Star clusters are dense groups of stars attracting each other by mutual gravitational forces. They are very commonly observed in all types of galaxies and can be divided into two types: open clusters (OCs) and globular clusters (GCs). OCs are young and small systems that contain about thousand stars and distributed in galactic disks while GCs are old (age > 10 Gyr) and massive. GCs have about one hundred thousand to million stars and populate galactic halos. Star cluster is a very different object from our solar systems, which is isolated and far from any other stars. Our nearest star is Proxima Centauri, which is 4.37 light years away. But in a typical star cluster, there are thousands to millions stars inside such a distance. Especially, the GCs, have a typical half-mass radius (the one containing half of the total mass) of the order of 1 - 10 pc, which means that the cores of GCs are very crowded places. The average distance between stars can be 100 times smaller than this distance to Proxima Centauri. We can imagine it so that the a GC looks like a big capital city (e.g. Warsaw), while our solar system looks like a small house in a desert. In a desert, it is very difficult to communicate with outside world, but in a crowded city, many things can happen and a life goes much faster there too. Similarly, the stars living in GCs can frequently get close to each other, which we called close encounters. There are also a lot of binaries present. The two members of the binary are strongly binding, living together in a cluster and very difficult to be separated. However, the binaries experience a lot of close interactions which might change them. If the intruder (star or binary) is massive enough it has enough power to kick out one of the members in the binary and take its place. After several such events, some of the binaries may come together so closely that they cannot be disrupted easily anymore. Moreover, such stars tend to occupy the centers of the GCs, just like the downtown of the city have higher buildings with more people working in them. The process of interactions is called “few body interactions” and the process of migrations of more massive stars into the cluster centre is called “mass segregation”. Large cities offering good jobs, entertainment and the opportunity to acquire a good education attracts people from different countries and continents. Similarly is in globular clusters we observe multiple stellar populations differing in their age and chemical composition.

All these interesting processes happened in GCs make them a very good laboratory for theoretical studies of the N-body gravitational dynamics including close interactions. On the other hand, due to these complicities, the theoretic studies of the GC evolution from the first principles are very difficult. In addition, all these physical processes need to be mutually considered when we want to understand the life of a GCs. Thus the numerical simulations are required to achieve this goal. The most accurate simulation method is the direct N-body method, in which a force of one star is calculated by adding the Newtonian force of all other stars, and the positions and velocities are predicted by using the calculated forces. However, this kind of simulation is very time consuming. The calculation of the actual evolution of globular cluster is extremely challenging and may take over a year. However, due to large number of initial parameters determining the subsequent cluster evolution the N-body method is not practical. The alternative is a Monte Carlo MOCCA code, developed in the Nicolaus Copernicus Astronomical Center Polish Academy of Sciences by Mirek Giersz's group. This code is extremely fast and at the same time takes into account all the interesting physical processes discussed above. The comparison between results of the MOCCA and direct N-body shows a very good agreement. The MOCCA code is the perfect choice to conduct surveys of globular cluster models.

For a long time, globular clusters were considered to be very chemically homogeneous in which all stars were formed in the same time. However, recent observations found that GCs contain several distinct stellar populations differing by chemical compositions and time of formation. The process of formation of several populations of stars in globular clusters is not fully understood theoretically. Therefore, it is necessary to examine this issue based on advanced numerical simulations. That is the main objective of this project. To achieve this goal the MOCCA code will be expanded to allow study the evolution of clusters consisting of two stellar populations, and the influence of removal of the gas left after star formation on the parameters describing the cluster initial properties. Additionally, tools will be developed for automatic analysis of the MOCCA-SURVEY database of the simulation results. Comparison of the results of our simulations with observational data already collected, as well as those of the GAIA mission will bring the understanding of the evolution of globular clusters to a new level.