Plasma polarization in massive astrophysical objects

I.L. Iosilevskiy

Moscow Institute of Physics and Technology (State University), Moscow, Russia

We discuss macroscopic plasma polarization, which is created in massive astrophysical bodies by gravitation and other inertial forces. A new source of such a polarization is introduced which is the polarization caused by non-ideality effects due to strong Coulomb interaction of charged particles. This "non-ideality" polarization may be significant in comparison with the well-known gravitational polarization. The latter polarization effect was established long ago by Pannekoek, Rosseland and others for the case of ideal, isothermal and non-degenerate plasma in outer layers of a star. Later their approach has been extended (for example, Bilsten et al.) to conditions of dense and degenerate interiors of compact stars. The present work presumes the incorrectness of this extension because it is based on partial pressures and "partial" hydrostatic equilibrium equations separately for each species of particles. The present consideration is based on the density functional approach combined with the "local density approximation". We study a simplified situation of a totally equilibrium isothermal star neglecting magnetic field and relativistic effects. The extremum condition for the thermodynamic potential results in two sets of equivalent conditions: constancy for generalized partial (electro-) chemical potentials and/or equilibrium for the forces acting on any charged particle. In this latter form, new "Coulomb non-ideality" force appears in the hydrostatic equilibrium equation, in addition to two traditionally studied gravitational and electrostatic forces. In most cases this new "force" increases the final electrostatic field in comparison with that of the standard ideal-gas solution. Our resulting formula reproduces two known limiting cases for a degenerate and non-degenerate ideal gas and leads to some additional effects. Hypothetical consequences of these effects on the structure, thermo- and hydrodynamics of neutron stars are discussed.