Abstract:
Star clusters are thought to be the birthplaces of stars as well as the building blocks of galaxies. They typically consist of thousands to millions of stars bound together by self-gravity. These systems evolve on the scale of Myr to Gyr, therefore, it is impossible for us to see any change in their global evolution even within hundreds of human lifetimes.

Although the equations of motion of stars in a star cluster are simple Newtonian, it is impossible to predict precisely history of any star within them to any point in the future. Therefore, we may either compare the observations of different star clusters at different age, we may invent theoretical approaches and analytical predictions, or we must follow their evolution numerically (e.g. with direct N-body integrators) which is the main focus of my research and this thesis.

First, we follow the evolution of star clusters in general while coming up with a novel method to estimate their characteristic timescale (i.e. the time of core collapse) based on global parameters. The core collapse is directly linked to the formation of hard binary stars, thus, we focus on their analysis as well. We also follow several recent observational results:

(i) *ALMA* observations of the Serpens South star-forming region indicate that star clusters are born mass segregated. But in the evolved clusters, this primordial mass segregation seems to be lost. We are the first to present an empirical estimate based on numerical simulations of the timescale on which the primordial mass segregation vanishes. We also apply our results on the Orion Nebula Cluster (for that we compiled the most complete dataset of this cluster yet, which is now also available online).

(ii) Galactic globular clusters are observed to contain up to 50 % of black holes. In order to constrain the initial retention fraction of black holes within them, we made a series of numerical models and an analytic model.

(iii) Finally, we looked at star clusters from a more global view in the Galaxy. We found that the recently measured γ-ray excess from the centre of our Galaxy may be due to millisecond pulsars which were deposited there by inspiraling and tidally disrupted globular clusters.