnementaux des composants du numérique eux-mêmes (le matériel, le logiciel, les infrastructures de communication) ; - Les approches dites Green-by-ICT visent à réduire les impacts d'un autre secteur (les transports, l'agriculture, le bâtiment, ...) grâce au numérique.

Dans cet exposé nous défendons l'idée que ces deux visions sont très insuffisantes pour envisager la place du numérique face aux bouleversements socio-environnementaux à venir. Les optimisations de l'approche Green-ICT sont souvent (voire toujours) synonymes d'effets rebond massifs qui annulent les gains réalisés sur les composants individuels. Les approches de type Green-by-ICT en sont toujours au stade de la promesse. Pour couvrir plus largement les futurs envisageables du numérique, il faut également s'intéresser aux scénarios non technooptimistes, en allant jusqu'à l'hypothèse extrême de la fin du numérique. C'est le scénario Fading-ICT, dans lequel on cherche à démonter proprement les infrastructures numériques, à couper les dépendances avec les autres infrastructures, à rendre plus robuste ce qui reste, ... Tout cela pour permettre de bifurquer des trajectoires actuelles non soutenables et de ralentir.

10:15 – 10:45 — Pause Café *