Landau damping and kinetics of neutron stars

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Kinetic properties (thermal and electric conductivity, shear viscosity) of neutron star matter are analyzed taking into account the exchange of transverse plasmons in collisions of charged particles. In contrast to direct Coulomb scattering via the exchange of longitudinal plasmons (leading to a static Debye-like screening), the exchange of transverse plasmons via relativistic current-current interaction leads to the dynamical Landau damping. In the relativistic degenerate matter, characteristic scales of transverse interactions are much higher than those for longitudinal interactions. The importance of transverse plasmon exchange was pointed out by Heiselberg and Pethick [1] in their studies of ultrarelativistic quark plasma. This effect has never been considered in the kinetics of neutron stars. The dynamical nature of plasma screening in the transverse channel suppresses all the kinetic coefficients, mediated by collisions of charged particles, and modifies their temperature dependence. For example, the electron and muon thermal conductivity in neutron star cores becomes temperature independent (instead of usual Fermi-liquid dependence $\kappa \propto T^{-1}$) and several orders of magnitude lower than has been thought before. The temperature dependence of the shear viscosity η and electrical conductivity along the magnetic field $\sigma_\parallel$ becomes $\eta \propto \sigma_\parallel \propto T^{-5/3}$, in contrast to the standard Fermi-liquid behavior ($\propto T^{-2}$).

We reconsider the thermal conductivity and shear viscosity owing to electron-electron collisions in a neutron star crust [2, 3], the thermal conductivity [4] and shear viscosity in a neutron star core, and the electric conductivity in a magnetized core [5]. The results in the core include the effects of proton superfluidity and are valid for any equation of state of dense matter. All results are approximated by analytic expressions to facilitate their implementation in computer codes.

We discuss several manifestations of updated kinetic coefficients, particularly, the effect of thermal conductivity on the cooling of young neutron stars.

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