Extended Theories of Gravity and Searching for New Physics

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General Relativity (GR) is based on the geometric formulation of gravitational interaction which determines the spacetime dynamics. Observational and experimental tests, ranging from the Solar System scale to the large-scale structures of the Universe, have probed Einstein's theory of gravity with high accuracy. More recently, the discovery of gravitational waves from binary black hole mergers and the black hole observations are providing further confirmations of GR. However, despite these successes, GR presents problems and shortcomings that require possible revisions. In particular, the unresolved issue of Quantum Gravity poses the problem of how to deal with spacetime at quantum level and with singularities like the Big Bang and black holes. On the other hand, modern Cosmology provides a current picture where the composition of the Universe is mostly dominated by some unknown forms of dark components (generically called dark matter and dark energy). There is up to now no experimental evidence of these dark components, so it is reasonable to pursue new theories based on extensions and modifications of GR, to explain the observations.

The lectures aim to present the physics of the Universe considering phenomena (mainly related to astrophysics and cosmology) that cannot be fully framed into the standard GR, as well as the standard Quantum Field Theory and Particle Physics described by the Standard Model.