

DIPOLE MAGNETOSPHERE OF NEUTRON STARS: COINCIDING BELTS OF CHARGED PARTICLES

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Abstract

Charged particle motion in magnetosphere of a neutron star endowed by a dipole magnetic field, which is combined with an external uniform magnetic field related to a distant magnetar. The neutron star is described by the Schwarzschild gravitational field of mass M and a dipole magnetic field characterized by the parameter b_d representing the ratio of electromagnetic and gravitational forces on the neutron star surface assumed at $R = 3M$. Similarly, the parameter b_u relates these forces for the external uniform magnetic field. The axes of both magnetic fields are assumed to be parallel.

We demonstrate how the additional uniform magnetic field influences the position of circular orbits "in" and "off" the equatorial plane and the charged particle motion in belts concentrated around the off-equatorial orbits allowed for dipole repulsion, and their relation to the curling motion. Trajectories of the particles with very large values of b_d, b_u are governed by the approximate scaling symmetry. The additional uniform magnetic field significantly influences the picture given by the sole dipole field - the region of stable equatorial circular motion is substantially extended for both magnetic repulsion and attraction and the particle belts under magnetic repulsion are strongly shifted to the neutron star surface. For example, even relatively small influence of the uniform field can cause large shift of belts created by protons (ions) or electrons to a close vicinity of the neutron star surface and their convergence. The most important effect is coincidence of the belts of various types of particles for even a very weak uniform magnetic field.