New horizons for gravity: from theoretical cosmology to observational astrophysics

Effective field theory approaches to gravity

Monday, 05 March 2018

Speaker: Cliff Burgess

Time: 09:30 – 10:15

Title: Open EFTs: Gravity as a Medium

Abstract: Precision calculations in de Sitter space (such as of inflationary predictions for primordial fluctuations) are often plagued by infrared problems and issues of secular time dependence. Similar issues about the breakdown of perturbation theory seem also to arise for information loss in black holes. This talk briefly summarizes how related problems can arise in other areas of physics, and how they are dealt with when they do. It is argued that Master-Equation/Lindblad techniques used in areas like optics also apply to cosmology (and possibly black holes) and can tell us how to extract reliably late-time predictions. Applied to inflation they lead to Starobinsky's stochastic methods, plus small but important corrections. This is argued to explain why stochastic inflation seems to resum IR effects in simple examples, and allows these tools to be generalized to apply more broadly. Mentioned in passing the relevance of Open EFTs to the problem of Schrodinger's Cosmologist: how primordial quantum fluctuations decohere sometime between their production during inflation and their observation early in the later Big Bang Epoch.

Speaker: John Donoghue

Time: 10:45 – 11:30

Title: Quantum Predictions from the Effective Field Theory of General Relativity

Abstract: I will review briefly some of the "low energy theorems of quantum gravity" which follow from the effective field theory treatment. Then the main focus is on the possibility to go beyond scattering amplitudes through the use of non-local effective actions. Successes and limitations will both be discussed. If there is time, I will describe some ideas for using quantum field theory as a UV completion of quantum gravity.

Speaker: Thibault Damour

Time: 14:00 – 14:45

Title: High-energy gravitational scattering and the general relativistic two-body problem

Abstract: Recently, a new technique was introduced for translating both the classical scattering function, and the quantum scattering amplitude, of two gravitationally interacting masses into a corresponding (effective one-body) Hamiltonian description of the post-Minkowskian type (i.e. valid for arbitrarily large velocities). Using this technique, we will discuss the high-energy structure of the (classical) one-loop (order O(G^2)) two-body Hamiltonian. We will also show how to exploit the ultra-high-energy, two-loop quantum scattering results of Amati, Ciafaloni and Veneziano. We finally indicate how the full, two-loop scattering amplitude of scalar masses could be used to deduce the O(G^3) effective one-body Hamiltonian.

Speaker: Christof Wetterich

Time: 15:15 – 16:00

Title: Scale symmetry in cosmology

Abstract: Scale symmetry can be a central ingredient in cosmology. It arises from fixed points of running couplings in quantum gravity - no intrinsic mass or length scales are present anymore. Such a world can be realised in the infinite past and future of our Universe.

The ultraviolet fixed point makes gravity asymptotically safe and non-perturbatively renormalizable. The approximate scale invariance close to the fixed point is reflected in cosmology in the almost scale invariant spectrum of the observed primordial cosmic fluctuations. The approach to the infrared fixed point in the asymptotic future is characterized by the dynamics of an almost massless cosmon - the pseudo Goldstone boson of spontaneously broken scale symmetry. It is responsible for dynamical dark energy.

Both inflation and the present dynamical dark energy arise from the same scalar field. The history of the Universe describes a crossover from a „past fixed point“ where all particles are massless, to a „future fixed point“ where exact scale invariance is spontaneously broken, generating the particle masses. The cosmological solution can be extrapolated to the infinite past in physical time - the Universe has no beginning and no physical singularity. A simple model is compatible with all present cosmological observations. It could be tested by the observation of huge lumps in the cosmic neutrino background, the detection of early dark energy, or rather large primordial graviton fluctuations generated during inflation.

Speaker: Robert Brandenberger

Time: 16:00 – 16:45

Title: String Cosmology and Challenges for Effective Field Theory

Abstract: tba

Tuesday, 06 March 2018

Speaker: Cesar Gomez

Time: 09:30 – 10:15

Title: IR physics and Classicalization

Abstract: tba

Speaker: Sergey Sibiryakov

Time: 10:45 – 11:15

Title: Progress in Horava-Lifshitz models of quantum gravity

Abstract: I will review recent developments in the approach to quantum gravity suggested by P.Horava, based on the idea that gravity can be rendered renormalizable at the expense of abandoning Lorentz invariance and substituting it with anisotropic (Lifshitz) scaling in the ultraviolet. The original argument for renormalizability relies on the power counting. I will explain why the power-counting argument by itself is incomplete. Next, I will present a rigorous proof of perturbative renormalizability for the so-called projectable version of Horava gravity. The key element of the proof is a choice of gauge which ensures the correct Lifshitz scaling of the propagators and their uniform falloff at large frequencies and momenta. I will also briefly mention the BRST structure of the theory. Finally, I will report an explicit calculation of running couplings in the three-dimensional model showing that this model is asymptotically free.

Speaker: Subodh Patil

Time: 14:00 – 14:45

Title: Tensor bounds on the hidden universe

Abstract: In this talk, we present an amusing observation that primordial gravitational waves, if ever observed, can be used to bound the hidden field content of the universe. This is because a large number of hidden fields can resum to potentially observable logarithmic runnings for the graviton two-point function in the context of single field inflation, courtesy of a `large N' expansion (and modulo certain subtleties regarding loop corrections on cosmological backgrounds). This allows one to translate ever more precise bounds on the tensor to scalar consistency relation into bounds on the hidden field content of the universe, with potential implications for phenomenological constructions that address naturalness with a large number of species. Along the way, we'll review how the cutoff for an EFT that includes gravity changes as we incorporate matter, identifying two distinct scales for gravity.

Speaker: Enrico Trincherini

Time: 15:15 – 16:00

Title: EFT for Black Hole perturbations: testing extensions to GR with Gravitational Waves

Abstract: I will show how to construct an Effective Field Theory for perturbations around spherically symmetric backgrounds. The quadratic operators of the Lagrangian can be constrained by the observations of quasi normal mode excitations during the ringdown of a black hole. This EFT can thus provide a model-independent way to parametrize deviations from General Relativity in theories with an extra scalar degree of freedom.

Speaker: Jürg Fröhlich

Time: 16:00 – 16:45

Title: Dark Matter & Dark Energy from a Modified Theory of Gravity

Abstract: After a brief discussion of some of the basic puzzles in cosmology I introduce a model of a scalar field that may serve as a source of "quintessence" and possibly also of Dark Matter. Moreover, the model is suggestive of a mechanism that may tune the Matter-Antimatter Asymmetry in the Universe. It can be derived from a theory of gravity in a space-time with a discrete extra dimension. A scenario for the late-time fate of the Universe is sketched.

Wednesday, 07 March 2018

Speaker: Karol Kampf

Time: 09:30 – 10:15

Title: From pions to gravitons

Abstract: There has been a huge progress in implementing of new theoretical ideas to a large class of quantum field theories. One example, the BCFW recursion relations have been a very successful approach to tree-level amplitudes for Yang-Mills or gravity. Such modern methods can also be implemented in effective field theories where the amplitudes do not exhibit the correct high-energy behaviour. We will discuss a bottom-up construction of effective field theories for scalar, vector and briefly also spin-2 particles.

Speaker: Scott Melville

Time: 10:45 – 11:30

Title: Gravitational EFTs: Signs from the UV

Abstract: Effective field theory techniques are so successful because they decouple complicated high energy physics from low energy observables. However, this blessing is also a curse, as it may seem like nothing can then be learned about the underlying UV structure of the theory.

But all is not lost, as I will show how non-trivial information about the UV, such as locality and boundedness, can be extracted from a low energy effective theory via ``positivity bounds''. These bounds exploit various analyticity properties to connect the scattering amplitudes of the EFT to those in the full (unknown) UV theory. This is particularly important in our quest for a UV theory of gravity, as it offers a way to probe high energy features using low energy data, but also a way to constrain EFT parameters to achieve certain desired UV behaviour.

I will review recent successes in developing these positivity bounds, and their fruitful application to gravitational theories.