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Pulsar radio beams and emission altitudes

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We verify the relationship proposed by Kijak and Gil (1996) for the pulsar radio emission altitudes

$$r_{KG} \approx 50 \cdot R\, \nu_{\rm GHz}^{-0.21}\, \tau_6^{-0.1}\, P^{0.33}\,, \qquad (1)$$

(see also Eq.3 in Gil & Krawczyk, 1996), using the pulse-profile Effelsberg raw data at 1.41 GHz. We measured profile pulse-widths at the lowest intensity level corresponding to 0.01% of the maximum intensity (Fig. 1b), using the polar–log-scale technique (Hankins and Fowler, 1986). We calculated opening angles (Fig. 1a) and emission altitudes (Fig. 1c) assuming that: *i*) pulsar radiation is narrow-band with radius-to-frequency mapping operating in the emission region, *ii*) pulsar emission is beamed tangentially to the dipolar magnetic field lines, *iii*) the extreme profile wings originate near or at the last open field lines.

We argue that the emission altitude depends on : pulsar period P, frequency ν, pulsar age τ_6 (in units of 10^6 years) approximately as $r \approx 50 \cdot R\, \nu_{\rm GHz}^{-1/5}\, \tau_6^{-1/10}\, P^{1/3}$, or

$$r \approx (55 \pm 5) \cdot R\, \nu_{\rm GHz}^{-0.21\pm0.07}\, \tau_6^{-0.1\pm0.02} \qquad (2)$$

where $R = 10^6$ cm is the neutron star radius. If the above conclusion is correct then the magnetic field in the emission regions is about $10^7 - 10^8$ G, independent of pulsar period P (Fig. 1d). Thus, the emission region is located close to the neutron star in short period pulsars and further away in longer period pulsars. However, the entire pulsar emission region lies within about 100 stellar radii, in consistency with independent estimates (e.g. Cordes 1992).

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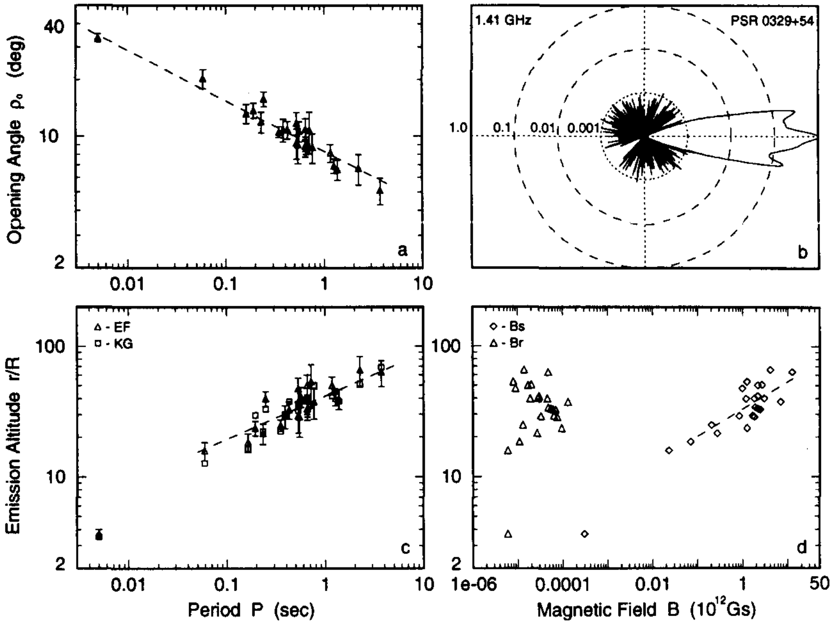

Figure 1. **(a)** Plot of the opening angle ρ_0 corresponding to the low intensity profile width W_0 (0.01% of maximum intensity corresponding to the last open field lines) versus pulsar period P. The formal fit is $\rho_0 = (8.3 \pm 0.2)\ P^{-0.27\pm0.03}$. **(b)** Plot of the profile PSR B0329+54 in the log-scale and the polar co-ordinates. **(c)** Plot of the emission altitude r/R versus pulsar period P for the Effelsberg data (triangles) and values following from the equation 1 (squares). The formal fit is $r = (42 \pm 2) \cdot R\ P^{0.33\pm0.04}$. **(d)** Plot of the emission altitude r/R versus the surface magnetic field B_s (diamonds). The formal fit is $r = (33 \pm 2) \cdot R\ B_s^{0.21\pm0.05}$. A vertical set of triangles represents the magnetic field in the emission region $B_r = B_s(r/R)^{-3}$. Notice that B_r is about $10^7 - 10^8$ G for all pulsars from our sample.

References

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