

Growing electrostatic modes in the isothermal pair plasma of the pulsar magnetosphere

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Abstract It is shown that a strongly magnetized isothermal pair plasma near the surface of a pulsar supports low-frequency (in comparison to electron cyclotron frequency) toroidal electrostatic plasma modes in the equatorial region. Physically, the thermal pressure coupled with the magnetic pressure creates the low frequency oscillations which may grow for particular case of inhomogeneities of the equilibrium magnetic field and the pair plasma density.

Keywords Pulsar magnetosphere · Pair plasma · Electrostatic mode

1 Introduction

Study of pair plasma in the pulsar magnetosphere is related to the investigation of radio emission coming from these sources (Buzzi and Hines 1995; Mofiz 1997 and the references therein). Radio pulsars, which are rotating neutron stars with spin periods ranging from 1.57 ms to 5 ms, are characterized by surface magnetic fields in the order of 10^{12} G, radii of about 10 km. A rotating magnetized neutron star generates huge potential difference between

different parts of its surface (Goldreich and Julian 1969). Theoretical models (Sturrock and Baker 1979; Ruderman and Sutherland 1975; Arons and Scharlemann 1979) have been developed to predict the production of pair plasma (electron-positron) in the pulsar magnetosphere. A mechanism of cascade generation of particles has been suggested, according to which secondary electrons and positrons result from pair production induced by high-energy curvature radiation photons-emitted by primary electron beams coming from pulsar surface. Pair plasmas are composed of charged particles with same mass and opposite charges, which admit the time and space scales that significantly differs from those of an electron-ion plasma. There appear a great variety of linear and nonlinear plasma modes in the strongly magnetized pair plasma. A good number of works are done by several authors (Sakai and Kawata 1980; Lominadze et al. 1983; Mofiz 1989, 1990, 1997; Mofiz et al. 1985, 1987; Shukla and Shukla 2007). Recent discoveries (Sana et al. 2010) of kilohertz quasi-periodic oscillations (kHz QPOs) may also be related with the typical dynamical time scales of pair plasma close to the surface of the neutron star.

In this paper, we have investigated the low frequency (in comparison to the electron cyclotron frequency) electrostatic oscillations in the equatorial region of the pulsar magnetosphere. We found that thermal pressure coupled with the magnetic pressure creates the low frequency oscillations which propagate along the toroidal direction of the equatorial plasma. The magnetic field inhomogeneities and the equilibrium plasma density in particular situations may admit growing low frequency electrostatic modes in the pulsar magnetosphere.

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