Thermal conductivity of ions in a neutron star envelope

A.I. Chugunov, P. Haensel

We analyze the thermal conductivity of ions (equivalent to the conductivity of phonons in crystalline matter) in a neutron star envelope. We calculate the ion/phonon thermal conductivity in a crystal of atomic nuclei using variational formalism and performing momentum-space integration by Monte Carlo method. We take into account phonon-phonon and phonon-electron scattering mechanisms and show that phonon-electron scattering dominates at not too low densities. We extract the ion thermal conductivity in ion liquid or gas from literature. Numerical values of the ion/phonon conductivity are approximated by analytical expressions, valid for T> 10^5 K and 10^5 g cm^{-3}<\rho < 10^{14} g cm^{-3}. Typical magnetic fields B~10^{12} G in neutron star envelopes do not affect this conductivity although they strongly reduce the electron thermal conductivity across the magnetic field. The ion thermal conductivity remains much smaller than the electron conductivity along the magnetic field. However, in the outer neutron star envelope it can be larger than the electron conductivity across the field, that is important for heat transport across magnetic field lines in cooling neutron stars. The ion conductivity can greatly reduce the anisotropy of heat conduction in outer envelopes of magnetized neutron stars.