Elbereth conference 2024

mercredi 28 février 2024 - vendredi 1 mars 2024

Institut d'Astrophysique de Paris

Recueil des résumés

Contents

Session 1 / 37

Detection of exoplanets using low frequencies radio imaging

Auteur: Quentin Duchêne[1]

[1] *LESIA, Observatoire de Paris*

Auteur correspondant quentin.duchene@obspm.fr

Radio interferometry is a great tool to study Jupiter's magnetic field, and NenuFAR provides quality low-frequencies observation of it from 10 to 85 MHz. As we expect star-planet interactions from gas giants near to their star to be visible in this range of frequencies, we try to detect them using radio imaging. This should provide useful information and constraints on these planets'magnetic field. In this presentation, I will introduce the basics of radio imaging, and the star-planet interactions we are looking for, before detailing an example of observation.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 1 / 38

Theoretical and numerical study of recurrent dynamics in dynamical systems and application to the N-body problem

Auteur: Alexandre Prieur[1]

[1] *IMCCE, Observatoire de Paris-PSL*

Auteur correspondant alexandre.prieur@obspm.fr

In a famous anagram, Newton wrote that the laws of nature are described by differential equations. However, these equations are not solvable in the general case, in the sense that their solutions cannot be expressed through elementary functions. Stemming from this observation, the theory of dynamical systems aims to determine not the exact state of a system over time, but rather the qualitative behaviour of solutions, possibly on large time scales.

Our work is part of this theory, and aims to highlight, using both mathematical and numerical methods, certain recurrent dynamics of these systems - periodic and quasi-periodic orbits, center manifolds, etc. In this talk, I will describe their application to the three-body problem, with the case of equal masses and that of a perturbed planetary problem.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

De préférence le mercredi, pas d'obligation cependant

Session 1 / 30

Implicit Likelihood Inference in cosmology while checking for survey systematics

Auteur: Tristan Hoellinger[1]

Co-auteur: Florent Leclercq [1]

[1] *Institut d'Astrophysique de Paris*

Auteur correspondant tristan.hoellinger@iap.fr

We present methodological advances to perform implicit likelihood inference of cosmology from arbitrarily complex models of cosmological surveys, while efficiently and extensively checking for systematics. This novel approach makes it possible to fully utilise our prior theoretical understanding of the initial matter power spectrum after inflation, in order to investigate the effects of known sources of systematics at play in the data generating process.

Astrophysics Field:

Cosmology

Day constraints:

I will probably not be available on Friday.

Session 1 / **28**

Cosmic Shear Nulling: reducing theoretical uncertainties on Dark Energy parameters derived by the Euclid Mission

Auteur: David Touzeau[1]

[1] *CEA Saclay/IPhT*

Auteur correspondant david.touzeau@universite-paris-saclay.fr

The Weak Lensing Shear is a powerful probe of cosmology. Along with Galaxy Clustering and the cross-correlation of those two probes, it gives the most effective set of Data, used by cosmological observations, to constrain cosmological parameters and study the large-scale structure of the universe. Yet, the nature of the Dark Energy, representing around 68% of the energy content of our current universe, is still unknown. Thus, any additional cosmological feature, data or probe that would give new constrains or information on cosmological parameters is of interest. One of those features could be the BNT (Bernardeau, Nishimichi, Taruya) transform as it provides a mostly geometrical property of Weak Lensing: The Nulling of the Cross-Spectra. This feature does not depend on the Galaxy Power Spectrum but only on Dark Energy Parameters and brings few additional systematics to the current analysis on Weak Lensing and Galaxy Clustering. As part of the Euclid consortium, we wish to exploit the Nulling property of the BNT transform to reduce theoretical uncertainties on Dark Energy parameters derived by the Euclid Mission.

Astrophysics Field:

Cosmology

Day constraints:

28 February or 1 March only (i will not be here on the 29 Feb)

Invited talk: Emmanuel Marcq / 53

Venus'atmosphere: an overview before next exploration missions

Auteur correspondant emmanuel.marcq@latmos.ipsl.fr

During the last 15 years, our knowledge about the atmosphere of Venus has expanded greatly, mainly due to the contribution of two dedicated orbiters: Venus Express from ESA (2006-2014) and Akatsuki from JAXA (2015-present). Both missions included a comprehensive payload which enabled them to measure key parameters about the atmosphere from the surface to the topmost layers. Among their discoveries are a much greater than anticipated spatial and temporal variability, partly due to unsuspected coupling between the surface and the upper atmospheric layers at cloud top level. They also highlighted gaps in our knowledge, some of them long standing like the nature of the unknown UV absorber. Undoubtedly, all these results contributed to the renewed interest for the planet Venus that was confirmed by the selection, in 2021, of three major space exploration missions targeting the planet in the 2030s (DAVINCI and VERITAS from NASA, EnVision from ESA). This review talk will summarize our current knowledge about the atmosphere of Venus including some key outstanding questions. It will then proceed in a review of the planned atmospheric investigations from the above mentioned selected missions, as well as others.

Astrophysics Field:

Day constraints:

Session 2 / 5

Photon Rings in the Images of Black Holes

Auteur: Irene Urso[1]

[1] *LESIA, Paris Observatory*

Auteur correspondant irene.urso@obspm.fr

The Event Horizon Telescope (EHT) collaboration released in 2019 the first horizon-scale images of the supermassive black hole M87*, dominated by a bright, unresolved ring. General relativity (GR) predicts that embedded whitin this images lie observable, thin, ring-shaped features produced by photons on extremely bent orbits: the "photon rings".
In a parametric framework of GR, the idea of this study is to consider these predicted photon rings and to analyse their dependence on the choice of the metric and on the emission process of the matter orbiting around the black hole.
The images are produced using numerical simulations of the electromagnetic radiation, and the features of interest are then retrieved via an additional data analysis code.

Astrophysics Field:

Compact objects (supernovae, black holes, neutron stars)

Day constraints:

Session 2 / 19

Colliding blast waves in the laboratory : a numerical study

Auteur: Marin Fontaine[1]

Co-auteurs: Clotilde Busschaert [2]; Émeric Falize [2]

[1] *CEA DAM Ile-de-France*

[2] *CEA DAM Ile-de-Fracne*

Auteur correspondant marin.fontaine@cea.fr

The study of supernovae is an area of great interest in astrophysics. After their explosion, the supernova remnant (SNR) goes through different phases, dispersing its energy into the interstellar medium (Truelove & McKee 1999). At the end of its evolution, the shock behaves like a Taylor-Sedov blast wave. It is during this phase that the SNR may collide with other objects, such as molecular clouds or other SNRs. The development of laboratory astrophysics using high energy density laser experiment has made it possible to reproduce and study those astrophysical phenomena. The collision of such blast waves in the laboratory was performed at the LULI2000 laser facility (Albertazzi et al. 2020). In this work, we reproduce this experiment numerically using the radiative hydrodynamics Arbitrary Lagrangian Eulerian (ALE) code TROLL, in order to study the expansion of these blast waves and their collisions in greater details. As we are simulating the experiment from the moment the laser is fired, this study also enabled us to test the ability of such an ALE code to reproduce the laser-plasma interaction leading to the generation of a blast wave.

Astrophysics Field:

Compact objects (supernovae, black holes, neutron stars)

Day constraints:

No constraints

Session 2 / 24

NOIRE: Objectives and Constraints

Auteur: Erwan Rouille[1]

[1] *LESIA*

Auteur correspondant erwan.rouille@obspm.fr

NOIRE (Nanosatellite pour un Observatoire Interferometrique Radio dans l'Espace) is an instrumental concept study. NOIRE aims to ba a very low frequency observatory. It will be an interferometer composed of a swarm of about 50 satellites. This instrument will enable to observe various objects and phenomena mostly unknown. Many scientific topics can be covered by NOIRE. This new type of instrument comes with new constraints. A spaceborne interferometer is very different from its ground-based conterpart.
In this talk, I will be presenting the intrumental concept, its scienctific objectives and how some of its constraints impact the observations.

Astrophysics Field:

Instrumentation

Day constraints:

Session 2 / 43

Numerical simulations of a two-loops AO system for high-contrast imaging

Auteur: Charles GOULAS[1]

Co-auteurs: Anthony Boccaletti [1]; Caroline Kulcsar [2]; Clémentine Béchet [3]; Emiliano Diolaiti [4]; Eric Gendron [1]; Eric Thiébaut [3]; Fabrice Vidal [1]; Florian Ferreira [1]; François Wildi [5]; Gaël Chauvin [6]; Henri-François Raynaud [2]; Isaac Bernardino Dinis [5]; Isabelle Tallon [3]; Johan Mazoyer [1]; Julien Milli [7]; Laura Schreiber [4]; Magali Loupias [3]; Markus Feldt [8]; Markus Kasper [9]; Maud Langlois [3]; Michel Tallon [3]; Miska Le Louarn [9]; Nicolas Galland [2]; Raphaël Galicher [1]

[1] *LESIA, Paris Observatory*

[2] *Laboratoire Charles Fabry, IOGS*

[3] *CRAL, Lyon Observatory*

[4] *INAF*

[5] *Univ. de Genève*

[6] *Observatoire de la Côte d'Azur*

[7] *IPAG, Univ. Grenoble Alpes*

[8] *MPIA*

[9] *ESO, Germany*

Auteur correspondant charles.goulas@obspm.fr

SPHERE has been a high-contrast instrument on sky at the Very Large Telescope since 2014. It makes infrared images of young giant planets, circumstellar disks, and characterizes them by spectroscopy and polarimetry. The next upgrade of SPHERE aims at improving the exoplanet detection capabilities, in particular closer to the star. To achieve this goal, the adaptive optics system will be improved by adding a second loop of correction, with a faster deformable mirror and a new type of wavefront sensor.

We use end-to-end numerical simulations of the two loops to quantify the improvement of the second loop and run a parametric study. The results are presented in terms of coronagraph images and stellar intensity profiles. We demonstrate an improvement of a factor 10 in residual intensity when adding the second loop. Finally, running the second loop at 2 kHz seems enough to get significant gain of performance.

In the future, a focal plane wavefront control loop will be added to the simulation to minimize the speckles intensities in the coronagraph images.

Astrophysics Field:

Instrumentation

Day constraints:

Session 2 / 35

The calibration of the p-factor of pulsating stars: an unanswered question ?

Auteur: Garance Bras[1]

[1] *Observatoire de Paris*

Auteur correspondant garance.bras@obspm.fr

The projection factor, or p-factor, is a way to link the observed radial velocity of the atmosphere of the star to the velocity of the photosphere. It was introduced in the context of the Baade-Wesslink technique, to determine distances of pulsating stars. However, after almost a century of using the method and of efforts put in the calibration of this factor, results still seem to be inconciliable. The dispersion between individual values remains of the 10% order, despite higher precision in distances measurements thanks to Gaia parallaxes for instance. Understanding the origin of this scatter is a key to improve our knowledge of the atmosphere of pulsating stars.

Astrophysics Field:

Solar & Stellar Physics

Day constraints:

Session 2 / 44

Caracterize stellar magnetic activity by counting spots on stars

Auteur: Lucie Degott[1]

[1] *IAS / LESIA*

Auteur correspondant lucie.degott@universite-paris-saclay.fr

Stellar magnetism still remains poorly understood : there is a huge variety of topology and magnetic phenomena which need to be characterized regarding the different stellar physical parameters such as the Rossby number.
The resulting magnetic activity is here use as a observable to improve our understanding of spot characteristics (area, lifetime…) and link these properties to the dynamo effect which rules all these phenomena.

We propose to characterize this activity using the signature of spots in the light curves of the Kepler mission, seen in the Fourier domain. For this, we revisit the model of Harvey et al. (1985) in order to take into account all the components present in the power spectra.
This method allows having access to two proxy of the activity : the mean spot coverage and the lifetime.
After validating this model with simulated light curves, we present the results from thousands of Kepler light curves of main sequence stars used by McQuillan (2014) and Santos (2022).

The results show the emergence of three different regimes of activity related to different value of Rossby number. These activity types are also linked to different stars population which are distinguished by their rotation period, mass, Rossby number, ect…
The gyrochronology allows seeing an evolution between these different types during the star evolution and give information about the development of the stellar magnetic field thought different phase.

Astrophysics Field:

Solar & Stellar Physics

Day constraints:

Session 3 / 14

From Mars to Mercury : ice spectroscopy and implications for the origin and evolution of water in the inner Solar System

Auteur: Apolline Leclef[1]

Co-auteurs: Mathieu Vincendon [2]; Cateline Lantz [2]

[1] *Institut d'Astrophysique Spatiale*

[2] *IAS*

Auteur correspondant apolline.leclef@universite-paris-saclay.fr

Understanding the presence, characteristics, and origin of water within the inner solar system can be enhanced by analyzing the properties (composition, dynamics) of ices present on terrestrial planets such as Mars and Mercury. This analysis, conducted through infrared spectroscopy, relies on data collected by instruments such as CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) aboard the Mars Reconnaissance Orbiter (MRO), OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) on the Mars Express mission, and VIHI (Visible Infrared Hyperspectral Imager Channel) aboard the Bepi-Colombo mission.

In the initial phase, the analysis focuses on Martian ices, particularly in areas near the South and North Poles where the presence of active flows has been observed. These flows are thought to be related to the seasonal formation of surface ice. The conceivable mechanisms to explain these flows depend on the properties of the ice, such as its composition in water, CO2, and contaminants, or its physical and optical properties (grain size, transparency). The aim of this work is to characterize these properties using spectroscopy, in order to differentiate among proposed mechanisms, which span from CO2 geysers to dry avalanches, and even to flows implicating a transition of water ice to a liquid state.

In a subsequent phase, the analysis will extend to Mercurian ices with the prediction of data expected from the Bepi-Colombo mission, set to orbit Mercury by the end of 2025. Simulating the expected spectral signatures involves experiments with mixtures of CO2/H2O/carbonaceous contaminants and irradiation tests to replicate the conditions on Mercury (analog production). The optical model developed for Mars will be adapted to predict spectral outcomes for Mercury. These predictions will subsequently be compared with the actual data after their analysis in early 2026.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Je suis désolée, mais je ne pourrai pas être disponible soit le 28, soit le 29 matin. Serait-il possible de planifier la présentation en après-midi ? Ou sinon, le vendredi matin. Merci de votre compréhension.

Session 3 / **45**

An innovative NIR spectrometer for monitoring planetary atmospheres

Auteurs: Cannelle Clavier[1]; Mustapha Meftah[1]

[1] *LATMOS*

Auteur correspondant cannelle.clavier@universite-paris-saclay.fr

The emergence of constellations of CubeSats provides a new paradigm in the observation of planetary bodies such as the Earth, Moon or Mars. The desire to observe planetary atmospheres in near-real time highlights the need for new miniaturized instruments with sufficient spectral resolution to meet scientific requirements. The main goal of this presentation is to describe the design

of a near-infrared miniaturized spectrometer that can be carried out onboard CubeSats to monitor planetary gases concentrations. As an example, we will focus on the Uvsq-Sat NG spectrometer developed for observing greenhouse gases concentrations of the Earth with a good accuracy (± 4 ppm for CO2 and ± 25 ppb for CH4). This new spectrometer pathfinder (1200-2000 nm wavelength range, 5 nm spectral resolution) will be one of the payloads of the Uvsq-Sat NG 6-unit CubeSat, scheduled for a launch in 2025. We will also present a new disruptive optical design of an echelle grating spectrometer, which allows observations with a 1 nm spectral resolution. This represents an important breakthrough to go beyond the state of the art for observing planetary atmospheres with a low spectral resolution spectrometer. Finally, we will present the method based the Levenberg-Marquardt approach for retrieving atmospheric gases concentrations.

Astrophysics Field:

Instrumentation

Day constraints:

Session 3 / 46

Jovian low-frequency radio-emissions, a laboratory for extrasolar systems.

Auteur: Emilie Mauduit[1]

Co-auteurs: Philippe Zarka [2]; Jean Mathias Griessmeier [3]; Laurent Lamy [2]; Jake Turner [4]

[1] *LESIA, Observatoire de Paris, Université PSL, Sorbonne Université, Université Paris Cité, CNRS, 92190 Meudon, France*

[2] *LESIA - Observatoire de Paris - PSL*

[3] *Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E) Universit´e d'Orléans/CNRS, Orléans, France*

[4] *Department of Astronomy and Carl Sagan Institute, Cornell University, Ithaca, NY, USA*

Auteur correspondant emilie.mauduit@obspm.fr

Studying Jovian low-frequency magnetospheric radio-emissions (≤40 MHz) allows to remotely probe their generation mechanism (especially the electron Cyclotron Maser –ECM) and the acceleration processes of electrons that power it. Those emissions have different time scales : from milliseconds (fast drifting radio bursts) to hours, and are mainly polarized elliptically (both circular and linear polarization are present).
We have developed a new method, based on Fast Fourier and Radon transforms, that allows an automatic detection of fast drifting bursts in massive high time-frequency resolution data. Applied to Jupiter observations, it allowed us to detect new burst types.
Besides, while propagating through the plasmas between the source and the observer, those radio emissions are subject to Faraday rotation, producing spectral fringes in linear polarization. Studying these fringes allows to retrieve the Rotation Measure (RM) of the emission and remotely study the interplanetary medium, the terrestrial ionosphere and especially the Jovian magnetosphere in our case. In this work, we analyze the dependence of the measured RM to source-observer geometry and periodicities related to the Jovian magnetosphere.
Finally, it has been convincingly argued that radio emissions from exoplanets and star-planet interactions are expected to have deep similarities with Jupiter's. Recently, fast drifting radio bursts very similar to Jupiter-Io ones have been detected from the star AD Leo. Thus, we evaluate the application of these detection methods to exoplanets by conducting 'Jupiter as an exoplanet'studies with data from the NenuFAR radio telescope, similar to that conducted with LOFAR data.

Astrophysics Field:

Not in the above

Day constraints:

I teach on Thursday afternoon at Université Paris-Saclay so I won't be available at that time.

Session 3 / 33

A New NeoNarval Pipeline with PyReduce

Auteur: Chloe Gutteridge[1]

Co-auteur: Keegan Thomson-Paressant [2]

[1] *Observatoire de Paris*

[2] *Observatoire de Paris / ESO*

Auteur correspondant chloe.gutteridge@obspm.fr

Since the commissioning of the NeoNarval instrument at TBL in 2019, concerns have been raised regarding the quality of results in polarimetry and precision in velocimetry. Data from NeoNarval fails to reproduce the 10% magnetic population in OB stars as obtained by its predecessor Narval among other instruments, and under-reports the field strength of well-studied magnetic stars. Investigations have revealed issues at the telescope, instrument and data reduction levels, which must be resolved in order to accurately exploit the data.
We present our discoveries of such issues, subsequent work performed to develop a new data reduction pipeline, and first results which we compare to those provided by TBL and data taken by other instruments. Building on PyReduce, an open-source reduction pipeline for echelle spectrographs, we have integrated polarimetric methods, as well as new routines to minimise the effect of instrumentation issues, allowing for the recovery of 4 years of previously obtained data.

Astrophysics Field:

Solar & Stellar Physics

Day constraints:

Session 4 / 12

Titan's methane cycle studied with mesoscale models

Auteur: Enora Moisan[1]

Co-auteurs: Audrey Chatain [2]; Aymeric Spiga [1]; Scot Rafkin [3]; Alejandro Soto [3]

[1] *Laboratoire de Météorologie Dynamique (LMD)*

[2] *LATMOS*

[3] *SwRI*

Auteur correspondant enora.moisan@lmd.ipsl.fr

Titan, the largest moon on Saturn, is the only moon in the Solar System to have a substantial atmosphere. It is also the only body besides Earth to have a liquid stable at its surface. For Titan, this liquid is composed of hydrocarbons, mainly methane, forming lakes and seas at the surface. The knowledge we have on Titan is based on observations from Earth, and from space missions, especially the Cassini-Huygens mission. Cassini orbited Saturn from 2004 to 2017, providing a lot of very valuable data. Huygens was a probe, which landed on Titan on January 14th 2005, providing profiles of temperature, winds, atmospheric composition, and the first pictures from Titan's surface.

To know more about the atmospheric circulation on Titan, and the interactions between the atmosphere and the surface, atmospheric models have been developed. Among them, the mtWRF model (mesoscale titan WRF, see Rafkin and Soto 2020), has been developed and adapted from a model used on Earth to produce weather forecasts and study the atmosphere. The mtWRF model has been used to study the atmospheric circulation around lakes on Titan (Rafkin and Soto 2020, Chatain et al. 2022, Chatain et al. 2024). Here we study the atmospheric circulation created by the lakes, and we present some results showing the effect of different surface properties (i.e. surface roughness, emissivity, albedo and thermal inertia) around small lakes (see Moisan et al. 2024 in prep). On Titan, some lakes are surrounded by sharp topographies, that we call ramparts here. We show that ramparts strongly affect the local atmospheric circulation around lakes.

We are now developing a new mesoscale model adapted to study Titan's convective methane clouds. This new model will also come from WRF for the dynamics. For the physical part, we will use the physics modeling developed for the Titan-PCM model (formerly IPSL Titan GCM, Lebonnois et al. 2012).

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Mercredi 28 : disponible jusqu'à 12h, puis à partir de 15h.
Jeudi 29 : disponible le matin jusqu'à 12h.
Vendredi 1er : disponible le matin jusqu'à 12h, mais je préfèrerais un autre jour (conflit avec la journée des doctorants du LMD)

Session 4 / 17

Unveiling the prebiotic chemistry of ocean worlds; laboratory and in situ investigations

Auteur: Alex Abello[1]

[1] *LATMOS/UVSQ*

Auteur correspondant alex.abello@latmos.ipsl.fr

In the coming years, space probes will be sent to the surface of ocean worlds of the solar system such as Titan, Europa and Enceladus to characterize their habitability and search for traces of life. In particular, the Dragonfly mission which was confirmed in June 2019 is expected to launch in 2028 and to land on Titan in 2034.

My thesis is intended to contribute to three main objectives in this context.

Firstly, I will take part in the development of the gas chromatograph that will be included on Dragonfly. This instrument includes injection traps which are meant to focus the sample's components before releasing them all at once into the chromatographic column where they will be separated. I will select the chemical adsorbents to be used in those traps and optimize the focusing and releasing conditions to ensure the best possible efficiency within the mission constraints.

Secondly, I will investigate in situ sample preparation methods. For example, the salts present on the surface of Europa and Enceladus may cause analytical interferences with the organic matter we are looking for, as well as damage to the instruments. Thus, it is essential to remove those salts from the samples before analyzing them. To this end, I will develop a desalting process to be used on the missions to these two worlds.

Finally, in order to facilitate the interpretation of future in situ data, I will characterize samples which are known to be analogous to the surface of those ocean worlds. Synthetic analogues to Titan aerosols –called tholins –can be obtained from the PAMPRE experiment, which simulates the atmospheric composition and conditions of this moon. In the case of Europa and Enceladus, natural analogues can be collected from terrestrial hyper-saline environments.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

I will not be available to present on the Thursday morning (February 29th). I will be available the rest of the time.

Session 4 / 4

Characterizing the correlation properties of the atmospheric emission in the 10-20GHz range with QUIJOTE data

Auteur: Apolline CHAPPARD[1]

[1] *Ias*

Auteur correspondant apolline.chappard@universite-paris-saclay.fr

The QUIJOTE MFI instrument (2012-2018) observed the sky at four frequency bands, namely 11, 13, 17 and 19Ghz, at 1 degree angular resolution. We can use the full database of MFI observations to characterize the correlation properties of the atmospheric signal in those frequency bands. This information will be useful to improve the current sky models at these frequencies, and could be used in further MFI reanalyses, or for the preparation of future observations at these frequencies (e.g. Tenerife Microwave Spectrometer). We will present the preliminary results of these analyses.

Astrophysics Field:

Cosmology

Day constraints:

Session 4 / 15

Small icy bodies revealed by JWST : a glimpse into the early outer solar system

Auteur: Elsa Hénault[1]

[1] *IAS*

Auteur correspondant elsa.henault@universite-paris-saclay.fr

Since their discovery about 30 years ago, observations of Trans-Neptunian Objects (TNOs) have been limited. These small icy bodies orbiting beyond Neptune were observed in the 0.5 to 2.5 μm range, where only bands of water and methanol ice could be detected and identified on non-dwarf planets (diameter < 800 km). In autumn 2022, a large JWST program began observing 54 TNOs, in the 0.7 to 5.1 μm range, providing an unprecedented look at their surface composition. We found that TNO surfaces fall into 3 spectral types whose characteristics reflect their distance to the sun before the planetary migration which placed them in their current orbit (Pinilla-Alonso et al. 2024). CO_2 was detected across all objects (De Prá et al. 2024), in abundances correlated to their spectral types. I am now studying the distribution of CO across 38 objects and investigating its possible irradiation

origin by comparing them to ion irradiation experiments on ices, that I conducted at IAS and IJCLab in Orsay.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Available all day on wednesday 28 and friday 1.
Available only after 3 PM on thursday 29

Session 4 / 32

Gas accretion on planets in the debris disc phase

Auteurs: Paul Huet[1]; Quentin Kral[1]

[1] *LESIA*

Auteur correspondant paul.huet@obspm.fr

Since gas has recently been discovered in debris disks, the current model of planetary accretion and evolution doesn't take this gas into account.
However, planets have already been discovered in debris disks with significant amounts of gas (e.g. Beta pic), and models predict that this gas can be regenerated by collisions for 100 Myr, 10 times more than in protoplanetary disks.
Because of this characteristic time, we may use a one-dimensional thermal model based on the stellar structure equation instead of hydrodynamic codes to follow the atmospheric evolution.
An analytical model developed in this context suggests a very efficient accretion. So we need a more complex numerical model to be more accurate.
We will describe how we are developing this model from scratch, based on a code developed to describe atmospheric accretion into protoplanetary disks.
We need to adapt it to the specific constraint of the debris disk as a limited maximum accretion rate.
We also need to determine the right level of complexity in our physical model, such as the radiative transfer description or the equation of state of the gas.
The aim is to determine the influence of different parameters such as the core luminosity, the opacity of the gas, the initial conditions (core mass, initial atmosphere…) on the accretion rate and the atmospheric structure.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 5 / 18

Study of nonlinear processes occurring during type III solar radio bursts using electromagnetic waveform analysis

Auteur: Francisco Javier Polanco Rodriguez[1]

Co-auteurs: Catherine Krafft [1]; Philippe Savoini [1]

[1] *Laboratoire de Physique des Plasmas (LPP)*

Auteur correspondant francisco-javier.polanco-rodriguez@lpp.polytechnique.fr

The study focuses on electromagnetic waves radiated by the Langmuir wave turbulence generated by electron beams in the solar wind and corona during type III solar radio bursts. The waveforms used for analysis are provided by 2D/3V large-scale and long-term Particle-In-Cell simulations. They allow us to highlight different nonlinear interaction processes between waves, such as the three-waves' electrostatic wave decay, for various plasma parameters as the ambient magnetic field, the ion-to-electron temperature ratio and the average level of the external random plasma density fluctuations. Hundreds of virtual satellites moving in the 2D simulation box and recording waveforms of electromagnetic fields and particle densities are modeled, in order to perform statistical studies. Plasma random density fluctuations are found to play a crucial role.

Astrophysics Field:

Solar & Stellar Physics

Day constraints:

Only available for the 28 and 29 February. 1st march is impossible to be present.

Session 5 / 23

Towards a better understanding of the D-layer of the ionosphere

Auteurs: Pauline Teysseyre[1]; Carine Briand[2]

[1] *LESIA*

[2] *LESIA - Observatoire de Paris*

Auteur correspondant pauline.teysseyre@obspm.fr

The D-layer is the lowest layer of the Earth's ionosphere, situated between 60 and 90 km. It is also the least known, as it is both too high for balloons and too low for satellites. However, it is a highly variable layer, which is perturbed by a variety of external sources: the Sun, electron precipitations from the radiation belts, gamma rays from supernovae, lightning strokes⋯. In the context of space weather, monitoring this layer is crucial, as it is responsible for the major part of HF absorption, which is a frequency band used by civil aviation.

The most powerful way to study the D-layer is by the means of waves in the range 15 –45 kHz (covering part of the VLF range, thereafter denoted VLF waves). They are man-made waves propagating in the Earth-ionosphere waveguide, propagating over long distances (thousands of kilometers). Thus, they can ensure a continuous survey of the D-layer of the ionosphere, especially over remote places such as oceans.

Any change in the D-layer electron density is a change of the Earth-ionosphere waveguide boundary. Therefore, the D-layer perturbations affect the propagation of the VLF waves. This occurs in particular for strong increases in the X-ray flux emitted by the Sun called solar flares, and which impact the entire dayside of the Earth.

In this talk, we will present the modelling of the propagation of the VLF waves from different transmitters to the receiver using a recent propagation code named Longwave Mode Propagator (LMP, (Gasdia & Marshall, 2021)). The result of this modelling will be compared to measurements in amplitude and phase from a VLF receiver situated in Nançay, in order to characterize the perturbations of the D-layer during solar flares.

Astrophysics Field:

Not in the above

Day constraints:

I can't be there on Wednesday, any other day is fine.

Session 5 / 7

A separate universe approach to multifield inflation

Auteur: Hugo Holland[1]

[1] *Institut d'Astrophysique Spatiale*

Auteur correspondant hugo.holland@universite-paris-saclay.fr

The endless quest for dark matter could end with the discovery of primoridal black holes, object which form from the collapse of large inhomogeneities in the very early universe. Stochastic inflation provides a way of studying the backreaction of these large inhomogeneities and estimating the number of primordial black holes. Because stochastic inflation focuses on large scales, a separate universe approach is necessary. To study the validity domain of said approach, we will study hamiltonian dynamics in a generic multifield inflation model, in which primordial black holes are likely to appear.

Astrophysics Field:

Cosmology

Day constraints:

I can present on the first two days (28/02/2024 and 29/02/2024) but I cannot make it on the Friday morning or early afternoon (01/03/2024)

Session 5 / 16

Thermal Sunyaev-Zeldovich power spectrum: analytical model and measures in simulations

Auteur: Emma Ayçoberry[1]

[1] *IAP*

Auteur correspondant aycoberr@iap.fr

The distribution of matter in the Universe is a powerful probe of cosmology. Measuring the efficiency with which gravity produces clusters against expanding Universe is the key to understanding, e.g. the equation of state of dark energy. Numerous projects aim at measuring the matter distribution across time in the Universe but no observable gives the perfect figure of this distribution (because of instrumental limitation, astrophysical limitation, or because they probe different redshifts). Cross-correlation of different probes is a powerful way to lift these limitations. My work focuses on the construction of a robust halo model for the thermal Sunyaev-Zeldovich power spectrum (one such tracer of the LSS) and to cross-correlate it with different probes of the distribution of matter (lensing, CMB lensing, galaxy count,⋯). To do so, I work with an analytical halo model of this power spectrum and I measure different profiles and power spectrums in the Horizon and Magneticum suite of hydrodynamical simulations to compare both and to test hypotheses of the model, such as the pressure profiles in halos and their link with feedback. In this talk, I will present and comment my results on these comparisons.

Astrophysics Field:

Cosmology

Day constraints:

Not Friday is possible, thank you!

Session 6 / 6

Dust dynamics during the gravitational collapse

Auteur: Gabriel Verrier[1]

[1] *CEA Saclay*

Auteur correspondant gabriel.verrier@cea.fr

Interstellar dust is about one percent of the mass of the interstellar medium. However, its presence significantly impacts stellar formation scenarios and observations in the visible, the infrared and the sub-mm, e.g. via the dust grains opacity, the surface chemistry, the coupling with the gas and the magnetic field, and the formation of planetary cores.

We are currently working on self-consistent descriptions of the dust dynamics together with the gas and the magnetic field during the gravitational collapse, which is the origin of the formation of protostars and protoplanetary disks. These models consider a grain size distribution, so we would be able to explore some cases for which the standard MRN distribution (5nm-250nm) is no longer valid, as recent observations by the JWST of the dense Chamaeleon I cloud (micrometer grains) suggest. We fully take the inertia of the grains into account, in order to model the dynamics of the biggest grains correctly. Predictions in typical dense cores conditions are achieved analytically, thanks to the study of the propagation of waves, and numerically, by implementing a multifluid of dust in the RAMSES code.

Astrophysics Field:

InterStellar Medium

Day constraints:

Session 6 / 36

Detection of interstellar radio recombination lines with NenuFAR

Auteur: Lucie Cros[1]

Co-auteurs: Alan Loh [2]; Pedro Salas [3]; Philippe Salomé [4]; Philippe Zarka [5]; Stepkin Sergiy [6]; antoine gusdorf [7]

[1] *LPENS - équipe astrophysique*

[2] *LESIA, Observatoire de Paris*

[3] *Green Bank Observatory*

[4] *LERMA*

[5] *LESIA, CNRS - Observatoire de Paris - PSL*

[6] *Institute of Radio Astronomy NAS of Ukraine*

[7] *lra/lerma*

Auteur correspondant lucie.cros@phys.ens.fr

We report detection of the low frequency carbon radio recombination lines (RRLs) towards several galactic radio sources using the NenuFAR array. Based at Nançay Radio astronomy station, NenuFAR (New Extension in Nançay Upgrading LOFAR) is a LOFAR extension and SKA precursor that can detect Carbon atoms at quantum numbers between n = 400 and n = 850, thanks to its frequency range spanning from 10 MHz to 85 MHz. Observations were carried out in the period from 2021 to 2023 both for the directions where low frequency RRLs were already observed (Cassiopeia A, Cygnus A, and Cygnus Loop) and towards new objects. Positive results have been obtained for the directions of Cassiopeia A, Cygnus A, Cygnus Loop, Cygnus X, and Taurus A. The achieved sensitivity corresponds to optical depths less than 0.0005. Strong dependence of the low frequency RRLs parameters on physical conditions in the interstellar medium where they arise makes them an effective probe of the cold partially ionized diffuse gas. Values of features'radial velocities observed towards Cygnus A, Cygnus Loop, Cygnus X, and Taurus A suggest that they arise in the medium connected with Galactic Plane. Well known carbon RRLs towards Cas A arise in the Perseus Arm of the Galaxy. Our Cas A and Cygnus A results are consistent with previously obtained data. All detected RRLs are observed in absorption. Our observations illustrate the promising opportunity of the low frequency RRLs studies with newly installed NenuFAR radio telescope.

Astrophysics Field:

InterStellar Medium

Day constraints:

Friday afternoon is not possible for me.

Session 6 / 49

Simulated methane clouds in the Titan troposphere with the TITAN PCM

Auteur: BRUNO DE BATZ DE TRENQUELLEON[None]

Auteur correspondant bruno.de-batz-de-trenquelleon@univ-reims.fr

On Titan, methane is at the origin of all characteristics of the climate and the prebiotic chemistry that take place there. Methane and minor gases from photochemistry, produce clouds and precipitation that sculpt the satellite's landscape. Despite the many observations made by Cassini and Huygens, we still have a limited understanding of the couplings between the different cycles taking place on Titan. We propose to use a new microphysical model of cloud, implemented in the Titan Planetary Climate Model to study the methane cycle, its sources, sinks and related processes including clouds and rains.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 6 / 13

Reanalysis of trace species in Titan's lower atmosphere measured by Cassini Huygens

Auteur: Koyena Das[1]

[1] *LATMOS*

Auteur correspondant koyena.das@latmos.ipsl.fr

In Titan, the two major gases nitrogen (N2) and methane (CH4) are ionized and/or photolyzed at high altitudes by the sunlight and the energetic particles from Saturn's magnetosphere, resulting in rich atmospheric chemistry and a wide variety of carbon and nitrogen-bearing atmospheric compounds. In the present work, we focus on studying the vertical profiles of trace species in the lower atmosphere to obtain a better insight into the atmospheric processes taking place on Titan.
To do so, we reanalyzed the data from the Gas Chromatograph Mass Spectrometer (GCMS) on the Huygens probe which executed its mission on 14th January 2005. The GCMS instrument sampled for nearly three and a half hours from a height of 146 km. It recorded data for two and a half hours in the atmosphere of Titan, then landed on the surface and kept on recording for another hour, after which the signal was lost. We analyzed the measurements made by direct sampling of the atmosphere (Niemann et al. 2010). These mass spectra obtained at different altitudes and pressure levels have been recalibrated to account for deadtime and saturation corrections to the measurements, and considered ion cross-section and transfer cross-section measurements from Cassini-Ion and Neutral Mass Spectrometer calibrations. We then analyzed the corrected mass spectra using Monte-Carlo deconvolution simulations. The simulations allow us to vary the peak intensities of fragmentation patterns of known species, which usually bears uncertainties on this kind of data, and then use a least-square fitting to deconvolve the mixed signals (Gautier et al. 2020, Serigano et al. 2020, 2022).

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 6 / **22**

Sub-Kelvin cryogenic developments for future CMB projects

Auteur: Anaïs Besnard[1]

[1] *Institut d'Astrophysique Spatiale (IAS)*

Auteur correspondant anais.besnard@universite-paris-saclay.fr

In order to reach a greater sensitivity, future CMB missions will need to have their focal plane to be cooled down to 100 mK typically. This will require a 2 μW cooling power delivered in a continuous and stable way. The current cooling technologies do not meet these requirements anymore. To achieve those goals, a Closed-Cycle Dilution Refrigerator is in development, using a mixture of 3He and 4He.

Moreover, as shown by the Planck space mission, this type of highly sensitive cryogenic detectors can be sensitive to Cosmic Ray hits, creating spurious signals in the data , seen as glitches. New generations of detectors for new space missions therefore need to be studied by irradiation with particles of different energy levels to mimic the Cosmic Ray hits. These effects are currently under study on transition edge sensors (TES) and microwave kinetic inductance detector (MKID) by testing them at 100mK in front of a particle accelerator.

Astrophysics Field:

Instrumentation

Day constraints:

No constraints.

Session 6 / 52

Shack-Hartmann wavefront sensor design for optical communications in strong scintillation conditions

In the case of an optical link with a LEO satellite, it is crucial to maximize the duration of the downlink,
even at low elevations, in order to transfer the largest amount of data possible at each pass. However, in
this context, amplitude fluctuations (or scintillation) are challenging the operation of Adaptive Optics
(AO) systems, starting with their wavefront sensing subsystems.
Indeed, low elevations imply a strong perturbation regime as the propagation distance through turbulent
atmosphere layers increases, causing log-amplitude variance to reach saturation, i.e. with propagation
conditions beyond Rytov's approximation [1].
In the case of a Shack-Hartmann Wavefront Sensor (SHWFS), scintillation induces a wide intensity
range across the pupil resulting in some subapertures being saturated and other being extinguished (cf.
Figure). Besides, when the intensity distribution is non-uniform in a given subaperture, the slope
measurement is biased [2]. Moreover, the point-spread functions of some subapertures suffer from
diffraction effects making it difficult to compute the centroids and to obtain accurate slope
measurements.
We have performed propagation simulations through strong atmospheric perturbations, representative
of daytime LEO downlink with r0 ranging from 4cm to 1cm, and σχ Rytov
2
ranging from 0,08 to 0,9 to

observe the effect of increasing scintillation.
We then study the effect on wavefront sensing accuracy of the sampling of the complex amplitude by
the subapertures grid. Without taking noise into account, we highlight the improvement brought by
oversampling the SHWFS on robustness and accuracy of the measurements.
Finally, regarding the issue of the large intensity variations due to scintillation, we present a centroid
estimator able to perform well from detector noise regime to photon noise and saturation regime.

Astrophysics Field:

Day constraints:

Session 7 / 11

Cosmological constraints from the Chandra-Planck galaxy cluster sample

Auteur: Gaspard Aymerich[1]

Co-auteurs: Gabriel Pratt [2]; Laura Salvati [3]; Marian Douspis [4]

[1] *Institut d'Astrophysique Spatiale, Université Paris-Saclay*

[2] *CEA Service d'Astrophysique*

[3] *IAS, Paris Saclay*

[4] *IAS*

Auteur correspondant gaspard.aymerich@universite-paris-saclay.fr

Galaxy clusters are a powerful cosmological probe: they track the most recent evolution of large scale structure and therefore are fundamental for testing the cosmological model in the recent Universe. To compare the observations of galaxy clusters with theoretical predictions and thus constrain the cosmological parameters of the underlying model, precise knowledge of cluster masses and redshifts is required. Scaling relations between the cluster masses and observables (like the richness in optical wavelength, Y_{SZ} in the mm-band or Y_X in X-rays) are usually used to compute the mass of clusters.
We provide a new scaling relation using a sample of clusters from the Planck Early Sunyaev-Zeldovich (ESZ) catalogue observed in X-rays by Chandra, and compare it to the results of the Planck collaboration from XMM-Newton observations of a subsample of the ESZ. We calibrate a mass bias for a subset of the Planck cosmological cluster sample using published weak-lensing data from the Canadian Cluster Cosmology Project and Multi Epoch Nearby Cluster Survey, for the new scaling relation as well as that from the Planck collaboration, using a novel method to account for selection effects. With these mass biases, we obtain $Y_{SZ} - M_{500}$ scaling relations that we apply to the full Planck cosmological cluster sample, to obtain new constraints on the cosmological parameters. We also provide constraints with a redshift evolution of the scaling relation fitted from the data instead of fixing it to the self-similar value, and find significant deviation from the self-similar value. We compare our results to those from recent analyses based on various cosmological probes, and find that our S_8 constraints are competitive with the tightest constraints from the literature. When assuming a self-similar redshift evolution, our constraints are in agreement with most late time probes and in tension with constraints from the CMB primary anisotropies. When fitting the redshift evolution from the data, we find no significant tension with results from either late time probes or the CMB.

Astrophysics Field:

Cosmology

Day constraints:

Session 7 / 21

Gas dynamics in the Intra-Cluster Medium of galaxy clusters : case study of a simulation of the Virgo cluster

Auteur: Théo Lebeau[1]

Co-auteurs: Jenny Sorce [2]; Nabila Aghanim [3]

[1] *Institut d'Astrophysique Spatiale, Université Paris-Saclay*

[2] *CRIStAL, Univ. Lille-CNRS*

[3] *Institut d'Astrophysique Spatiale*

Auteur correspondant theo.lebeau@universite-paris-saclay.fr

Galaxy clusters are the most massive gravitationally bound structures in the Universe. They lie at the nodes of the cosmic web and are connected to each others by cosmic filaments. These objects are mostly made of dark matter which generates a gravitational potential well in which cosmic gas is trapped and heated, we call it the Intra-Cluster Medium (ICM). Assuming hydrostatic equilibrium, i.e. the balance between gravitational forces and pressure in the ICM, we can infer their mass from X-rays and sub-millimetre observations, and thus use them as cosmological probes. However, complex physics processes (e.g. turbulence, shocks, magnetic fields,⋯) happen in the ICM, which can lead to biased hydrostatic mass estimation. It is therefore crucial to investigate these process in order to accurately measure cluster's masses. In this talk, I will present some investigations about ICM physics in a case study of a simulation of the Virgo cluster.

Astrophysics Field:

Cosmology

Day constraints:

Pas présent à la conférence le mercredi matin et le jeudi matin

Session 7 / 25

Exploring the Uncharted: Proposing High-Frequency Gravitational Wave Detection in the MHz-GHz Range

Auteur: Léonard Lehoucq[1]

[1] *Institut d'Astrophysique de Paris*

Auteur correspondant lehoucq@iap.fr

The gravitational wave (GW) spectrum is a vast frontier, teeming with diverse sources and spanning a wide range of frequencies. The groundbreaking work of LIGO/Virgo in the kHz regime has unveiled approximately 100 compact binary mergers, with ongoing observations in its O4 run promising new and intriguing detections. In the nHz band, pulsar timing arrays (PTAs) are diligently exploring the cosmos, providing initial evidence of a low-frequency stochastic gravitational background, likely emanating from the cosmic dance of supermassive black hole mergers.
Looking ahead, the recently accepted LISA project by the European Space Agency (ESA) holds promise for probing the mHz band in the near future. However, the terrain above LIGO/Virgo frequencies remains largely unexplored. This talk aims to address the intriguing question: What lies in the high-frequency realm, specifically in the MHz-GHz range? Are there plausible sources that could generate GWs at such elevated frequencies, and what innovative detection strategies could be envisioned to unlock this cosmic symphony? Join us as we delve into the uncharted territories of high-frequency GWs, proposing a framework for their detection and opening new avenues for our understanding of the gravitational wave universe.

Astrophysics Field:

Compact objects (supernovae, black holes, neutron stars)

Day constraints:

Session 7 / 42

Investigating the nature of cosmic gamma-ray bursts with MXT aboard SVOM

Auteur: Clara Plasse[1]

[1] *Université Paris-cité, CEA*

Auteur correspondant clara.plasse@cea.fr

Gamma-Ray Bursts (GRB) are the most luminous explosions in the Universe. These intense flashes of gamma rays are either created by the collapse of very massive stars, or the merging of two compact objects - namely two neutron stars. The event of the 17th August 2017, as the first joint observation of a gamma-ray burst electromagnetic signal along with its gravitational wave counterpart, opened the way to multi-messenger astrophysics, and offered astrophysicists solid evidences to hone models involving the merging of two neutron stars. However, some aspects of those models remain open

questions. In particular, the nature of the object arising from such mergers is still widely discussed. SVOM (Space based Variable astronomical Object Monitor) is a Sino-French mission, dedicated to the study of these cosmic explosions. It is planned for launch early 2024 for a nominal mission lifetime of three years. It will carry on-board four instruments, among which the Micro-channel X-ray Telescope (MXT), a focusing X-ray telescope with a field of view of about 1°x1°, sensitive in the 0.2-10 keV energy range. In this talk, I will present the SVOM mission in the context of the multi-messenger era, review MXT performances, and discuss how this mission, and in particular MXT, could enable us to better understand GRBs progenitors.

Astrophysics Field:

Compact objects (supernovae, black holes, neutron stars)

Day constraints:

Session 8 / 40

Characterization and comparison of sample returns from the C-type asteroids Ryugu and Bennu

Auteur: Laura Nardelli[1]

[1] *IAS*

Auteur correspondant laura.nardelli@universite-paris-saclay.fr

Primitive asteroids are remnants of the early stage of the Solar System evolution and may have preserved the mineralogical and molecular phases formed during this period.
In 2020, the Hayabusa2 mission of JAXA brought back to Earth, samples from the C-type asteroid Ryugu, a primitive near-Earth object, collected at two different locations and depths. The samples are now preserved and submitted to a first round of analyses at the ISAS Curation center (Sagamihara, Japan) under an ultraclean nitrogen purged chamber to prevent H2O/CO2 contamination. In particular, the MicrOmega instrument, a NIR hyperspectral microscope conceived at IAS, contributes to the characterization of the returned samples (e.g. Pilorget et al. 2022). Recently, the NASA mission OSIRIS-REx also brought back samples from the near-Earth primitive asteroid Bennu (Lauretta et al. 2022). A fraction of these samples will be transferred to ISAS in a Curation Facility similar to that of Ryugu samples, allowing us to characterize, with MicrOmega, the mineralogical and molecular composition of the grains in the same conditions as for Ryugu samples. The comparison between these two asteroids samples using the same instrument under the sames measurements conditions will allow us to better constrain the genericity or specificity of the processes identified.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

not Wednesday 28 morning

Session 8 / 3

First measurement of the composition of exocomets.

Auteur: Théo Vrignaud[1]

[1] *Institut d'Astrophysique de Paris*

Auteur correspondant vrignaud@iap.fr

Extrasolar comets –or exocomets –are icy bodies placed on elliptical orbits which sublimate when they reach their periastron, producing extensive clouds of dust and gas –the so-called 'cometary tails' . The most famous star known to harbor such objects is Beta Pictoris, a young (20 Myr) A-type star, for which transiting comets are detected daily using absorption spectroscopy.
However, despite more than 35 years of observations, still very little information on the composition of these objects is known. Here, I will present a new analysis of archival HST/STIS data, which led to the first measurement of the abundance of several metallic species –Si, Fe, Ni, Mn… - within the tails of Beta Pictoris exocomets, and to the estimate of their physical properties. These results are of crucial importance to better understand the history of these objects and the main mechanisms at work within their gaseous tails.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

I won't be available on Friday afternoon (March 1st).

Session 8 / **29**

Particle content of inclined cosmic-ray air showers for radio signal modeling

Auteur: Marion Guelfand[1]

[1] *LPNHE*

Auteur correspondant marion.guelfand@sorbonne-universite.fr

Ultra high energy (UHE) cosmic rays, with energies above 10^{17} eV, can provide us key information on the most extreme processes in the Universe. When reaching the Earth, UHE cosmic rays penetrate the atmosphere and interact with air molecules, inducing a cascade of secondary particles, a so-called extensive air shower (EAS). The electromagnetic part of this cascade is mainly responsible for the emission of a radio signal. The detection of this radio emission is a new challenge for next generation UHE particle experiments, such as GRAND, an envisioned observatory which will consist of 200,000 radio antennas deployed in sub arrays at different locations worldwide. These experiments will focus on very inclined air showers, to maximize the size of the radio footprint on the ground, hence the detection efficiency. The physics of these very inclined air showers has however not been thoroughly studied. In this work, we examine the electromagnetic content of air showers arriving to Earth with various inclinations, their energy contribution to radio emission and their spatial distribution. We use the detailed Monte Carlo simulation tools CORSIKA and CoREAS and analytical modeling from physical principles, and we find that very inclined air showers submitted to an intense geomagnetic field present characteristic features which could lead to clear signatures in the radio signal, and hence impact the detection and reconstruction strategies of GRAND.

Astrophysics Field:

Not in the above

Day constraints:

Session 8 / **50**

Probing High Energy Physics With the Cosmological Collider

Auteur: Arthur Poisson[1]

[1] *IAP*

Auteur correspondant poisson@iap.fr

It is well established that the paradigm of cosmological inflation is the correct framework for understanding the physics of the very first moments of our universe. It states that the universe went through a short phase of accelerated expansion in which the microscopic quantum fluctuations of its matter content were stretched to macroscopic scales, becoming the seed for all the observed structures of the cosmos e.g. the Cosmic Microwave Background or the Large Scale Structures.
Apart from its manifest interest in the understanding of the first moments of the universe, it is also the best way we know to probe the fundamental physics at very high energies. In particular, the spontaneous production of massive particles due to the expanding background can leave potentially visible imprints in the correlation functions known as the cosmological collider signal.
In this talk, I will expose a framework that allows one to treat the interactions of the necessary present inflaton field fluctuations and some massive particles and I will review the kind of processes that can lead to the above-mentioned signal. In particular, the theory features a necessary quadratic mixing which allows flavor oscillations between the two fields which will be the subject of our future work.

Astrophysics Field:

Cosmology

Day constraints:

Session 8 / **27**

Unveiling the Cosmic Dawn: numerical simulations and machine learning to analyse the first billion years of the Universe

Auteur: Romain Meriot[1]

[1] *LERMA - observatoire de Paris*

Auteur correspondant romain.meriot@obspm.fr

My PhD project aims at improving the modelling of the Cosmic Dawn (z~25 to 10) and the Epoch of Reionization (z~10 to 6), periods in the history of the Universe that corresponds to the birth of the very first galaxies, and at developing novel methods for extracting model parameters from current and future 21cm observations by e.g. NenuFAR/LOFAR/HERA/SKA. To do so, I present LoReLi, a public dataset now containing 10 000 21cm signals computed from radiative hydrodynamics Licorice simulations. I will discuss the design of machine-learning-based inference pipelines and their applications to the latest measurements of the HERA interferometer, showing that "cold" reionization scenarios are unlikely to accurately represent our Universe.

Astrophysics Field:

Cosmology

Day constraints:

Session 8 / **51**

Precession and Polar Motion of Venus

Auteur: Pierre-Louis Phan[1]

[1] *IMCCE*

Auteur correspondant pierre-louis.phan@obspm.fr

Examining the rotational dynamics of an object can offer clues about the nature and properties of its interior. Our knowledge of Venus' internal structure is currently limited, in particular for its core whose size still lacks meaningful constraints, and whose state (liquid or solid) is unknown.
The variations of orientation of a planet are usually modeled as a rotation about a spin axis, which can move with respect to the fixed celestial sphere (precession + nutation) and can also move with respect to the surface itself (polar motion). The precession motion of the spin axis of Venus has recently been measured for the first time albeit with an uncertainty too large to help constrain interior models, and its polar motion has yet to be measured.
Several exploration missions to Venus are planned for the next decade, and the EnVision orbiter (ESA) will use its radar to image the surface with a resolution of tens of meters over a few years. Here, we develop a model of Venus'precession and polar motions by taking into account last estimation of its moments of inertia (triaxial body), orientation measurements and orbital perturbations.
The analysis of this rotational dynamic will contribute to refining models of the planet's internal properties ; such knowledge is necessary to improve our understanding of the history of Venus as a whole system.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 9 / 8

Characterizing exoplantery atmospheres with SPIRou

Auteur: Adrien Masson[None]

Co-auteurs: Sandrine Vinatier [1]; Bruno Bézard [1]; ATMOSPHERIX team

[1] *LESIA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université Paris Cité, 5 place Jules Janssen, 92195 Meudon, France*

Auteur correspondant adrien.masson@obspm.fr

High-resolution spectroscopy (HRS) enables the unprecedented atmospheric characterization of transiting exoplanets. However, conducting these ground-based observations requires careful data processing and analysis to eliminate the Earth's atmospheric contribution and the signature from the background host star.

In this presentation, I will introduce the techniques currently employed by the HRS community to detect molecular and atomic signatures in the atmospheres of transiting exoplanets. These methods allow us to derive constraints on atmospheric components, investigate potential atmospheric escape, and highlight the complementary nature of ground-based observations to space-based missions such as JWST, PLATO, and Ariel.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

I am limited to Friday 1st March only

Session 9 / 2

An experimental simulation of the atmosphere of the temperate exoplanet K2-18b

Auteur: Orianne SOHIER[1]

[1] *LATMOS*

Auteur correspondant orianne.sohier@latmos.ipsl.fr

Observations made in recent years by the Kepler, Hubble, Spitzer and James Webb space telescopes have revealed the presence of an atmosphere around the temperate exoplanet K2-18b. According to the latest JWST observations, this H2-rich atmosphere contains significant proportions of carbon-bearing molecules such as CO2 and CH4. The detection of such molecules is extremely interesting in the context of astrobiology; indeed, we can imagine the formation of more complex organic molecules through photochemical reactions in the upper atmosphere. These potential photochemical products would be present in small proportions, not necessarily detectable in observations.
To investigate the possibility of forming longer carbon chains through photochemical reactions in an atmosphere like that of K2-18b, it is necessary to rely on laboratory experiments. A gaseous mixture, analogous to K2-18b's atmosphere, is produced in a cold AC plasma reactor (PAMPRE) and subjected to a plasma simulating the energetic radiation to which the exoplanet's upper atmosphere may be exposed. The reactions taking place in the chamber are monitored by mass spectrometry, enabling us to identify the chemical evolution of the gas mixture.
The results indicate the production of carbon monoxide, water vapor and some organics, which would therefore be minor components of K2-18b's atmosphere. We have also highlighted that methane cannot be a simple product of CO2 dissociation, implying another source of CH4 to explain the observations.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 9 / 9

A Glimpse into the Dark Ages: the JWST's UNCOVER program and high-redshift Discoveries

Auteur: Iryna Chemerynska[None]

Co-auteur: Hakim Atek [1]

[1] *Institut d'Astrophysique de Paris*

Auteur correspondant iryna.chemerynska@iap.fr

Over the past few years, the JWST has made some remarkable discoveries. The JWST UNCOVER program, which made observations through the lensing cluster A2744, has led to the discovery of 16 galaxy candidates at redshifts between 9 and 11, and three candidates in the range $11 < z < 13$. Detailed studies of these candidates show a rapid evolution of the mass-luminosity relation and the UV continuum slope beta towards high redshift. Interestingly, some of these candidates at $z > 9$ have shown a clear indication of a Balmer break or strong optical emission lines. With ultra-deep NIRSpec follow-up observations, we reported a 100% success rate in their spectroscopic confirmation, which demonstrates the accuracy of the photometric selection. Furthermore, using comprehensive lensing simulations, we constructed the most accurate UV luminosity function at $z > 9$. Our analysis has led to a clear overabundance of bright galaxies (with Muv > -20) compared to theoretical predictions and previous findings by the HST, which is consistent with recent JWST studies. Looking ahead, we eagerly anticipate the JWST Cycle 2 program GLIMPSE, which will obtain the deepest observations

on the sky to date, to identify the faintest galaxy populations from the Dark Ages to the epoch of reionization.

Astrophysics Field:

Not in the above

Day constraints:

not Thursday morning

Session 9 / **20**

Tracing gaseous filaments connected to galaxy clusters: the case study of Abell 2744

Auteur: Stefano Gallo[None]

Auteur correspondant stefano.gallo@ias.u-psud.fr

Due to their sizes and postions, at the nodes of the cosmic web, galaxy clusters are particularly suited to study the mechanisms of baryon accretion throughout the large scale structures of the Universe. Filaments connected to clusters are crucial environments in this process, where baryons heat and interact, while being funnelled towards the clusters'deep gravitational potentials. Galaxy clusters are composed for about 15% of their mass of baryons, the majority of which are in the form of gas. Inside clusters gas reaches high densities and temperatures, which makes it detectable at different wavelenght. On the other hand, identifying gas in filaments is often a challenge, due to their lower density contrast which produces faint signals. The best chance to detect these signals is therefore in the outskirts of galaxy clusters, and indeed an indication of extended X-ray emission from filamentary structures has been reported by Eckert et al. (2015), around the dynamically complex galaxy cluster Abell 2744. In this work, we revisit these data using statistical estimators of anisotropic matter distribution to identify filamentary patterns around A2744. We report for the first time the blind detection of filaments connected to a galaxy cluster from X-ray observations. We compare this results with visually identified regions, and with filaments extracted from the distribution of spectroscopic galaxies, through which we demonstrate the robustness and reliability of our techniques in tracing filamentary structures connected to galaxy clusters.

Astrophysics Field:

Cosmology

Day constraints:

Possibly not on Friday afternoon

Session 10 / **41**

Deep learning for focal plane wavefront control for direct imaging of exoplanets

Auteur: Yann Gutierrez[1]

[1] *Observatoire de Paris/LESIA*

Auteur correspondant yann.gutierrez@obspm.fr

Direct imaging of exoplanets will facilitate the search for habitable worlds by enabling the generalized characterization of their atmospheres. High-contrast imaging instruments equipped with coronagraphs suppress starlight, allowing the detection of faint exoplanetary companions. However, optical aberrations introduce starlight residuals (speckles) that hinder the detection performance in the coronagraphic image. High-precision focal plane wavefront control methods utilize deformable mirrors guided by focal plane aberration estimation to minimize the intensity of the speckles. Current methods rely on imperfect physical models of the instruments, limiting correction accuracy to a few nanometers, falling short of the sub-nanometer precision demanded for Earth-like exoplanet detection. This thesis investigates the potential of deep learning to surpass current limitations in focal plane wavefront control. Specifically, we explore the application of model-free reinforcement learning to circumvent the need for physical models. In this presentation, we will show initial training on a simpler non-coronagraphic active optics problem in simulations which lays the foundation for future exoplanet imaging applications.

Astrophysics Field:

Instrumentation

Day constraints:

Friday March 1st

Session 10 / 34

Test of Cosmic Web-Feeding Model for Star Formation in Galaxy Clusters in the COSMOS Field

Auteur: Eunhee Ko[1]

Co-auteurs: Clotilde Laigle [1]; Myungshin Im [2]; Seong-Kook Lee [2]

[1] *IAP*

[2] *Seoul National University*

Auteur correspondant eunhee.ko@iap.fr

It is yet to be understood what controls the star formation activity in high-redshift galaxy clusters. One recently proposed mechanism is that galaxy clusters can remain star-forming when fed by infalling groups and star-forming galaxies from large-scale structures surrounding them. Using the COSMOS2020 catalog that has half a million galaxies with high accuracy ($\sigma_{\Delta z/1+z} \sim 0.01$) photometric redshifts, we study the relationship between star formation activities in galaxy clusters and their surrounding environment to test the web-feeding model. We first identify 68 cluster candidates at $0.3 \leq z \leq 1.4$ with halo masses at $10^{12.9} - 10^{14.4}\ M_{\odot}$, and the surrounding large-scale structures (LSSs) with the friends-of-friends algorithm. We find that clusters with low fractions of quiescent galaxies tend to be connected with extended large scale structures as expected in the web-feeding model. We also investigated the time evolution of the web-feeding trend using the IllustrisTNG cosmological simulation. Even though no clear correlation between the quiescent galaxy fraction of galaxy clusters and the significance of large scale structures around them is found in the simulation, we verify that the quiescent galaxy fractions of infallers such as groups ($M_{200} \geq 10^{12}\ M_{\odot}$) and galaxies ($M_{200} < 10^{12}\ M_{\odot}$) is smaller than the quiescent fraction of cluster members and that infallers can lower the quiescent fraction of clusters. These results imply that cluster-to-cluster variations of quiescent galaxy fraction at $z \leq 1$ can at least partially be explained by feeding materials through cosmic webs to clusters.

Astrophysics Field:

Cosmology

Day constraints:

Session 10 / 47

A hierarchical approach for field level inference using Quijote Simulations

Auteurs: Anirban BAIRAGI[1]; Benjamin Wandelt[1]

[1] *IAP*

Auteur correspondant anirban.bairagi@iap.fr

Advancing cosmological parameter inference with reduced uncertainties is a vibrant area of research, especially with the wealth of data from next-generation surveys like Euclid, DESI, and the Vera Rubin Observatory. This talk focuses on Simulation-Based Inference (SBI), utilizing summary statistics such as the Power Spectrum P(k) and Bispectrum B(k). However, these summaries fail to fully harness the non-Gaussian and non-linear features of the cosmological density field. To extract this crucial information, a field-based analysis is preferable, although its success hinges on model architecture, hyperparameter tuning, and the ability to fit high-resolution density fields into GPUs. We introduce a hierarchical approach that combines small-scale information from sub-volumes (patches) with large-scale information from the Power Spectrum. Our method demonstrates enhanced Fisher information about the cosmological parameters compared to using P(k) or B(k) alone.

Astrophysics Field:

Cosmology

Day constraints:

Preferably in the afternoon, March 1st

Session 10 / 26

Collision Course: Reevaluating the Origin of Mars' Moons through Orbital Simulations

Auteur: Ryan Dahoumane[1]

Co-auteurs: Kévin Baillié [2]; Valéry Lainey [2]

[1] *IMCCE, Observatoire de Paris*

[2] *IMCCE, Observatoire de Paris, PSL Research University, Sorbonne Université, CNRS, Université Lille, Paris, France*

Auteur correspondant ryan.dahoumane@obspm.fr

This conference presentation delves into recent advancements in understanding the formation and evolution of Mars' moons, Phobos and Deimos. Building upon Bagheri et al.'s 2021 hypothesis suggesting the dislocation of a larger progenitor as the origin of these moons, the study by Hyodo et al. in 2022 challenges this idea. Hyodo et al. argue that under reasonable assumptions about the post-dislocation orbits of Phobos and Deimos, a collision between the two moons becomes almost inevitable within 10,000 years, leading to their mutual annihilation. These findings are based on n-body simulations, accounting for Mars' J2 and J4 gravitational perturbations and mutual perturbations between the moons.
In this presentation, we extend these simulations by incorporating additional factors such as solar perturbations, Mars' axial precession, and its deformation along three axes. We also change some of the hypothesis taken by Hyodo et al concerning the initial distribution of Phobos and Deimos after the dislocation. Our analysis reveals that including these additional influences does not alter the ultimate fate of Phobos and Deimos. The moons still converge towards collision within comparable timescale, supporting Hyodo et al.'s conclusions : the formation of Mars'moons from the dislocation of a progenitor is very unlikely.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

I will not be able to make a presentation on Friday afternoon

Session 10 / 31

Phobos photometic properties from Mars Express HRSC observations

Auteur: Antonin Wargnier[1]

Co-auteurs: Sonia Fornasier [1]; P. H. Hasselmann [2]; Daniela Tirsch [3]; K.-D. Matz [3]

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The Mars Express mission has been orbiting Mars since 2004, and it has acquired several observations of Phobos which were never published in the literature. We have analyzed resolved images of Phobos, available at the ESA Planetary Science archive, acquired between 2004 and 2022 by the High Resolution Stereo Camera (HRSC) on board the Mars Express spacecraft. We used both data acquired with the blue-green-red and IR filters of HRSC, which are absolutely calibrated in flux, and the panchromatic data of the Stereo Resolution Camera, which are relatively but not absolutely calibrated. The SRC data are quite unique because they cover small phase angles (0.2°-10°) permitting to investigate Phobos opposition effect. Photometric analysis was performed both on disk-averaged photometry and, for the 4 absolute calibrated filters, on disk-resolved images. The opposition surge parameters were determined from Hapke (2012) model of the SRC data, after arbitrary normalization to match the radiance of the HRSC green filter data at 5° of phase angle. The results of the modeling show that the surface of Phobos is dark with an albedo of 6.85 % in the green filter, centered at 538 nm, and diffusing the light in the backward direction. We find that Phobos has a relatively strong opposition effect due to shadow-hiding, with amplitude and half-width of the opposition surge values of 2.28 and 0.057, respectively. These values are considerably lower compared to those determined by Simonelli et al. (1998), and similar to those found for comet 67P (Fornasier et al., 2015). We also found a surface porosity of 87% , indicating the presence of a thick dust mantle or of fractal aggregates on the top surface. We present in this work the results of the photometric modeling for the different HRSC filters, the single scattering albedo maps, and a comparison of Phobos photometric properties with those of other satellites and dark minor bodies. These results are of high interest in support of the JAXA Martian Moons Exploration mission (MMX). This mission has as main goals the return of Phobos samples, the detailed investigation of Mars satellites and to determine the origin of the martian moons.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Only possible:
-28th in the morning
- 1st (morning+afternoon)

Session 10 / 39

MODÉLISATION DU CYCLE DES POUSSIÈRES SUR LA PLANÈTE MARS

Auteur: Thomas Pierron[None]

Auteur correspondant thomas.pierron@lmd.ipsl.fr

Le climat et la météorologie de la planète Mars que nous connaissons aujourd'hui sont contrôlés par la présence d'aérosols minéraux soulevés par les vents qui créent de véritables tempêtes de poussières. Ces tempêtes peuvent être locales, régionales, et même certaines années globales. Dans ce dernier cas la quasi-totalité de la planète est alors cachée sous une épaisse couche de poussière. Malgré des années d'observation et de modélisation, la saisonnalité et la localisation de ces tempêtes restent mal comprises. Nous présenterons donc une nouvelle approche de modélisation de ce cycle de poussières Martien en utilisant toute une hiérarchie de modèles numériques à différentes résolutions afin de comprendre et reproduire les tempêtes telles qu'elles sont observées.

Astrophysics Field:

Planetology (including small bodies and exoplanets)

Day constraints:

Session 4 / 10

Mass-Metallicity Insights from Extreme Low-Mass Galaxies

Auteur: Iryna Chemerynska[1]

Co-auteur: Hakim Atek [1]

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Auteur correspondant iryna.chemerynska@iap.fr

During this talk, I will be discussing our findings on the mass-metallicity relation (MZ) in low-mass galaxies. Our sample consists of eight galaxies at a redshift of 7, which we identified in the JWST/NIRSpec data of the lensing cluster Abell 2744 as part of the JWST Cycle 1 program, UNCOVER. By combining ultra-deep NIRSpec observations with the strong gravitational lensing boost of Abell 2744, we were able to derive the first spectroscopic constraints on the prevalence of faint galaxies and their ionizing properties during the first billion years of the Universe.
We used the strong lines method with the new metallicity calibrations to determine the metallicities of the galaxies. We then obtained the MZ relation and star-formation-rate (SFR)-MZ relations at this redshift. Our best-fit relation shows a similar slope to the FIRE simulations but with an upward shift. Overall, we found that these low-mass galaxies have slightly higher metallicities than expected from extrapolation from their massive counterparts and theoretical predictions of galaxy formation. These higher metallicities may indicate weaker outflows and a lower efficiency of gas removal. The observed dispersion can also be the consequence of highly stochastic star formation and ISM enrichment, which is expected in these low-mass systems.

Astrophysics Field:

Not in the above

Day constraints:

not Thursday morning