

Abstracts

Cosmological implications of the cosmic flow at large scales

Vincent Bouillot

Recent velocity surveys have discovered an anomalously high signal. This was first interpreted as a deviation from the cosmological paradigm Λ CDM. We prove the reason of such a deviation is an environmental effect.

We also propose a way to find cosmological information in the velocity fields.

Études des chocs d'accrétion radiatifs dans les variables cataclysmiques magnétiques en astrophysique de laboratoire des hautes densités d'énergie

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Les variables cataclysmiques magnétiques sont des systèmes binaires contenant une naine blanche fortement magnétisée qui accrete de la matière provenant d'un compagnon, dirigée selon les lignes de champs magnétiques de l'étoile. Cette matière forme, au niveau du pôle magnétique de la naine blanche, une colonne d'accrétion.

Grâce aux lasers de puissances, il est désormais possible de produire en laboratoire des phénomènes présentant des propriétés de similarité avec les colonnes d'accrétion et qui permettent d'en reproduire une maquette à des échelles diagnosticables en laboratoire autorisant ainsi une meilleure compréhension des mécanismes en action. C'est tout l'enjeu du projet POLAR dont nous détaillerons ici la justification théorique et présenterons les premiers résultats expérimentaux. Ces expériences permettent ainsi de tester les modèles astrophysiques et les codes visant à simuler ces processus d'accrétion.

A Glimpse Into Multisymplectic Gravity

Dimitri Vey

The idea underlying the talk lies in the Hamiltonian description of classical fields theory within the context of any effort towards understanding gravitation: since space-time should merge out from the dynamics we need a description which does not assume any space-time/field splitting *a priori*.

There is no space-time structure given *a priori*, but space-time coordinates should instead merge out from the analysis of what are the observable quantities and from the dynamics. In such a framework we are interested in the so called *multisymplectic* formalism : a fully covariant Hamiltonian formulation for the calculus of variations with several variables. We present here, after briefly recall modern framework of gravity as a gauge theory in a Palatini-like form, the first step on this path : the deDonder-Weyl theory for Palatini action. As perspectives, if time allows, we should also briefly give a birdseye on the next step : namely the issue of observables and example of generalized Lepage-Dedecker correspondance.

La marée d'équilibre du cœur jusqu'à la surface des planètes et des étoiles

Françoise Remus

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Un nombre important de planètes extrasolaires orbitent très près de leur étoile hôte, au point de subir de très fortes perturbations de marée. En transformant l'énergie mécanique en chaleur, ces effets de marée contribuent à l'évolution dynamique de tels systèmes. Ceci nous motive à acquérir une meilleure compréhension des processus à l'origine de cette dissipation d'énergie, qui dépend de la structure interne et des propriétés physiques du corps considéré. Cette structure peut être de nature exclusivement fluide s'il s'agit d'étoiles, tandis que les planètes peuvent également présenter des régions solides viscoélastiques, comme le manteau des planètes de type telluriques ou le noyau des planètes géantes. Nous examinerons ici la marée d'équilibre, i.e. l'ajustement hydrostatique au potentiel de marée, dans une planète en rotation ou une étoile.

Nous présenterons dans un premier temps le cas fluide et ses équations, et montrerons comment séparer rigoureusement la marée d'équilibre de la marée dynamique, cette dernière résultant de l'excitation des modes propres. Nous discuterons en particulier de la manière dont le facteur de dissipation Q est lié à la viscosité turbulente de la zone convective.

Nous examinerons alors la marée d'équilibre dans le noyau solide d'une planète géante, en prenant en compte la présence d'une enveloppe fluide. Ici encore la dissipation de marée dépend fortement de la friction interne, mais également de la rhéologie et de la taille du noyau. Ainsi, la modélisation de ce type d'interaction présente un intérêt élevé pour fournir des contraintes sur les propriétés des planètes. Nous montrerons comment obtenir les différents nombres de Love qui décrivent la déformation du noyau. Nous discuterons de la dépendance du facteur de dissipation Q au choix d'un modèle anélastique.

Nous montrerons enfin comment les résultats permettent de décrire l'évolution dynamique des systèmes planétaires.

Simulating observations to test general relativity in its strongest regime at the Galactic Center

Frederic Vincent

Probing gravity in the immediate vicinity of a supermassive black hole would be a powerful test of general relativity (GR). The Galactic Center is an ideal laboratory to do so, particularly the immediate vicinity of the central supermassive black hole, Sgr A*. The accretion structure that may surround this compact object can be used to constrain the properties of Sgr A*. Moreover, radiation flares are regularly observed there, which could be due to a hot spot orbiting on the last stable orbit of the black hole: a perfect probe of strong gravity.

In order to determine at what level future observations will be able to constrain general relativity, a full GR ray-tracing code has been developed: GYOTO. The aim of this talk is to present recent results from this code.

I will first show simulations of the black hole silhouette, should it be surrounded by a specific accretion torus named *polish doughnut*. I will present simulations of the emitted spectrum of such a structure, which can be used as a tool to constrain the black hole's properties.

The precise observation of Sgr A*'s flares will be possible in the near future thanks to the second generation VLTI beam combiner GRAVITY. I will show recent results on the simulation of a hot spot orbiting around the central black hole. These results are in turn used as inputs to a code simulating the GRAVITY instrument. The final objective is to determine to what extent GRAVITY will allow to constrain the nature of the central compact object and to probe spacetime in its surroundings.

Simulations numériques de structures d'accrétion-éjection dans les Objets stellaires jeunes

Petar Todorov

Les jets des étoiles jeunes sont des éjections de matière à grande vitesse (nombre de Mach élevé) aidant à évacuer le moment cinétique de la proto-étoile et permettant ainsi l'effondrement gravitationnel. Les simulations numériques MHD sont un outil performant pour comprendre la nature des vents et des jets astrophysiques, puisque des solutions analytiques existent seulement pour des cas simples, comme le polytrophe. Les modèles semi-analytiques pour les jets non-polytropiques décrivent plusieurs aspects de ces écoulements. Cette thèse vise à tester leur stabilité (notamment quand on étudie des jets à deux composantes: jet stellaire et vent de disque) et leur validité près de la surface de l'étoile. Cela va permettre de calculer correctement la quantité de moment cinétique emporté par le jet et de tracer l'évolution dynamique de la proto-étoile.

A Bayesian Approach to Gravitational Lens Model Selection

Irène Balmès

Over the past decades, advancements in the physical understanding of several astrophysical phenomena have allowed us to infer a concordance cosmological model that successfully accounts for most of the observations of our universe. This has opened up the way to further studies that aim to determine more accurately the constants of the model, and confront its predictions with those of other competing scenarios. Here, we use strong gravitational lenses as cosmological probes. Strong lensing, as opposed to weak lensing, produces multiple images of a single source. Whether a single galaxy, a group or a cluster, extracting cosmologically relevant information requires an accurately modeling of the lens mass distribution. A variety of models are available to this purpose, nevertheless it is hard to discriminate between them, as they can fit the data equally well. This is a problem of model selection that we address in the Bayesian statistics framework by evaluation of the Bayes factors. Using simple test cases, we show that the assumption of more complicate lens models may not be justified given the level of accuracy of the data.

Collective excitations in neutron star crust

Luc Di Gallo

TBA

Étude d'un déphaseur achromatique pour la détection directe de planètes extrasolaires

Damien Pickel

Un des grands défis actuels de l'astrophysique est la détection directe de planètes extrasolaires, afin d'en mesurer leur spectre pour déterminer si elle sont susceptibles d'accueillir la vie. L'interférométrie annulante est une des voies explorées. Elle requiert un déphaseur achromatique de π . Nous avons conçu et réalisé un déphaseur de ce type, qui se présente sous la forme de 2 sous-pupilles, chacune ayant la structure d'un damier possédant plusieurs cellules de différentes épaisseurs, qui introduisent des déphasages, multiples pair et impair de π , pour une longueur d'onde choisie. Ce déphaseur est actuellement testé sur le banc DAMNED (Dual Achromatic Mask for Nulling Experimental Demonstrator) afin de confronter les résultats expérimentaux et théoriques. Nous présentons ici les résultats.

Thermal evolution of neutron stars and constraints on their internal properties

M. Fortin, J.-L. Zdunik, J. Margueron, P. Haensel

Modeling the thermal evolution of both isolated and accreting neutron stars enables to put

constraints on the poorly known composition and properties of their interior.

The theoretical modeling of the thermal evolution of an isolated neutron star shows that the cooling depends on the properties of crust, in particular the superfluidity -Lattimer et al., ApJ (1994), Gnedin et al., MNRAS (2001)-. I will present new calculations of the specific heat of superfluid neutrons in the crust taking into account the presence of the nuclei and cooling curves in the fast cooling scenario, with enhanced neutrino emission -Fortin et al., PRC (2010).

Recently the first direct observation of the cooling of a young and isolated neutron in Cassiopeia A supernova remnant has been reported -Heinke and Ho, ApJL (2010). So far, only the temperatures at one point in time of neutron stars with different ages and different masses were known. Modeling the thermal evolution of CasA neutron star, two groups -Shternin et al., MNRAS (2011); Page et al., PRL (2011)- conclude that the protons in the core are superfluid and superconducting. They also put constraints on the superfluid properties of the neutrons in the core and the associated neutrino emissivity. Future monitoring of the source offers exciting perspectives.

A subclass of accreting neutron stars, the so-called quasi-persistent X-ray transients, also constrains the properties of the matter in neutron stars.

These transients accreted matter from a low-mass companion during years to decades before accretion stops. In the deep-crustal heating scenario, the accreted matter undergoes a series of nuclear reactions while it sinks deeper into the crust under the weight of the newly-accreted material. The reactions produce heat that also propagates in quiescence and is radiated away.

The modeling of the thermal relaxation after accretion stops depends on the accretion rate, the composition and mass of the neutron star and the microphysical input.

Shternin et al., MNRAS (2007) show that the thermal relaxation of one of these four sources, KS 1731-260 exclude fast cooling due to enhanced neutrino emission in the core and is consistent with a crystalline crust with superfluid neutrons. Brown and Cumming, ApJ (2009) conclude the thermal relaxation of KS 1731-260 and MXB 1659-29 implies that the impurity parameter which describes the distribution of nuclide charge numbers is of the order of 1. I will present some new results of the modeling of the thermal evolution of all the four quasi-persistent X-ray transients based on an up-to-date description of the microphysics in the outer layers of neutron stars.

Effect of abundance stratifications on pulsations of Chemically Peculiar A and B stars

Satenik Ghazaryan

First part of the work is devoted to the analysis of CoRoT lightcurves to which we apply a new quasi-automatic procedure we have developed (collaboration with G. Alecian & H. Harutyunyan). This IDL procedure corrects the abnormal jumps and the instrumental drifts which survived in N2-exoplanet data. The method we present can be used for the CoRoT targets observed through exoplanets channel. We study 3 stars already considered by Alecian et al. (2009) who used less sophisticated methods for corrections, and another one on which a huge transit effect is observed, and used an older release of the N2 data. With our method we succeed to remove random jumps and systematic trends encountered in typical CoRoT data for the first three stars. We describe the algorithm and compare our new results to the old ones published in 2009.

K-edge shift and X-ray Absorption Near Edge Spectroscopy (XANES) investigation of laser driven shock-compressed Aluminium

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Compressed matter belongs to the Warm Dense Matter (WDM) regime, which is lying at the frontier between condensed matter and plasma physics. This regime is characterized by near or above solid densities and temperatures $\leq 100\text{eV}$. Despite the considerable interest to various fields of physics such as condensed matter, inertial confinement fusion or planetology, the physical properties and the behavior of this state of matter are still not very well known. Indeed, it is very difficult to simulate and calculate its properties since there is a lack of experimentally validated theoretical models.

In this work, we study time resolved laser compressed Al K-edge and XANES on a large domain of extreme conditions in density and temperature. We observe the absorption spectrum changes of Al under conditions unexplored up to now.

The experiment was performed at LULI laboratory where we used one long pulse (500ps, $I_L \approx 8 \times 10^{13} \text{ W/cm}^2$) to create a uniform shock and a second ps beam ($I_L \approx 10^{17} \text{ W/cm}^2$) to generate a ultra-short broadband X-ray source near the Al K-edge. The spectra were registered by using two conical KAP Bragg crystals. The hydrodynamical Al conditions were measured by using independent rear-side diagnostics : VISARs interferometers and self-emission.

The absorption spectrum changes have been observed by increasing the delay between the two beams. Two different regimes have been probed : recharged Al (density ≈ 3 solid density and $T \approx 8\text{eV}$) and unloading Al. The relocalization of the 3p valence electrons occurring in the metal-non metal transition has been also put in evidence.

In parallel, ab initio calculations at the conditions found in the experiment have been performed to compare experimental data and theoretical model.

The halo mass function in the excursion set theory for non spherical collapse and primordial non gaussianity

Ixandra Achitouv

I will review the computation of the dark matter halo mass function using the Excursion Set formalism for a diffusive barrier with linearly drifting average which captures the main features of the ellipsoidal collapse model.

We include non-Markovian corrections due to the sharp filtering of the linear density field in real space with a path-integral method. We also extended our mass function to the case of primordial non gaussianity. In both case We find an unprecedented agreement with N-body simulation data with deviations $< \sim 5\%$ over the range of masses probed by the simulations. This indicates that the Excursion Set in combination with a realistic modelling of the collapse threshold can provide a robust estimation of the halo mass function.

Transport de neutrinos, simulations de supernovae gravitationnelles et schéma de fuite

Bruno Peres

Les neutrinos sont un des ingrédients essentiels pour la détermination de la dynamique des supernovae gravitationnelles. Je présenterai un schéma simplifié de traitement des neutrinos, le schéma de fuite, qui les considère soit piégés dans le fluide soit libres de s'échapper.

Lepto-hadronic modelling of blazar emission

Matteo Cerutti

The characteristic double-bumped spectral energy distribution (SED) of blazars is usually explained by either leptonic or hadronic models. We present here a new stationary lepto-hadronic code that evaluates at the same time both the leptonic and the hadronic interactions. Apart from the standard synchrotron-self-Compton (SSC) or proton synchrotron models, the code enables the study of interesting mixed lepto-hadronic scenarios, where both processes significantly contribute to the high-energy bump.