

The current paradigm of the nature of spacetime is provided by the theory of General Relativity, which is the currently established theory of gravity. When applied to cosmology, it gives an accurate description of the behavior and evolution of our universe. Nowadays, this description is very accurate and it has given rise in the last years to important discoveries. However, the theory breaks down in some regions, predicting the appearance of singularities, such as cosmological singularities (as the Big Bang) or black hole singularities. Near these singularities, due to the scales of the theory, quantum effects are expected to be dominant. For that reason, it is expected that an underlying theory of quantum gravity will resolve the singularities and provide a complete picture of the universe. However, we are still far from having a complete and satisfactory theory of quantum gravity. Despite the lack of a final theory, one can use approaches to these regions to provide, on one side, a complete picture of spacetime and fields close to the singularity that allow us to understand the seeds of the early universe. On the other side, we also expect that these models provide us with some hints for searching for the elusive theory of quantum gravity.

This project aims for building a complete description of the spacetime in the vicinity of singularities. The evolution towards the singularities in General Relativity is chaotic and the different spatial points become disconnected. My goal is to determine how and when this mechanism emerges and derive a general model for this behavior when we introduce quantum gravity effects in a formalism that is compatible with the different candidate theories to quantum gravity and introduces constraints on them.

Then, the main results of the research project are the understanding of the spacetime near the singularities and how this new model changes our current cosmological and black holes paradigms, showing new ways to solve the conundrums that are still present in the topic.