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# A possible mechanism for flattening of pulsar spectra at high frequencies

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Pulsar spectra have three characteristic parts: a low frequency turnover (the region of the maximum), a linear part with a constant spectral index, and a high frequency cut-off (after it the spectrum becomes considerably steeper) (Malofeev et al. 1994). These three parts can be described in the frame of the usual model of curvature radiation (Malov 1979; Ochelkov & Usov 1984; Kuz'min & Solov'ev 1986; Malov & Malofeev 1991). Kramer et al. (1997) have found a flattening in the spectra of 4 pulsars at frequencies above 30 GHz. It cannot be understood in such model. We propose the possible explanation for the unusual behaviour of these spectra.

Relativistic electrons can acquire considerable pith-angles $\psi$ At large distances from the surface of a neutron star (Machabeli & Usov 1979), and synchrotron radiation (s.r.) becomes more important than curvature radiation (c.r.). The ratio of the power $q_{sr}$ of synchrotron emission to the power $q_{cr}$ of curvature one

$$\delta = \frac{8 \cdot 10^{60}}{9\pi} \frac{e^2 B_{12}^2 P r_1 \sin^2 \psi}{m^2 c^3 r_2^6 \gamma^2} \tag{1}$$

is equal to $1.4 \cdot 10^{12} \frac{B_{12}^2}{P^5 \gamma^2}$ for $\psi = 0.1\, rad$, $r_2 = 0.9 r_{LC}$, $r_1 = 10^8 cm$. Here $r_1$ and $r_2$ are distances where s.r and c.r are generated, $r_{LC} = \frac{CP}{2\pi}$. One can see that in fact $\delta > 1$ for $\gamma < 10^6$. We believe that at some level in the pulsar magnetosphere where the frequency $\nu = \nu_*$ the intensities of the local s.r. and c.r., escaping from deeper layers, are equal to each other (Fig.1). At higher frequencies incoherent s.r. predominates and the intensity increases for $\nu > \nu_*$.

We compare the calculated luminosity

$$L_\nu = \frac{\pi^3 d^2 W_{0,5} S_\nu}{P} = 8,17 \cdot 10^{15} d^2(\mathrm{kpc}) W_{0,5}(\mathrm{deg}) S_\nu(\mathrm{mJy}) \frac{\mathrm{erg}}{\mathrm{s} \cdot \mathrm{Hz}} \tag{2}$$

where $d$ is the distance to the pulsar, $W_{0,5}$ and $S_\nu$ are the pulse width and the flux density at $\nu_* = 43\,\mathrm{GHz}$, with the prediction of the synchrotron model:

$$L_s = \frac{0,1\pi^3 e B_s R_*^3 \psi^2 \nu \gamma_b}{c^2 P \gamma_p} \tag{3}$$

Here $\gamma_b$ and $\gamma_p$ are Lorentz-factors of beam particles and the secondary electrons, respectively.

Adopting $\gamma_b = 10^7$, $\gamma_p = 10$, $\nu = 43\mathrm{GHz}$, $R_* = 10^6\mathrm{cm}$, and equating $L_s$ to the observed values we can estimate pitch-angles

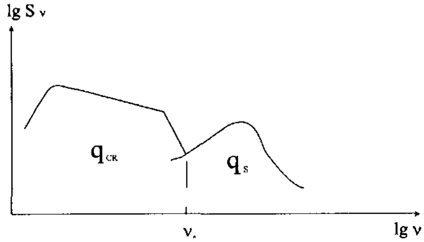


Figure 1. Model representation of a pulsar spectrum

$$\psi = 2 \cdot 10^{-9} \left( \frac{L_\nu P}{B_{12}} \right)^{1/2}, \tag{4}$$

The values $\psi$ for the pulsars PSR 0329+54, 0355+54, 1929+10 and 2021+51 are equal to 0.04 - 0.44 rad. We can use these values to calculate the frequency $\nu_m$ of the maximum in the synchrotron spectrum using the Epstein's results (Esptein 1973) for small pitch-angles ($\gamma\psi \sim 2, 5$):

$$\nu_B = \frac{5eB}{\pi mc\gamma\psi^2} \sim 50\,\mathrm{MHz} \tag{5}$$

Here we have taken the dipole magnetic field at distances $\sim 10^9\,cm$. The synchrotron spectrum in this case has in a rather broad maximum. This could explain the equality of the fluxes at 43 and 87 GHz reported in (Kramer et al. 1997).

The electric field vector eies in the plane of the magnetic field line for c.r. and it is perpendicular to this plane in the case of s.r. Therefore the position angle of the linear polarization should vary during a transition between these two mechanisms. A detaled study of the behaviour of this angle at high frequencies would be useful for testing the proposed model.

Our model suggests for the first time that s.r. may play a significant role in normal pulsars with long period.

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## References

Esptein R.I. 1973, ApJ, 183, 593.

Kramer M., Jessner A., Doroshenko O., Wielebinski R. 1997, ApJ, 488, 364.

Kuz'min A.D. and Solov'ev A.G. 1986, AZh, 63, 62.

Machabeli G.Z. and Usov V.V. 1979, Pis'ma AZh, 5, 445.

Malofeev V.M., Gil J.A., Jessner A. et al 1994, A&A, 285, 201.

Malov I.F. 1979, AZh, 56, 368.

Malov I.F. and Malofeev V.M. 1991, AZh, 68, 362.

Ochelkov Yu.P. and Usov V.V. 1984, Nature, 309, 332.