Thermalization time and specific heat of neutron stars crust

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The thermalization process of the neutron stars crust can give important informations about the properties of the crust matter. This is indeed the case in the rapid cooling of isolated neutron stars [1] and in the thermal afterburst relaxation of neutron stars from X-ray transients [2]. In the rapid cooling process an important quantity is the cooling or thermalization time of the crust, defined as the time needed for the crust matter to arrive to the temperature of the cold core. Since the outer crust and the envelope have high thermal conductivity, the cooling time is essentially determined by the inner crust matter, formed by nuclear clusters, unbound neutrons and ultrarelativistic electrons.

We discuss the thermalization process of the neutron stars crust described by solving the heat transport equation with a microscopic input for the specific heat of baryonic matter. The heat equation is solved with initial conditions specific to a rapid cooling of the core. To calculate the specific heat of inner crust baryonic matter, i.e., nuclear clusters and unbound neutrons, we use the quasiparticle spectrum provided by the Hartree-Fock-Bogoliubov approach at finite temperature. In this framework we analyze the dependence of the crust thermalization on pairing properties and on cluster structure of inner crust matter. It is shown that the pairing correlations reduce the crust thermalization time by a very large fraction. The calculations show also that the nuclear clusters have a non-negligible influence on the time evolution of the surface temperature of the neutron star.

[1] J.M. Lattimer, K. A. Van Riper, Madappa Prakash and Manju Prakash, ApJ 425, 802 (1994)
[2] A. Potekhin et al, APJ 594 (2008)404