High Frequency Cutoff and Change of Radio Emission Mechanism in Pulsars

V. M. Kontorovich[1,2] • A. B. Flanchik[1]

Abstract Pulsars are the fast rotating neutron stars with strong magnetic field, that emit over a wide frequency range. In spite of the efforts during 40 years after the discovery of pulsars, the mechanism of their radio emission remains to be unknown so far. We propose a new approach to solving this problem for a subset of pulsars with a high-frequency cutoff of the spectrum from the Pushchino catalogue (the "Pushchino" sample). We provide a theoretical explanation of the observed dependence of the high-frequency cutoff from the pulsar period. The dependence of the cutoff position from the magnetic field is predicted. This explanation is based on a new mechanism for electron radio emission in pulsars. Namely, radiation occurs in the inner (polar) gap, when electrons are accelerated in the electric field that is increasing from zero level at the star surface. In this case acceleration of electrons passes through a maximum and goes to zero when the electron velocity approaches the speed of light. All the radiated power is located within the radio frequency band. The averaging of intensity radiation over the polar cap, with some natural assumptions of the coherence of the radiation, leads to the observed spectra. It also leads to an acceptable estimate of the power of radio emission.

Keywords pulsars: radio emission, spectra

1 Introduction

Pulsars are magnetized neutron stars that have a magnetosphere filled with an electron-positron plasma of about the GJ density (Smith 1977; Manchester & Taylor 1977; Beskin, et al. 1993). New discoveries of double pulsar system (Lane, et al. 2004) and intermittent pulsars (Kramer, et al. 2006; Lorimer, et al. 2012; Camilo, et al. 2012) give the direct observational support to that idea. It is thought that this plasma in the region of open magnetic field lines over the magnetic polar cap is generated by particles (through gamma quanta production) accelerating in a gap under the magnetosphere (Sturrock 1971; Ruderman & Sutherland 1975; Arons 1981; Beskin 2010). The acceleration of electrons occurs in the gap in the electric field that is longitudinal with respect to the magnetic field and induced by the rotation of the magnetized star. Directed coherent electromagnetic radiation of relativistic particles from the region of open lines creates the beacon effect that results in the pulses observed (the most popular explanation).

In explanation of radio emission of pulsars (see reviews (Malov 2004; Manchester 2009) and addition references in (Malov & Machabeli 2009; Kontorovich 2009; Beskin & Philippov 2012)) the instabilities of plasma flow, beam instabilities and similar effects in the magnetospheric plasma[1] have been discussed. Apparently, various mechanisms of radio emission are actually realized and may in certain circumstances succeed each other.

We show in this paper that for the observed pulsar radio emission a coherent radiation produced in a polar gap may be responsible, at least for pulsars of the

V. M. Kontorovich

A. B. Flanchik

[1]Institute of Radio Astronomy of National Academy of Sciences of Ukraine, 4 Chervonopraporna Str., Kharkov 61002, Ukraine.

[2]Karazin Kharkov National University, 4 Svobody Sq., Kharkov 61077, Ukraine.

[1]Note apart the plasma-beam (see as example (Usov 1987; Kazbegi, et al. 1992)), also the cyclotron, drift, modulation instabilities, Zakharov's wave collapse and magnetic reconnection for GP, low-frequency "tails" of the synchrotron, Cherenkov, Doppler and curvature radiation in the relativistic electron-positron plasma.