Cosmology, i.e. the study of the Universe on the largest observable scales, is a rather young field of science as it only emerged from astronomy around the first half of the 20th century. In the last 20 years it developed rapidly due to the large influx of observational data (cosmic microwave background, i.e. the "echo" of the early Universe, the light from very distant and bright objects, for example supernovae). It was at that time that the currently accepted cosmological model, called the ΛCDM model, appeared. It assumes that the matter content of the Universe consists of the dark energy, responsible for the accelerated expansion, the weakly interacting and directly unobservable dark matter and a small quantity of the ordinary, so-called barionic matter. The observations indicate that the dark and ordinary matter is not distributed homogeneously, but rather exhibits a tendency to cluster while leaving some regions empty. The distribution of matter seems hierarchical: the largest clusters are made of walls, fibers, which in turn are made of galaxy clusters etc. Since the presence of this structure affects the rate of the Universe expansion and the way light from very distant sources moves through the spacetime, good understanding of its emergence and evolution is necessary to interpret the observational data in cosmology.

In this project I want to investigate the emergence and the evolution of the cosmic structure using mathematical tools from theoretical physics and computers. I will take into account the effects of general relativity, the modern theory of the shape of the Universe and gravity. The main goal is to find out how the presence of the hierarchical distribution of matter affects the way light travels through the Universe. In particular I will focus on the drift effects, i.e. slow changes in the way distant objects look on the sky, due to the Universe expansion and the presence of evolving inhomogeneities.