Testing General Relativity with Cosmological Observations

Abstract: General Relativity (GR) is immensely successful. With the late discovery of gravitational waves from black hole and neutron star mergers, it has passed all the tests with flying colours. But so far, all observations have mainly tested the vacuum equations of GR. The most important non-vacuum case, cosmology, is in agreement with GR only after the introduction of two otherwise unknown components, 'Dark Matter' and 'Dark Energy', which amount to about 96% of the total energy budget of the present Universe. This let people in the field question the validity of GR for cosmology. Might it be that GR is flawed on large, cosmological scales? Or in the presence of matter in general? But how can we test Einstein's equation in the presence of matter. Can't we simply move any modification of the Einstein tensor to the right-hand side and call it a 'dark matter/dark energy' component?

In my talk I shall discuss possible ways (partially) out of this dilemma. How to test both, the left and the right-hand side of Einstein's equations with cosmological observations.

Analyticity in the Sky with (causal) Diamonds

Abstract: The direct detection of gravitational waves marks the beginning of a new era for physics and astronomy, with an opportunity to probe gravity at its most fundamental level. I will discuss the subtle interplay between the behaviour of gravity as we observe it at low energies, and its embedding within a meaningful high energy completion. In particular, I will emphasise how the mathematical notion of '*analyticity*' encodes the physical notion of '*causality*', and how gravity subtly affects this, a consideration which is particularly relevant for putting constraints on the physical theories we use to describe observations.