Nuclear symmetry energy and neutron star cooling

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In this talk, the bulk properties of asymmetric nuclear matter are discussed in the framework of various self-consistent mean field approaches which are nowadays widely used for finite nuclear systems. These approaches have in common the fact that they can describe at a quantitative level the properties of a large variety of finite nuclei with a limited number of adjusted parameters and therefore, one may think that their predictions of bulk nuclear matter properties are reliable, at least in a range of moderate densities. One of the interesting issues concerns the behaviour of the symmetry energy S with increasing baryonic density ρ_b. This behaviour governs the density dependence of the so-called proton fraction $X(\rho_b)$ and it decides of the possibility that the rapid cooling of a neutron star via the direct URCA process may occur, or not. This question has been studied recently in the non-relativistic framework [1] as well as in the relativistic one [2], and we shall review here the present status.

The various models can be divided into 2 categories, those which predict that $S(\rho_b)$ is an increasing function of ρ_b for $\rho_b \geq 1.5\rho_0$ (Asy-stiff models) and those which predict that $S(\rho_b)$ decreases when $\rho_b \geq 1.5\rho_0$ (Asy-soft models). For the direct URCA process to become possible, an Asy-stiff behaviour is a necessary condition. A large majority of Skyrme-type forces correspond to the Asy-soft category [3], as well as other non-relativistic Hartree-Fock models based on finite range interactions like the Gogny and the Nakada forces. On the other hand, the relativistic models based on the relativistic Hartree (Relativistic Mean field, or RMF) or relativistic Hartree-Fock (RHF) belong to the Asy-stiff category. Thus, just the knowledge of the properties of finite nuclei cannot solve this dilemma and more experimental data at densities above the saturation density ρ_0, along the line of the pressure data coming from heavy ion flow measurements [4] would be quite helpful.

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