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Gravity and thermodynamics: a new point of view in the analysis of equilibrium and dynamical evolution of globular clusters.

In the analysis of the 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, being binary relaxation time shorter than the age of such systems.
On the other hand, the observations of luminosity profiles of globular clusters, at different values of the central gravitational potential, show self similar curves that suggest a unique distribution function (King DF) with changing thermodynamical parameters during the dynamical evolution, according to the numerical simulations existing in literature. This means that the evolution of globular clusters can be studied by considering small thermodynamic transformations which keep constant the functional form of the velocity distribution of stars like in the framework of Boltzmann statistical mechanics.
We then construct King models with a different approach by applying thermodynamic principles to a Boltzmann distribution function with an Hamiltonian function which contains an effective potential depending on the kinetic energy of the stars. In this way, we obtain new relations for the thermodynamical equilibrium in presence of a gravitational potential, a different form of the virial theorem and introduce the concept of thermodynamical and kinetic temperature and pressure. We can also demonstrate that a globular cluster can be described as a Lynden-Bell model containing regions with positive and negative specific heat producing thermodynamic instabilities which drive the systems towards the so called gravothermal catastrophe, first described by Lynden-Bell and Wood in the well known paper in 1968.
The results, applied to the new Harris Catalogue for globular clusters, give an important agreement between theory and observations.

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