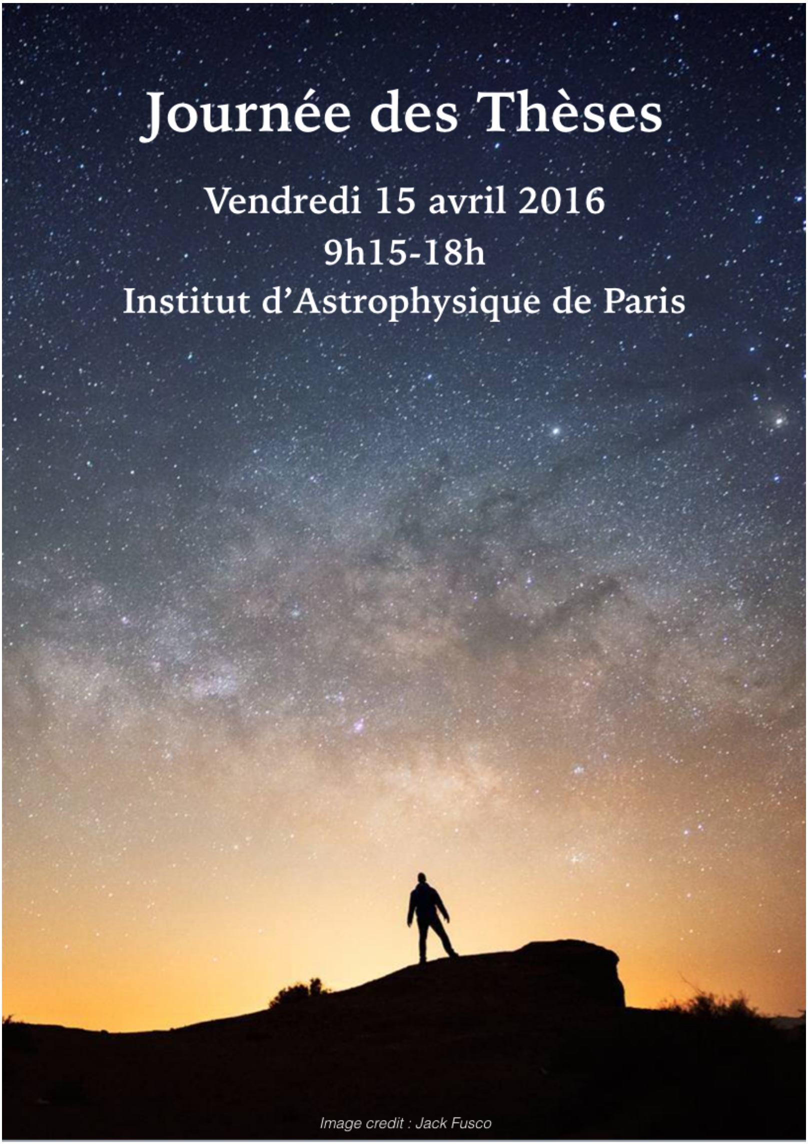
Journée des Thèses
Vendredi 15 avril 2016
9h15-18h
Institut d'Astrophysique de Paris
Image credit : Jack Fusco

Timetable

09:15	*Welcoming*
09:30	Laura Bernard
09:50	Clotilde Laigle
10:10	Federico Mogavero
10:25	Erwan Allys
10:40	Thomas Lacroix
11:00	*Coffee*
11:20	Oscar Ramos
11:35	Caterina Umiltà
11:50	Alba Vidal Garcia
12:10	Rebekka Bieri
12:30	Sébastien Carassou
12:45	*Lunch*
14:45	Tanguy Marchand
15:00	Jean-Baptiste Fouvry
15:20	Jesse Palmerio
15:35	Luciana Ziino
15:50	*Coffee*
16:15	Florian Sarron
16:30	Céline Gouin
16:45	Nicolas Cornuault
17:00	Mélanie Habouzit
17:20	Siwei Zou
17:35	Tilman Hartwig
18:00	*Cocktail*

Dynamics of non-spinning compact binaries at the fourth post-Newtonian order

The coalescence of compact binary systems are among the most promising sources of gravitational waves for the current and next generations of interferometers. Due to the faintness of the signal, both the detection and precise determination of the physical parameters require highly accurate template banks of theoretical waveforms, which are then filtered against the detector data.

During the inspiral phase of the coalescence, when the two objects are widely separated, the perturbative post-Newtonian approach allows one to describe the dynamics of the binary system and to compute the radiation energy flux, from which the orbital phase evolution can be derived.

In this talk, I will address the question of the equations of motion at the fourth post-Newtonian order in harmonic coordinates. I will present a method based on a Fokker action, adapted to the specificities of the post-Newtonian formalism in harmonic coordinates. In particular, I will focus on the treatment of the so-called tail effects which appear for the first time in the dynamics at 4PN.

Supervisor: Luc Blanchet

Understanding galaxy populations throughout Cosmic Time: Joint analysis of observed and simulated lightcones

The study of the co-evolution of the cosmic web and galaxies embedded within it, from the epoch of cosmic dawn (formation of the first galaxies) to today relies heavily on comparisons of real observations on large field with virtual galaxy surveys produced by state-of-the-art cosmological hydrodynamics simulations. They allow to carry out meaningful statistical measurements of the differences between models and observations. In other words, analysing images of galaxies, whether captured by a telescope or generated with a supercomputer tuned to have the same limitations as this telescope, ensures that we are comparing (millions of) apples to apples. I will present results of such comparative analyses based on COSMOS field and Horizon-AGN, which provide invaluable detailed insight on the evolution of galaxy stellar masses and morphological transformations as a function of environment and cosmic time.

Supervisors: Henry McCracken & Christophe Pichon

Microlensing planet detection via geosynchronous and low Earth orbit satellites

The gravitational lensing of light has lead to the discovery of dozens of extrasolar planetary systems during the last decade. Moreover, it provides one of the very few methods to measure mass and abundance of free-floating planets and isolated brown dwarfs in the Galaxy. However, planet detection through microlensing is usually limited by a well-known degeneracy in the Einstein timescale t_E, which prevents mass and distance of the lens to be univocally determined. It has been shown that a satellite in geosynchronous orbit could provide masses and distances for most standard planetary events ($t_E \approx 20$ days) via a microlens parallax measurement. We extend the analysis to shorter Einstein timescales, $t_E \approx 1$ day, when dealing with the case of Jupiter-mass lenses. We then study the capabilities of a low Earth orbit satellite on even shorter timescales, $t_E \approx 0.1$ days. We show that a geosynchronous satellite could detect parallaxes for Jupiter-mass free floaters and discover planetary systems around very low-mass brown dwarfs. Moreover, a low Earth orbit satellite could lead to the discovery of Earth-mass free-floating planets.

Supervisor: Jean-Philippe Beaulieu

Bosonic structure of supersymmetric cosmic strings in a realistic GUT context

The most advanced observations in cosmology can probe the early universe up to energies around 10^{15} GeV, where we expect a grand unification theory to describe particle physics. At this scale, the data are compatible with a phase of inflation, which would create the primordial fluctuations that seed the large scale structures. In a realistic particle physics model, the production of topological defects like cosmic strings is unavoidable, and could be observed in principle. However, their microscopic structure is rarely considered, and usually only toy-models are used. We will describe how the complete microscopic structure of such objects can be studied in this context, using the most recent cosmological and high energy physics theories, such as hybrid inflation and super-symmetric grand unified theory. We will then discuss the properties of those realistic strings, and the cosmological consequences they imply.

Supervisor: Peter Patrick

Interpretations of new gamma-ray emissions from the center of the Milky Way and Centaurus A

Gamma rays are an extremely valuable source of information on the high-energy processes taking place at the center of galaxies. In this presentation I will describe two very intriguing features recently reported in the gamma-ray spectra of the central region of the Milky Way and the Centaurus A radio galaxy. I will discuss the interpretation of these features in terms of the high-energy emission of electrons and positrons produced either by the annihilation of dark matter particles distributed in a very steep density spike in the central region of galactic halos, or by a population of millisecond pulsars.

Supervisors: Joseph Silk (IAP) & Céline Boehm (Institute for Particle physics Phenomenology, Durham, UK)

Testing Lorentz Invariance by binary black holes

The recent detection of gravitational waves has opened a new avenue towards the highly-relativistic and dynamical strong-field regime of the Einstein equations. It's therefore possible to test GR in a new arena characterized by velocities comparable to the speed of light and by large, dynamical curvatures. After describing how gravitational waves and binary black holes can be used to test GR, we will focus upon one particular alternative: Lorentz-violating gravity. Although Lorentz-invariance is at the heart of theoretical physics, it's violation in the gravitational sector may lead to a quantum theory of gravitation, for instance. Thus, we will show the first steps towards the ambitious project of using GW signals to test Lorentz-violating theories.

Supervisors: Luc Blanchet & Enrico Barausse

Improving Planck cosmological results with component separation

The Planck mission provided whole sky maps in the microwave range, which have opened a window on precision cosmic microwave background (CMB) science in cosmology. For this purpose, accuracy in the separation technique of foreground astrophysical emissions becomes crucial. A lot of effort has been done within the Planck Collaboration, however, the CMB maps they delivered still have a residual foreground contamination too high for cosmological exploitation. Among these residuals, the unresolved point sources background is one of the most perturbing, since this is a not well known emission ad since it is degenerate with the small scales of the CMB angular power spectrum. This degeneracy can be removed either by assuming a model for the CMB, as is the case for the Planck 2015 likelihood, or by introducing some physical knowledge about the point sources background. I will present our work to tackle this problem, by modeling the unresolved point sources as two independent families, a radio and an infrared one. This constraint breaks the degeneracy and allows, through the blind component separation algorithm SMICA, to better characterize the foreground residual, which is a crucial step towards estimating cosmological parameters.

Supervisors: Karim Benabed & Jean-François Cardoso

Modeling ultraviolet-line diagnostics of stars, the ionized and the neutral interstellar medium in star-forming galaxies

I will present a combination of state-of-the-art models for the production of radiation by young stellar populations and its transfer through the ionized and the neutral ISM to investigate the ultraviolet spectral diagnostics of these three components in star-forming galaxies. We investigate the ultraviolet spectral features individually most sensitive to the properties of stars, the ionized and the neutral gas. Beyond an a posteriori justification of the main spectral diagnostics useful to characterize stellar populations, the ionized and the neutral ISM, our models provide a means of simulating and interpreting in a versatile and physically consistent way the contributions by these three components to the ultraviolet emission from star-forming galaxies.

Supervisors: Stéphane Charlot

Feedback from Radiatively-driven AGN Winds

The observed co-evolution between the properties of galaxies and the mass of supermassive black holes (SMBHs) in their center is commonly explained via a self- regulating mechanism involving feedback from Active Galactic Nuclei (AGN), whereby phases of rapid gas accretion onto black holes can lead to a release of large amounts of energy. Radiation driven winds are dominant in the high-redshift Universe when galaxies are gas-rich and feed the central SMBH engine at close to the Eddington limit. Usually, sub-grid models for AGN-feedback in simulations rely on a number of assumptions. I will talk about a more ad-hoc approach where we self-consistently modelled the radiation from a SMBH via radiation-hydrodynamics (RHD). I will talk about our simulations that allow us to examine the detailed physics of the quasar feedback by observing the interaction of the photons with a two-phase interstellar medium. The simulations allow us a better quantification of the efficiency of the matter-radiation coupling as well as the dominant effect responsible in driving an outflow.

Supervisors: Joseph Silk, Gary A. Mamon & Yohan Dubois

Inferring the spectro-morphometric evolution of galaxies from image simulations

After 20 years of large and small scale galaxy surveys (SDSS, CFHTLS, UDF etc.), the field of galaxy evolution is now well established in the era of Big Data. We can extract the spectrophotometric and morphometric properties of millions of galaxies, over a period that covers more than 9 billion years of cosmic history. But current constrains on models of galaxy evolution suffer from selection biases that, if not taken into account carefully, can lead to contradictory predictions (e.g. the size evolution of bulges from $z \sim 2$).

To adress this issue, we are developing a new approach combining sampling techniques (in a Bayesian framework) and empirical modeling with realistic image simulations that reproduce a large fraction of these selection effects. This will allow us to perform a direct comparison between observed and simulated images and therefore infer robust constraints on model parameters predicting the evolution of bulges and disks from $z \sim 2$ to $z \sim 0$.

Supervisors: Valerie de Lapparent, Emmanuel Bertin & Damien le Borgne

4.5 Post-Newtonian order project: tails-of-tails-of-tails terms

Post-Newtonian theory enables us to predict the waveform of the gravitational waves emitted in the inspiral phase by a system of two compact objects coalescing. State-of-the-art computations provide the waveform up to 3.5PN (i.e. a precision of $1/c^7$). In the current project of 4.5PN (i.e. obtaining formulae up to $1/c^9$), the so-called tails terms, which are non-linear interactions between the mass and source multipole of a coalescing system and its mass needs to be computed to high order. After having briefly presented the role of Post-Newtonian works in the landscape of gravitational wave physics today, we'll present the 4.5PN project focusing specifically on the tails-of-tails-of-tails terms.

Supervisor: Luc Blanchet

Secular diffusion in discrete self-gravitating tepid discs

Fluctuations in a stellar system's gravitational field cause the orbits of stars to evolve. Fluctuations can either originate from external perturbers (collisionless framework) or from the intrinsic discreteness of the system (collisional framework). When accounting for finite-N effects, one may rely on the inhomogeneous Balescu-Lenard equation, to capture the induced secular diffusion. I will present this formalism and show how one can account for the system's susceptibility via the matrix method. When applied to a tepid stellar disc, it predicts the formation of narrow ridge-like structures in action-space, in agreement with numerical simulations. In astrophysics, the inhomogeneous Balescu-Lenard equation is a rich framework, which may describe the secular diffusion of giant molecular clouds in galactic discs, the secular migration and segregation of planetesimals in proto-planetary discs, or even the long-term evolution of population of stars within the Galactic centre. It could also be used as a valuable check of the accuracy of N-body integrators on secular timescales.

Supervisors: Christophe Pichon (IAP) & James Binney (Oxford).

Gamma ray bursts as a tool for cosmology : population models and host galaxies

Gamma Ray Bursts (GRBs) are brief flashes of gamma rays that the are associated with relativistic jets produced by stellar-mass black holes formed after the collapse of massive star or the merger of two neutron stars/black holes. These events are among the most luminous in our universe and can be detected up to very high redshift. Therefore gamma-ray bursts are not only studied for their interesting physics but can also provide very useful tools to explore the distant Universe. The Sino-French mission SVOM, to be launched in 2021, is devoted to these two aspects. In this context, my PhD project is focused on constraining GRB progenitors using two complementary approaches : (1) observational studies of GRB host galaxies ; (2) GRB population models.

Supervisors: Frédéric Daigne & Susanna Vergani (GEPI/IAP)

Study of exoplanet atmospheres through high resolution spectroscopy

During a transit, when the light from a star is partially blocked by a planet, we can perform a differential observation that will measure a transmission spectrum of the thin atmospheric ring of the planet at its terminator. Such measurements are being successfully made today from the ground using for example CRIRES on the VLT. Snellen et al. (2010) studied the high resolution CRIRES spectra of the star HD209458, revealing absorption lines from carbon monoxide produced in the planet atmosphere. The observed spectra were completely dominated by numerous telluric absortion lines, caused mainly by methane and water vapour in the Earth's atmosphere. To model the Earth's atmosphere I will use a different approach, first working on the same data set analysed by Snellen. The new method will make use of Molecfit, a software tool (created by ESO) that corrects astronomical observations for atmospheric absorption features, based on fitting synthetic transmission spectra to the astronomical data.

Supervisor: Jean-Philippe Beaulieu

Clusters of galaxies in the cosmic web

Numerical simulations of the formation of large scale structures in the universe paint the picture of galaxy clusters being located at the intersection of cosmic filaments and accreting galaxies and groups of galaxies along these preferred directions throughout cosmic time.

These filaments have proven to be hard to detect due to their intrinsic low density contrast with respect to the field. Detection of such structure has been limited to relatively low redshifts ($z \lesssim 0.3$) and usually through the use of spectroscopic redshifts. Since clusters of galaxies are thought to form around redhifts of $z \sim 1$, being able to study their environment up to such a range of redshifts is of critical importance to put constraints on their formation and evolution scenarios.

We are searching for such filaments around the thousands of clusters detected in the Canada France Hawaii Telescope Legacy Survey (up to redshift $z = 1.5$ in the Deep fields, $z = 1.2$ in the Wide fields) through the use of photometric redshifts. For this, we draw 2D galaxy density maps in redshift slices, applying an adaptive kernel technique. This allows us to detect the structures in the physical environment of each cluster. We are currently developing tools to study the characteristics of such structures, and quantify a possible evolution of these with cluster redshift and mass/richness, and will present preliminary results.

Supervisors: Florence Durret (IAP) & Christophe Adami (LAM)

Gravitational lensing through numerical simulations: signature of the cosmic web through the azimuthal shape of galaxy clusters

With the advent of large volume hydrodynamical cosmological simulation and in the context of near future precision lensing experiments like the Euclid mission, we are in a good position for making accurate predictions, identifying new systematics and exploring new probes of the mass content in the Universe. This is the main goal of my thesis work. As a preambule, I used the PLUS N-body simulation to measure the shear signal around massive galaxy clusters and focused on multipolar moments of this signal as a probe of the connectivity of clusters since they make up the nodes of the cosmic web. We make predictions on the signal amplitude as a function of cluster-centric distance, mass and redshift and present the prospects for measuring it in current and future lensing data sets.

Supervisors: Christophe Pichon & Raphael Gavazzi

How do cosmological filaments feed galaxies?

As matter gravitationally condenses at galactic scales, its main component, namely dark matter (DM), settles in the form of halos and its baryonic component may then decouple from DM because electromagnetics provide it with specific thermodynamic properties. Following this decoupling, the halo gas is able to condense to give birth to a galaxy at the center of its host halo. The further growth of the galaxy results from this ability to maintain efficient condensation of the gas. Interactions between the galactic outflows and radiations and the accreting gas regulate this efficiency through processes gathered under the name of 'feedback'. However, Those interactions are strongly depend on the nature of the accreting flows.Apart from the specific case of halo mergers, at halo scale, we can divide those flows into two main categories. The first one, that has been extensively studied, is that of spherically infalling gas, idealized as isotropic and referred to as 'smooth' accretion. The second one has been given interest recently mainly due to numerical simulations and concerns relatively confined streams of gas that is denser than its surroundings, in the form of filamentary structures. The fact that a strong shock wave may propagate along a filament raised the question of its state when it reaches the galaxy – is it able to radiate away enough of its internal heat to efficiently accrete on the galaxy? On the other hand, recent observations tend to show that halo gases may be multiphase and theoretical studies now account for this. Moreover, other observations and simple physical considerations tend to show that almost all cosmological gas flows are highly turbulent. We argue here that taking into account both thermal fragmentation and turbulent motions in the possibly shocked streams may strongly affect the nature of the accreting filaments as well as their interactions with galactic feedback.

Supervisors: Matt Lehnert (IAP), François Boulanger (IAS) & Pierre Guillard (IAP)

Formation of supermassive black holes

Massive black holes (MBHs) of millions of solar masses and above reside in the center of most local galaxies, including our own Milky Way. They are known to power active galactic nuclei and quasars, and are able to acquire 10^9 solar masses within a span of less than 1 Gyr. However, as they formed in the very early universe, large uncertainties on their formation still remain. Direct collapse of pristine gas in primordial halos is one of the most promising scenarios addressing MBH formation as it predicts the formation of 10^{4-5} solar mass seeds. However, some physical prescriptions are required for the pristine gas to collapse instead of fragmenting and forming stars, namely the absence of metals and molecular dissociating radiation coming from nearby star-forming galaxies. Cosmological hydrodynamical simulations provide us with a very good tool to track metal enrichment as well as direct collapse candidates environment. Using several sets of simulations (different resolution, supernova feedback recipes), we have investigated the number density of potential direct collapse candidates through cosmic time.

Supervisor: Marta Volonteri

The gas in and around high redshift galaxies

We study a complete sample of neutral atomic carbon quasar absorption systems, observed with the Very Large Telescope. Such absorbers probe highly shielded gas in which molecules are expected to form. We will get information on the depletion of the dust, metallicity, molecular content and physical state of the gas in the ISM of high redshift galaxies.

Supervisors: Patrick Petitjean & Pasquier Noterdaeme

Gravitational Waves from the Remnants of the First Stars

Gravitational waves (GWs) provide a revolutionary tool to investigate yet unobserved astrophysical objects. Especially the first stars, which are believed to be more massive than present-day stars, might be indirectly observable via the merger of their compact remnants. I have developed a self-consistent, cosmologically representative, semi-analytical model to simulate the formation of the first stars to track the binary stellar evolution of the individual systems until the coalescence of the compact remnants. I present estimates of the contribution of primordial stars to the intrinsic merger rate density and to the detection rate of the Advanced Laser Interferometer Gravitational-Wave Observatory (aLIGO). Owing to their higher masses, the remnants of primordial stars produce strong GW signals, even if their contribution in number is relatively small. I find a probability of $\sim 1\%$ that the current detection GW150914 is of primordial origin and we can expect that aLIGO will detect roughly 1 primordial BH-BH merger per year for the final design sensitivity, although this rate depends sensitively on the primordial initial mass function. Turning this around, the detection of black hole mergers with a total binary mass of $\sim 300 M_{\odot}$ would enable us to constrain the primordial initial mass function.

Supervisor: Marta Volonteri

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