Abstract for the general public of the project
"Formation and evolution of barred galaxies in clusters and groups"

A significant fraction of spiral galaxies in the Universe, including the Milky Way, contain an elongated structure called a bar. Bars can affect the evolution of galaxies for example by contributing to the formation of their central bulges. The formation and evolution of bars can be studied theoretically by numerical simulations which follow a large number of particles in the role of stars and dark matter. Such simulations have shown that bars can form spontaneously in disks and are influenced by the presence of dark matter haloes. Another way to form bars in galaxies may be via interactions with other galaxies or clusters of them. If such interactions can induce bars, we should observe an increased fraction of barred galaxies toward the cluster center where the tidal forces are the strongest.

Unfortunately, there is at present no clear evidence from observations for such a relation, although early studies seemed to support this hypothesis. However, other studies seem to have reached less firm or even conflicting conclusions suggesting that the environment is not the most important factor and plays a secondary role in bar formation and evolution, and that the bar fraction instead depends on the galaxy stellar mass. This complicated picture calls for a systematic study of barred galaxies in clusters. The purpose of this project is to explain and clarify the processes that influence the formation and evolution of these objects using state-of-the-art cosmological simulations and new observations.

We will use the publicly available simulations from the IllustrisTNG project to select galaxies with sufficient resolution and classify them as barred or unbarred. We will then study the population of barred galaxies in at least ten most massive simulated clusters, calculate the bar fractions and compare them to those present outside the clusters. We will also measure how the bar fraction depends on the distance from the cluster center and on the stellar mass and compare them to observations for nearby clusters such as Coma and Virgo.

Next, the identified population of simulated barred galaxies in clusters will be traced back in time to investigate the origin of bars. We will check how many of the bars were induced by interactions and how the bar formation depends on the orbit of the galaxy in the cluster and the properties of the galaxy before it became a cluster member. We will also study the population of barred galaxies in clusters at different epochs to find how the bar fraction evolves in time and compare these findings with the values measured for distant clusters from the new observations performed by the James Webb Space Telescope (JWST).

A significant fraction of barred galaxies in clusters probably originated in groups. We will investigate how often this phenomenon occurs, namely what fraction of barred galaxies in clusters were actually formed while they were still members of groups that later formed the cluster. We will also study how the "preprocessing" in groups affects the properties of these barred galaxies and whether they differ significantly from other barred galaxies in clusters.

Combining state-of-the-art cosmological simulations and new observations from JWST the project will bring us closer to understanding important stages of galaxy formation and thus have significant impact on this specific research field and astrophysics in general.