Leiden-BNU Astronomy Summer School 2019: Computational Astrophysics projects

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Please refer to the Github repository[1] for detailed descriptions and template scripts for the projects. You can also find additional examples in the AMUSE repository[2].

1 Project 1: Stellar merger

Stellar collisions are rare in the Solar neighborhood, but frequent in regions of higher stellar density such as star clusters and the galactic center. "Blue stragglers", a type of star found in clusters which seem to be much younger than the rest of the cluster population, might form from the collision of other stars. In this project the students will model the interior of two stars using SPH codes, together with stellar evolution codes. They will then produce a stellar merger between the two stars and analyze the evolutionary properties of the merger product.

2 Project 2: Dynamical evolution of star clusters

The most accepted theories in star formation propose that this process takes place in star clusters and stellar associations. After a star cluster is formed, its dynamical evolution is driven by internal and external processes. Examples of internal processes are two body relaxation and stellar evolution. External processes can be the interaction with the tidal field of the galaxy, or with giant molecular clouds. In this project, students will learn to model star clusters using different initial conditions and dynamical codes. They will learn about the dynamical evolution of star clusters, and they will investigate how different interactions with the environment affect such evolution.

3 Project 3: Dynamical modeling of the Milky Way-Andromeda merger

Galaxy mergers are among the most important dynamical processes in the evolution of galaxies. Depending on their speeds, impact angles, and mass ratios, galaxy mergers can produce irregular, lenticular, elliptical, or even spiral galaxies. Within the local group, the Andromeda galaxy (M31) is approaching the Milky Way at a speed of roughly 110 km/s. It is predicted that the two galaxies will eventually collide in about 4.5 Gyr from now, merging into an elliptical galaxy. In this project the students will develop a simulation of a galaxy merger using different dynamical codes, and they will analyze how different initial conditions yield different merger results.

4 Project 4: Mass accreting from a stellar companion

Binaries and higher-order multiple stellar systems are very common, and the interactions between their different components can have important consequences in their evolution. Depending on the stellar types of the components, stars can accrete mass from their companions and, in extreme

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[1]https://github.com/franciscaconcha/LeidenBNU2019
[2]https://github.com/amusecode/amuse/tree/master/examples

cases, this process can trigger a supernova explosion. In this project, students will evolve a binary star system in which one of the components is accreting mass from its companion. They will use SPH codes to model the flow of matter between the stars, and compare the simulation results with theoretical approximations of mass loss for this specific case.