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The investigations of pulsar integral radio luminosities

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We have calculated accurate integral radio luminosities L for 232 pulsars (Malov et al., 1994) using new average spectra of these objects. Histogram of L-distribution is characterized by the mean value $<\log L>= 28.45$ and by the mean-square-root deviation $S = 1.0$. We have analysed also data for short-periodic pulsars ($P < 0.1$ s) and long-periodic ones ($P > 1$ s) separately.The main goal of such separation was to test the hypothesis on two types of pulsars (Malov, 1987): i) for the first group of objects radiation is emitted from the neighbourhood of the light cylinder ($r = r_{LC} = cP/2\pi$, P is the pulsar period), ii) for the second one emission is generated at distances $r \ll r_{LC}$. In the second case the main mechanism of radiation is curvature radiation. For the first group of pulsars the radiation is connected with the cyclotron mechanism. The difference between two basic mechanisms and the locations of the emission generation regions must cause some differences in the observable features for these two classes of pulsars.

Our analysis has shown that $N(\log L)$ for pulsars with long periods is nearly the same as for the whole sample. However the distribution for objects with $P < 0.1$ s is uniform in the range $\log L = 27 - 32$ and characterised by values $<\log L>= 29.8$ and $S = 1.4$. There is the evident difference in the values of transformation coefficients

$$\eta = L/\dot{E} = LP^3/4\pi^2 I\dot{P} \qquad (1)$$

($\dot{E}$ - the rate of losses of rotation energy, I - moment of inertia) for two pulsar groups. The mean value is much more for pulsars with long periods: $\overline{\log \eta} = -5.85$ ($P < 0.1s$), $\overline{\log \eta} = -3.45$ ($P > 1s$). The dependences $\eta(P)$ have opposite signs:

$$\begin{aligned} \log \eta &= (-1.4 \pm 0.7) \log P - 8.4 \pm 1.3 \qquad P < 0.1\, s \\ \log \eta &= (1.8 \pm 0.2) \log P - 3.8 \pm 0.1 \qquad P > 0.1\, s. \end{aligned} \qquad (2)$$

It is shown that the luminosity for both groups is constant during few millions years.

There are many arguments for generation of observed radiation near the light cylinder in pulsars with short periods (Malov, 1992). Here the intensity of cyclotron (or synchrotron) radiation is much higher than that of curvature radiation (Smith, 1977). For single electron the total power of synchrotron emission is

$$q_B = \frac{2e^4 B^2 \sin^2 \theta \gamma^2}{3m^2 c^3}, \qquad (3)$$

where θ is the pitch-angle and γ is Lorentz-factor of emitting electrons. This formula shows that for pulsars with $P < 0.1$ s the luminosity must increase with increasing of magnetic field B_{LC} near the light cylinder. In fact for our data there is the noticeable correlation (the correlation coefficient is $k = 0.87 \pm 0.20$) between $\log L$ and $\log B_{LC}$:

$$\log L = (1.2 \pm 0.3) \log B_{LC} + 15.0 \pm 3.5\ . \tag{4}$$

The power of curvature radiation

$$q_{cr} = 2e^2 c\gamma^4/3\rho^2 . \tag{5}$$

does not depend on B and the correlation between L and B must not be observed. We obtained that there is no such correlation in fact. These results confirm the idea on two types of pulsars. We construct the dependence $L(B/P^2)$ (cf. (Stollman, 1987)) using mean values of $\log L$ and $\log(B/P^2)$ for appropriate intervals. All 7 points fall very well on the same straight line:

$$\log L = (0.64 \pm 0.05) \log(B/P^2) + 20.54 \pm 0.68\ . \tag{6}$$

($k = 0.98 \pm 0.08$). It is well known that the power of magnetodipolar radiation is equal [4] to

$$W_{md} = 2B^2 R^6 \cos^2 \theta \Omega^4/3c^3 \tag{7}$$

($\Omega = 2\pi/P$). So $W_{md} \propto B^2/P^4$. It is proposed usually that $W_{md} = \dot{E}$, and it follows from equations (6) and (7) that

$$L \propto \sqrt[3]{\dot{E}} \tag{8}$$

Using the dependence

$$\log L = 0.91 \log_{TML} + 26.36\ , \tag{9}$$

between our values of L and $L_{TML} = S_{400}\ (mJ)\ d^2\ (kpc)$ from (Taylor et al., 1993) we constructed the luminosity function. It is very interesting that there is no pulsars in Galaxy with $L < 10^{26}$ erg/s. Our estimations showed that such pulsars can be observed up to distances 0.43 kpc. 8 pulsars are known inside this volume, but all of them have luminosities $L > 10^{26}$ erg/s. It is worth noting that the luminosity function has also a cut-off at $L > 10^{32}$ erg/s. $L = \dot{E}$ in this point, i.e. losses of the rotation energy equal to power of radio emission. At last we have estimated the total number of pulsars in Galaxy from the luminosity function $n = 2.5 \cdot 10^5$ and the birth rate of pulsars $\nu = 0.024$ pulsars per year.

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