Gravity and Thermodynamics. I. Fundamental principles

In the dynamical evolution of globular clusters, stellar encounters strongly contribute in phase space mixing of stellar orbits. In this scenario, thermodynamics plays a central role in the gravitational equilibrium and stability of the clusters. On the other hand, the observations of luminosity profiles suggest a unique distribution function allowing the study of the evolution as a sequence of thermodynamic transformations, keeping constant the distribution of the star velocities, like in the framework of Boltzmann statistical mechanics. Then, we can construct equilibrium models with a different approach by applying thermodynamic principles to a Boltzmann distribution function, with an Hamiltonian which contains an effective potential depending on the kinetic energy of the stars. We also obtain new relations for the thermodynamical equilibrium in presence of gravity and introduce the concept of thermodynamic and kinetic temperature and pressure. The models present regions with positive and negative specific heat, producing thermodynamic instabilities which drive the clusters towards the so called gravothermal catastrophe.