Neutron Stars : from the crust to the interior

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Abstract

Neutron stars are born in the aftermath of supernova explosions of very massive stars. Newly born neutron stars which are hot and neutrino-rich, are known as protoneutron stars. The protoneutron star is deleptonised with the emission of trapped neutrinos and later cools down by emitting thermally produced neutrino-antineutrino pairs in a few hundred seconds. Finally a cold and dense neutron star is born.

Neutron star encompasses a wide range of densities - from the density of iron nucleus at the crust to several times normal nuclear matter density in the core. They are natural laboratories for cold and dense matter that can not be produced on the earth. Gross properties of neutron stars such as, mass, radius, surface temperature and magnetic field are determined from observations. In particular, a comparison of the observed masses and radii of neutron stars with those calculated theoretically might shed light on the equation of state (EoS) and composition of neutron star matter and might also tell us about the existence of exotic phases of matter such as, hyperons, and Bose-Einstein condensates of pions and kaons.

Here we discuss neutron star crust as well as the core. We adopt a relativistic model of nucleon-nucleon interaction mediated by the exchange of mesons to construct the EoS of dense matter in neutron star interior. We discuss the connection of the symmetry energy with the proton fraction and the behaviour of the EoS at high density. We continue our discussion on the EoS with the inclusion of exotic forms of matter such as hyperons. Finally we estimate masses and radii of neutron stars using the EoS and confront our theoretical findings with the observations.