Theoretical Gravitation and Cosmology

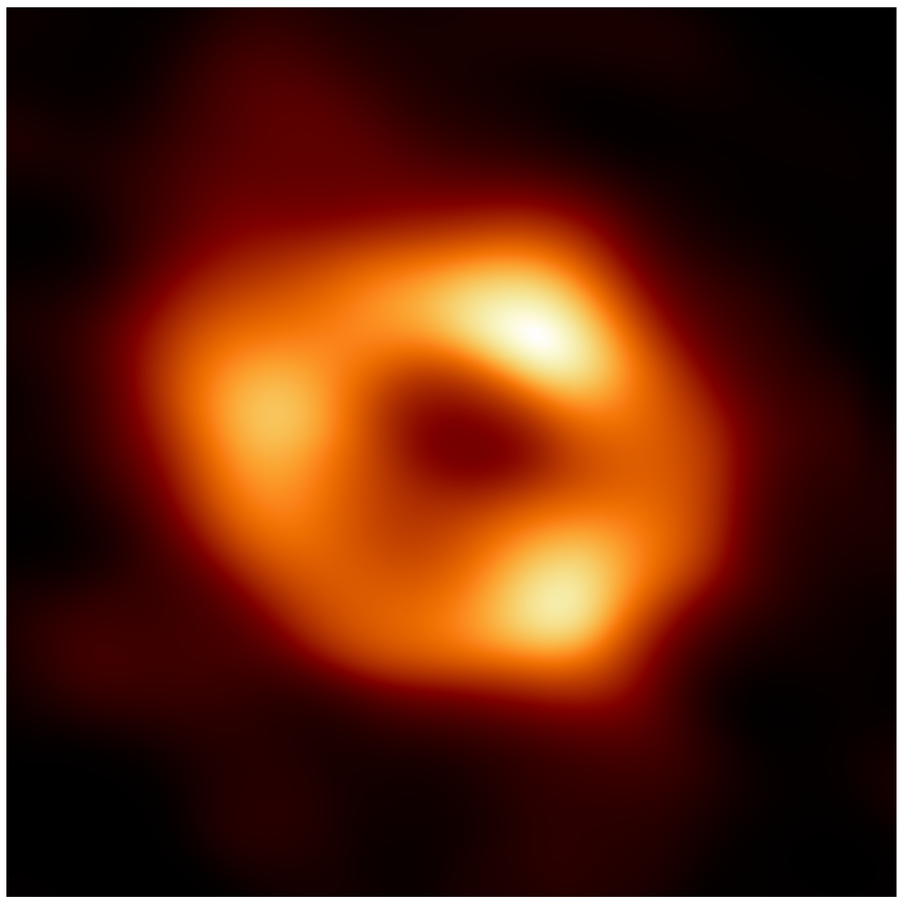
Iniziativa specifica: «FLAG»

Black Hole Physics

First predicted by Einstein's theory of General Relativity (GR) back in 1915, black holes are extremely dense objects where gravity is so strong that nothing, not even light, can escape them.
Over one century after their theoretical formulations, the Event Horizon Telescope has presented the first images of the shadows of the black holes in the Milky Way, SgrA*, and the M87 galaxy, M87*.

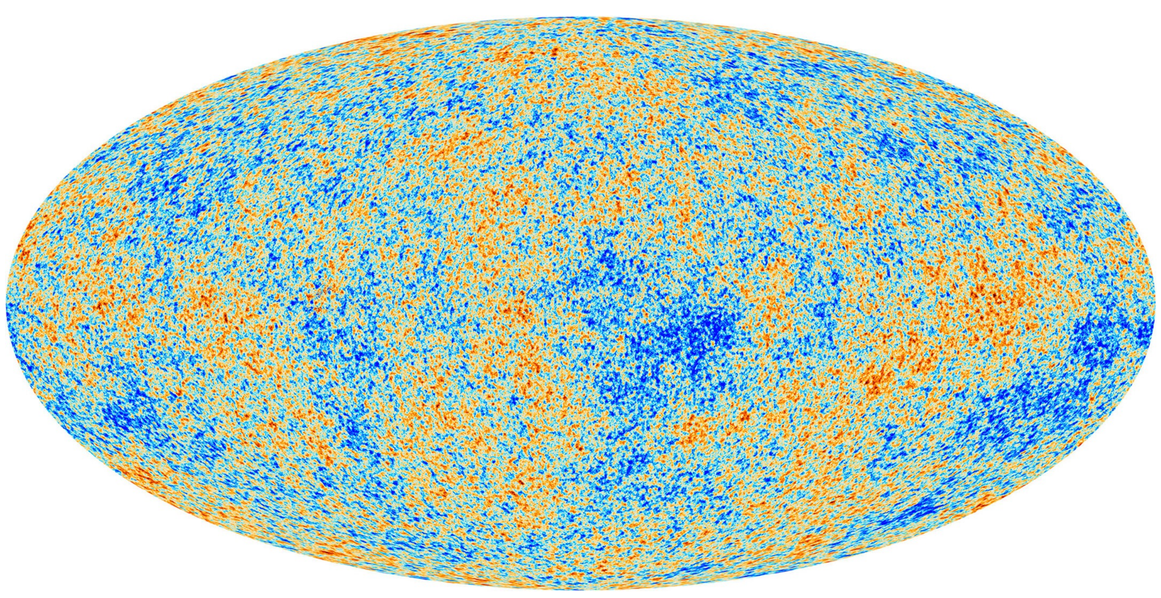
Black holes are essential probes to test the validity of General Relativity in the limit of strong spacetime curvature, where deviations from the behavior observed so far – on terrestrial and solar scales – could be at play.

Such tests can be performed using gravitational wave signals coming from the coalescence of dense objects, like BHs, or using black hole shadows. The latter can indeed constrain possible deviations from GR, through direct comparisons of the predictions of alternatives models of gravity with the shape and size of the observed shadows of M87* and SgrA*.



Cosmology

The technological developments of the past century have turned cosmology from a pure speculative subject to a data-driven science. The great experimental effort of the last decades has unraveled a lot of mysteries about our Universe. Still, we only know 5% of its total content. The remaining part is given as a combination of what is known as dark energy and dark matter, mysterious and elusive components whose nature is still unclear.



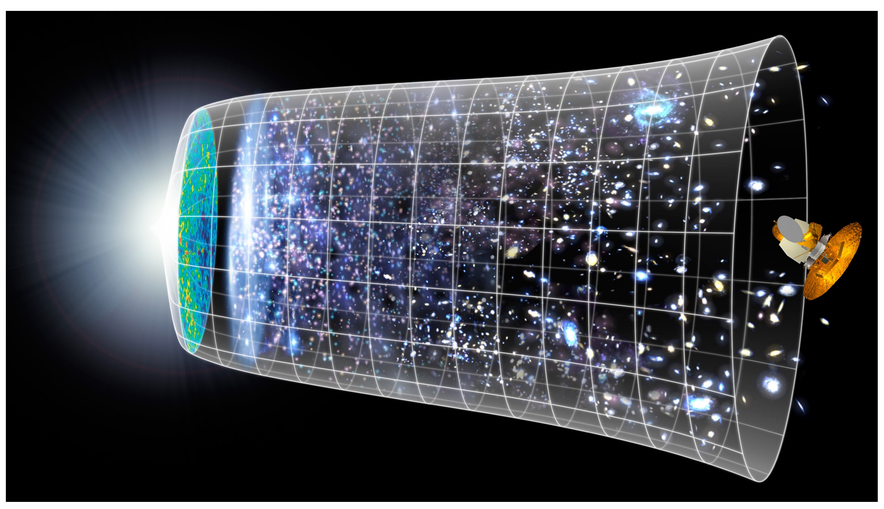
The research interests of our group cover a wide variety of topics, from the primordial Universe to its late time evolution.

In its earliest stages, the Universe has undergone a phase of exponential, superluminal expansion known as cosmic inflation. We are using the accurate measurements of the cosmic microwave background to test different inflationary scenarios. We are also involved in studying black holes formed in this primordial era.

Another line of research is dedicated to the study of cosmological tensions as possible hints for new physics beyond the standard cosmological model.

Modified Gravity

The goal of Modified Gravity is to provide an explanation for the current accelerated expansion of the Universe, as well as dark matter and cosmic inflation, possibly in a unified way.
To this aim, we have considered the possibility of implementing GR with fundamental fields, Higgs inflation, or fundamental symmetries, scale-invariant and f(R) gravity.



Cosmological Tensions

An important area of investigation for our group is the study of cosmological tensions, i.e., discrepancies in the values of cosmological parameters inferred from probes at different redshifts.

In particular, we are interested in exploring whether these tensions can be a sign of new physics beyond the concordance LCDM model or whether they are just a sign of residual systematics.

In our group we explore the possibility of such tensions shedding light on the microphysical nature of dark matter and dark energy, by formulating models that may solve the tensions.