Rencontre des groupes de travail ”Formes d’onde” et ”Tests de la relativité générale et théories alternatives”

mardi 4 février 2020 - mardi 4 février 2020

Observatoire de Meudon, salle de conférence du château

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From Scattering Amplitudes to Classical Observables

Auteur: David Kosower[None]

I outline a formalism for computing classically measurable quantities directly from on-shell quantum scattering amplitudes. I will discuss the ingredients needed for obtaining the classical result, and show how to set up the calculation to derive the result efficiently. The formalism is not specific to a given theory, and is ultimately destined to be used for general relativity. In this talk, I will show an examples from spinless scattering in electrodynamics: the momentum transfer to next-to-leading order.

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BMS flux-balance laws

Auteurs: Geoffrey Compère[1]; Roberto Oliveri[2]; Ali Seraj[1]

[1] *ULB*

[2] *CEICO - Czech Academy of Sciences*

Asymptotically flat spacetimes admit both supertranslations and Lorentz transformations as asymptotic symmetries known as BMS symmetries. Furthermore, they admit super-Lorentz transformations, namely superrotations and superboosts, as outer symmetries associated with super-angular momentum and super-center-of-mass charges. In this talk, we present the flux-balance laws for all such (extended) BMS charges in terms of radiative multipole moments. Fluxes of energy, angular momentum and octupole super-angular momentum arise at 2.5PN, fluxes of quadrupole supermomentum arise at 3PN and fluxes of momentum, center-of-mass and octupole super-center-of-mass arise at 3.5PN. If time permits, we argue how each BMS flux-balance law can be thought of as a constraint on the source evolution.

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The 4PN phase of non-spinning compact objects: where are we ?

Auteur: Quentin Henry[None]

The new generation of gravitational wave detectors, such as LISA, requires to have precise analytical models for gravitational wave form. These models are useful for data analysis, tests on alternative theories of gravity and comparison with numerical relativity. To this day, we know the full GW phase for non-spinning compact binary systems at the 3.5 post-Newtonian (PN) order. We now push the computation to the 4PN order. The calculation involves challenging technical issues associated with the point-mass regularization and appearance of infra-red divergences, non-linear tail effects and the large amount of calculation involved. I will make a brief overview of what has been done so far and what is left to do.

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Scattering Amplitudes in Effective Gravitational Theories

Auteur: Stavros Mougiakakos[1]

[1] *IPhT, CEA-Saclay*

Since the first detection of gravitational waves (GWs) from a binary black hole coalescence was announced in 2016, it has become increasingly pressing to provide high precision theoretical predictions for the modeling of GW templates. In this context, various methods have been employed to push the precision of the computations higher such as EOB Hamilitonian, PNEFT, Scattering Amplitudes etc. The aim of this talk is to give an overview of the PNEFT(NRGR), the connections/intersections with the Scattering Amplitudes computations and the presentation of our latest results concerning the complete gravitational cubic-in-spin effective action at the next-to-leading order for the interaction of generic compact binaries via the effective field theory for gravitating spinning objects which enters at the fourth and a half post-Newtonian (4.5PN)

1

New synergies between traditional PN methods and EFT: contributions of the logarithmic tails in the energy.

Auteur: François Larrouturou[1]

[1] *Institut d’Astrophysique de Paris*

Combining different techniques, we derive the logarithmic contributions to the two-body conservative dynamics. Those logarithms come from the conservative part of non linear gravitational-wave tails and their iterations. Explicit, original expressions are found for conservative dynamics logarithmic tail terms up to 6PN order by adopting both traditional PN calculations and effective field theory (EFT) methods. We also determine all logarithmic terms at 7PN order, fixing a sub-leading logarithm from a tail-of-tail-of-tail process by comparison with self-force (SF) results. Moreover, we use renormalization group techniques to obtain the leading logarithmic terms to generic power n, appearing at (3n+1)PN order, and we resum the infinite series in a closed form.

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Dark energy after gravitational wave observations

Auteur: Filippo Vernizzi[None]

The observed accelerated expansion of the Universe opens up the possibility that general relativity is modified on cosmological scales. While this has motivated the theoretical study of many alternative theories that will be tested by the next generation of cosmic large scale structure surveys, I will show that the recent observations of gravitational waves by LIGO/Virgo have dramatic consequences on these theories.

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Rotating black holes in higher order theories

Auteur: Christos Charmousis[None]

We will discuss an analytic rotating black hole in scalar tensor theories. The scalar gravitational degree of freedom will be related to the geodesics of the black hole spacetime.

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A new phenomenological time-domain model of gravitational waveforms for tests of general relativity

Auteur: Leïla Haegel[1]

Co-auteurs: Hector Estrelles [2]; Antoni Ramos [2]; Sascha Husa [2]

[1] *APC*

[2] *University of Balearic Islands*

Current tests of general relativity with the LIGO-Virgo gravitational waves detections relies on using frequency-domain phenomenological models of gravitational waveforms. The design of tests varying parameters defined by their frequency can lead to ambiguity in the interpretation of the deviation measured. In this talk, I will present the first time-domain phenomenological model of gravitational waveforms, that notably includes the main radiation mode and precession effects. I will also mention the elaboration of agnostic tests of general relativity that we will implement.

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EMRI waveforms for LISA via the self-force program

Auteur: Bernard Whiting[None]

Among the much-anticipated gravitational wave sources for LISA are inspiraling binaries with an extreme mass ratio (EMRIs), where the mass ratio is of order 1E-3 to 1E-9, arising when a solar-massed object falls into a supermassive black hole at the center of a galaxy. Such sources are expected to be observable by LISA for up to a year before merger, resulting in more than 100,000 gravitational wave cycles and requiring phase coherence over that time of better than one part in 10^6. Because of their extreme mass ratio, EMRI sources are not currently amenable to full numerical relativity, so alternative computational schemes are required, the most promising being a perturbative expansion in the mass ratio. As phase error at first order accumulates roughly as the square root of the mass ratio, this perturbative expansion must be carried out to second order in the mass ratio. That effort is work in progress.

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Hairy Extreme mass ratio inspirals

Auteurs: Adrien Kuntz[None]; Federico Piazza[None]; Riccardo Penco[None]

The presence of scalar ‘hair’ around a black hole could have signatures in the waveform produced by inspiralling objects. We propose a unifying description of hairy inspirals in the extreme mass ratio case when a single scalar field is present in the action, and we derive the dissipated power in the odd sector of the perturbations up to 3.5PN order beyond the quadrupole formula. Our formalism relies on an effective field theory setup previously considered for inflation, dark energy, and quasi-normal modes ; the deviations from General Relativity are encoded in a set of coefficients directly related to the parameters of the fundamental action. We expect our template to be relevant for modeled searches of an inspiralling signal in modified gravity.

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Mimicking black hole mimickers

Auteurs: Alexandre Toubiana[1]; Luis Lehner[2]; Enrico Barausse[3]; Stas Babak[4]

[1] *APC/IAP*

[2] *PI*

[3] *SISSA/IAP*

[4] *APC*

Black holes mimickers, e.g. boson stars, are compact objects with similar properties to black holes. The gravitational wave signal emitted by a binary of such putative objects during the inspiral phase is difficult to distinguish from the one emitted by a black hole binary. Nevertheless, significant differences might appear in the post merger signal. Inspired by the known behavior of black holes, neutron stars and boson stars we propose a toy model that captures potential characteristics of such systems composed by such mimickers. This model can be exploited to assess how well such signal could be recovered with gravitational waves observations from earth based detectors using standard templates. By analyzing the residuals, i.e. the difference between the injected signal and the best fit template, one can also develop strategies to extract the new physics described by these new signals.

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Waveform challenges for the parameter estimation of binary black hole signals with LISA

Auteur: Sylvain Marsat[1]

[1] *APC, Paris*

The future LISA detector will enable the detection of supermassive black hole coalescences, as well as stellar mass black hole inspirals in the lower-frequency band of the gravitational waves spectrum, complementing ground-based observations of gravitational waves by LIGO and Virgo and their successors. To simulate realistically the recovery of individual source parameters by LISA, accurate waveform models are needed, together with a complete treatment of the instrument response carrying itself information about the source. The assessment of the LISA scientific performance remains to be explored with state-of-the-art waveform models. We highlight recent results showing the importance of subdominant harmonics in the signal, as well as the frequency dependency in the instrument response. We review briefly prospective waveform requirements for LISA.