New horizons for gravity: from theoretical cosmology to observational astrophysics

Gravitational waves in modified gravity

Monday, 28 May 2018

Speaker: Luc Blanchet

Time: 09:30 – 10:15

Title: Gravitational Waves and Post-Newtonian Theory

Abstract: The gravitational wave detectors LIGO/VIRGO have discovered the signals generated by the coalescence of binary black holes and neutron stars. The theoretical and numerical works on the two-body problem in general relativity play a very important role when analyzing the gravitational wave signals. In this talk, we shall present the state-of-the-art on approximation methods in general relativity, and in particular discuss the latest developments in the famous post-Newtonian approximation.

Speaker: Shinji Tsujikawa

Time: 10:45 – 11:30

Title: Hairy black hole solutions and gravitational waves in vector-tensor theories

Abstract: We study static and spherically symmetric black hole (BH) solutions in vector-tensor theories with nonminimal vector field derivative couplings to gravity. We find concrete Lagrangians which give rise to exact BH solutions by imposing two conditions of the two identical metric components and the constant norm of the vector field. We also derive non-exact solutions in power-law coupling models including vector Galileons and numerically show the existence of regular black holes with a primary hair. We then study the stability of BHs against odd-parity perturbations and show that some of BH solutions including the exact solution found by Chagoya et al are excluded by an instability problem in the vicinity of the event horizon. We also derive the propagation speeds of tensor and vector perturbations around the static and spherically symmetric BHs and show the possibility of constraining models further from the speed of gravitational waves.

Speaker: Lucas Lombriser

Time: 14:00 – 14:45

Title: Cosmic Self-Acceleration from Modified Gravity before/after GW170817

Abstract: Modifications of gravity have long been considered as an alternative explanation for the late-time accelerated expansion of our Universe. The recent gravitational wave measurement GW170817 with its electromagnetic counterparts brought the challenge to the concept of cosmic self-acceleration from modifying gravity that had been anticipated for such an event. I will first discuss why a rigorous discrimination between acceleration from modified gravity and from a cosmological constant or dark energy was not possible with observations of the large-scale structure alone and how that measurement has particularly impacted the landscape of scalar-tensor gravity theories. I will conclude with an outlook on how surviving self-accelerated models will ultimately only be exhaustively probed with a large number of Standard Sirens. Finally, I will sketch new concepts that have been brought forward of how an evolving speed of gravity may nevertheless be the driver of cosmic acceleration yet remain compatible with the tight GW170817 constraint.

Speaker: Paolo Pani

Time: 15:15 – 16:00

Title: Testing the nature of compact objects with gravitational waves

Abstract: Gravitational wave (GW) astronomy allows us for unprecedented tests of the nature of dark compact objects. In this context, I will discuss two signatures of new physics at the horizon scale: GW “echoes” in the postmerger ringdown phase of a binary coalescence, and finite-size effects of exotic compact objects that affect the inspiral premerger phase. In the first case, the ringdown wave-form of exotic ultracompact objects is initially identical to that of a black hole, and putative corrections at the horizon scale appear only at later times as a modulated and distorted train of echoes of the modes of vibration associated with the photon sphere. As for the second case, I will discuss the tidal heating and tidal Love numbers of different families of boson stars, gravastars, wormholes, and other toy models for quantum corrections at the horizon scale. These corrections display a universal logarithmic dependence on the location of the surface in the black-hole limit. I will discuss the ability of present and future GW detectors to measure these effects. Both LIGO, ET and LISA can impose interesting constraints on boson stars, while LISA is able to probe even Planckian corrections. We argue that these effects provide a smoking gun of new physics at the horizon scale, and that future GW measurements of a binary coalescence provide a novel way to test black holes and general relativity in the strong-field regime.

Speaker: Philippe Jetzer

Time: 16:05 – 16:50

Title: Tests of General Relativity with LISA and ACES

Abstract: I will discuss the tests of general relativity that will become possible with space-based gravitational-wave detectors like LISA and with atomic cloks in space as e.g. ACES. The fundamental aspects of gravitation that can be tested with LISA include the presence of additional gravitational fields other than the metric; the number and tensorial nature of gravitational-wave polarization states and the velocity of propagation of gravitational waves. One of the primary goals of ACES is to measure the gravitational redshift, a central prediction of Einstein's general relativity and a fundamental constituent of the Einstein Equivalence Principle (EEP).

Tuesday, 29 May 2018

Speaker: Ira Rothstein

Time: 09:30 – 10:15

Title: Extracting Short Distance Physics from Gravitational Wave Data

Abstract: tba

Speaker: Leo Stein

Time: 10:45 – 11:15

Title: Probing strong-field gravity: Black holes and mergers in general relativity and beyond.

Abstract: General relativity—Einstein's theory of gravitation—has been studied for more than 100 years. Over the past century, we have learned that the theory agrees with all available experimental and observational tests. At the same time we know that the theory is incomplete, as it leads to inconsistencies when coupled with quantum mechanics.

The strong-field regime is our best hope to study GR, both observationally and theoretically, and thus understand how to correct its shortcoming. In this talk, I will discuss investigations in the strong field, including black holes and neutron stars, in GR and theories beyond GR. The main focus will be predicting gravitational waves from merging black holes beyond GR. These predictions will allow for the most rigorous testing of general relativity, using LIGO, in the dynamical strong-field regime.

Speaker: Ulrich Sperhake

Time: 14:00 – 14:45

Title: Long-Lived Inverse Chirp Signals from Core-Collapse in Massive Scalar-Tensor Gravity

Abstract: We model stellar core collapse in massive scalar-tensor theories of gravity. The presence of a mass term for the scalar field allows for dramatic increases in the radiated gravitational wave signal and may stretch out the signal to last for years or even centuries. There are several potential smoking gun signatures of a departure from general relativity associated with this process. These signatures could show up within existing LIGO-Virgo searches.

Speaker: Diego Blas

Time: 15:15 – 16:00

Title: Probing dark matter properties with pulsar timing

Abstract: The high quality of the data from pulsar timing makes of it a fantastic resource to understand gravitational phenomena. Traditionally this has been used to test general relativity. In this talk I will describe a less explored possibility: using pulsar timing to understand dark matter properties. I will focus on (possibly) detectable modifications of binary orbits due to the interaction with dark matter in different scenarios.

Speaker: Helvi Witek

Time: 16:05 – 16:50

Title: New prospects in numerical relativity -- Black-hole binaries in Einstein-dilaton Gauss-Bonnet gravity

Abstract: Despite the ever stronger observational support for general relativity (GR) as our standard model of gravity, open questions concerning, e.g., the nature of dark matter or the reconciliation of GR with quantum physics indicate the existence of a more fundamental theory of quantum gravity. While the exact theory is unknown, most candidate theories of quantum gravity predict modifications to GR. Black holes, and the gravitational wave signal emitted during their collision, provide a novel way to search for signatures of these underlying theories. To do so, however, requires accurate theoretical predictions of the waveforms, an undertaking that is still in its infancy. In the present talk I will give a brief progress report on numerical relativity in modified gravity before focusing on the specific example of Einstein-dilaton Gauss-Bonnet gravity that involves higher curvature corrections to GR. In particular, I will report on the first studies of black-hole collisions in this theory.

Wednesday, 30 May 2018

Speaker: Michele Maggiore

Time: 09:30 – 10:15

Title: Nonlocal gravity and GWs

Abstract: We will discuss conceptual aspects and cosmological implications of a nonlocal gravity model developed by our group, stressing in particular the predictions of the model on modified GW propagation, and the possibility of testing it with standard sirens.

Speaker: David Langlois

Time: 10:45 – 11:30

Title: Scalar-tensor theories and modified gravity after GW170817

Abstract: This talk will present the very general framework of Degenerate Higher-Order Scalar-Tensor (DHOST) theories, which includes and extends Horndeski and Beyond Horndeski theories. I will discuss some cosmological aspects of these theories and how they can lead to deviations from standard gravity in astrophysical bodies. I will also explain how these theories are constrained by the recent observation of the gravitational wave event GW170817 with its electromagnetic counterpart.