Agenda for the Postdoc & Engineer Day

Time	Speaker	
10:00-10:05	Opening	
10:05-10:20	Grégoire Aufort	Studying the Effect of Environment on Star Formation History with Simulation Based Inference
10:20-10:35	Neda Heidari	Detection and characterization of long-period planet
10:35-10:50	Étienne Camphuis	Cosmological parameters from CMB temperature and E-mode polarization anisotropies with 2019 and 2020 data from the South Pole Telescope
10:50-11:05	Joe Lewis	Understanding the first galaxies
11:05-11:25	Coffee break	
11:25-11:40	Angelo Caravano	Lattice simulations of inflation
11:40-11:55	Lennart Balkenhol	Cosmic Microwave Background Analysis with a Differentiable Likelihood
11:55-12:10	Deaglan Bartlett	Fast, interpretable, high-precision formulae for the LCDM linear and nonlinear matter power spectra
12:10-12:25	Céline Gouin	Matter accretion from galaxy clusters to cosmic filaments
12:25-12:40	Frank Soldano	Data Quality Control for the Euclid VIS instrument: how to deal with Euclid post-launch surprises to produce the best possible science?
12:40-12:55	Filip Alamaa	Intrapulse spectral evolution in photospheric gamma-ray bursts
12:55-13:05	Conclusion	
Buffet		

Gregoire Aufort:

Title: Studying the Effect of Environment on Star Formation History with Simulation Based Inference

Abstract:

Using Simulation-Based Inference, we investigate the correlations between environmental factors and the Star Formation History of galaxies. Leveraging the hydrodynamical simulation Horizon-AGN, we aim to exploit photometric data from the Euclid Deep Fields to quantify the role of the environment, such as the the distance to the nodes and filaments of the Cosmic Web, in shaping stellar population formation and evolution. Our approach enables the extraction of detailed insights from the cosmological simulation and its effective use to perform rigorous statistical inference using only few photometric broad-bands. We present results on a simulated catalogue, as well as preliminary observations from the COSMOS survey.

Neda Heidari:

Title: Detection and characterization of long-period planet

Abstract:

Transiting planets with orbital periods longer than 40 days with mass and radius determined are extremely rare, accounting for only 1% of the 5000+ discovered planets. The two methods of radial velocity and photometry, each have their own unique challenges when it comes to detecting these long-period planets. As a result, the study of planet demographics, formation, evolution, and star-planet relations is hampered by the absence of these populations. In this talk, I will discuss my work at IAP to discover and characterize this "missing population".

Étienne Camphuis:

Title: Cosmological parameters from CMB temperature and E-mode polarization anisotropies with 2019 and 2020 data from the South Pole Telescope.

Abstract:

SPT-3G, the third-generation camera on the South Pole Telescope, is being used to observe the cosmic microwave background (CMB) anisotropies to unprecedented depth at arcminute resolution. The temperature and E-mode polarization anisotropies of the CMB provide a wealth of information on the composition and evolution of the universe. Upcoming constraints on cosmological parameters from power spectrum analyses based on data collected in 2019/2020 will be comparable to Planck's, while remaining mostly independent from the satellite experiment, thus allowing to test the consistency of the two data sets and potentially discover evidence of new physics. In this talk, I will describe the analysis pipeline, showcase our measurement and outline the steps towards cosmological parameters.

Joe Lewis:

Title: Understanding the first galaxies

Abstract:

Great strides are being made in the detection and description of the most distant and early galaxies. Constraining the population of the first galaxies is a key task in understanding galaxy formation, but to this day, much about these primordial objects still eludes us. In this talk, I will present the Reionization of the IGM as acomplementary probe of the population of early galaxies. Fully leveraging this probe requires an extensive study of the link between the formation of galaxies and the ionization of neutral Hydrogen in the IGM. I will discuss how this link can be uncovered using numerical simulations of Reionization and galaxy formation.

Angelo Caravano:

Title: Lattice simulations of inflation

Abstract:

Developing non-perturbative methods might be crucial for understanding inflation and its predictions. In this talk, I will present a nonlinear study of the inflationary epoch of the Universe based on numerical lattice simulations. Using some

examples, I will show that the simulation can be a powerful tool for understanding inflation and its predictions, both for large-scale observables (such as large-scale structure and CMB) and small-scale observables (primordial black holes and gravitational wave backgrounds).

Lennart Balkenhol:

Title: Cosmic Microwave Background Analysis with a Differentiable Likelihood

Abstract:

Upcoming Cosmic Microwave Background (CMB) data sets will allow us to substantially improve on Planck results. But with great data comes great responsibility; any result hinting at new physics is only as credible as its underlying analysis pipeline is robust. In this talk, I present candl: a JAX-powered, differentiable, python-based likelihood for CMB data. Thanks to JAX's automatic differentiation algorithm, calculating the derivatives of candl likelihoods - and by extension Fisher matrices - is robust, quick, and easy. I go through a series of example calculations showing data robustness tests, survey optimisation, and gradient-based likelihood exploration techniques. candl comes with the latest primary CMB and lensing data from the South Pole Telescope and Atacama Cosmology Telescope collaborations; candl is pip-installable and publicly available on GitHub.

Deaglan Bartlett:

Title: Fast, interpretable, high-precision formulae for the LCDM linear and nonlinear matter power spectra

Abstract:

The matter power spectrum of cosmology, P(k), is of fundamental importance in cosmological analyses, yet solving the Boltzmann equations and running N-body simulations can be computationally prohibitive if required several thousand times, e.g. in a MCMC. Emulators for P(k) as a function of cosmology have therefore become popular, whether they be neural network or Gaussian process based. Yet one of the oldest emulators we have is an analytic, physics-informed fit proposed by Eisenstein and Hu (E&H). Given this is already accurate to within a

few percent for the linear case, does one really need a large, black-box, numerical method for calculating P(k), or can one simply add a few terms to E&H? In this talk I demonstrate that Symbolic Regression can obtain such a correction, yielding sub-percent level predictions for P(k), both for the linear and nonlinear case. Our work greatly increases the speed and accuracy of symbolic approximations to P(k), making them significantly faster than their numerical counterparts without loss of accuracy.

Céline Gouin:

Title: Matter accretion from galaxy clusters to cosmic filaments

Abstract:

Galaxy clusters are connected at their peripheries to the large scale structures by cosmic filaments that funnel accreting material. I investigate these filamentary structures to probe both environment-driven galaxy evolution, out-of-equilibrium gas physics, and structure formation processes. First, I will present how the number of filaments that are connected to clusters can be related to the dynamical state and the formation history of galaxy clusters by using IllustrisTNG simulation (Gouin et al., 2021). Secondly, I will show how the gas is distributed around these simulated galaxy clusters, from the hot plasma inside clusters, up to the warm hot intergalactic medium slowly infalling along filaments (Gouin et al., 2022), and explaining soft X-rays observations (Gouin et al., 2023). Finally, the quenching of infalling galaxies, from filaments to clusters is explored in both SDSS data and Magneticum simulation (Gouin et al., 2020).

Frank Soldano:

Title: Data Quality Control for the Euclid VIS instrument: how to deal with Euclid post-launch surprises to produce the best possible science?

Abstract:

During the first months of the Euclid mission, many surprises have appeared, such as ice or X-rays. At the same time, the instrument has shown that it meets all the requirements to produce excellent scientific data. In this talk, I

will present how we are dealing with all these surprises and what we have integrated to control the quality of the data provided to the researchers.

Filip Alamaa:

Title: Intrapulse spectral evolution in photospheric gamma-ray bursts

Abstract:

Gamma-ray bursts (GRBs) originate in ultra-relativistic jets. These jets are initially optically thick, which means that the radiation inside cannot escape. The trapped radiated is released near the photosphere, leading to a short-duration pulse in the observer frame. However, photons experience their last scattering across a wide range of radii, over which the photon distribution could change drastically. In this talk, I show how changes to the local radiation spectrum close to the photosphere can leave an imprint on the emitted signal and characterize the observed signal as a function of time.