*Young Neutron Stars and Their Environments*
*IAU Symposium, Vol. 218, 2004*
*F. Camilo and B. M. Gaensler, eds.*

# Reception of Radio Waves from Pulsars

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**Abstract.** The beamed emission by relativistic sources moving along the magnetic dipolar field lines occur in the direction of tangents to the field lines. To receive such a beamed radiation line-of-sight must align with the tangent within the beaming angle $1/\gamma$, where $\gamma$ is the particle Lorentz factor. By solving the viewing geometry, in an inclined and rotating dipole magnetic field, we show that at any given pulse phase observer can receive the radiation only from the specific altitudes. We find the outer conal emission is received from the higher altitudes than the inner conal components including the core. At any pulse phase, low frequency emission comes from the higher altitudes than the high frequency emission. As an application of our model, we have applied it to explain the emission heights of conal components in PSR B0329+54.

## 1. Introduction

Pulsar radio emission beam has been widely attempted to interpret in terms of emission in purely dipolar magnetic field. Gangadhara & Gupta (2001) have estimated the emission heights of different radio pulse components in PSR B0329+54 based on the aberration–retardation phase shift, and the revised estimates are given by Dyks, Rudak, & Harding (2003). Here we solve the viewing geometry and estimate the altitudes from which observer can receive the radio waves.

## 2. Emission Beam Geometry

Consider a magnetic dipole situated at the origin with magnetic axis ($\hat{\mathbf{m}}$) inclined by $\alpha$ with respect to the rotation axis ($\hat{\mathbf{\Omega}}$), and rotated by $\phi'$ around $\hat{\mathbf{\Omega}}$. Let $\hat{\mathbf{n}} = (\sin\zeta,\, 0,\, \cos\zeta)$ be the line of sight, where $\zeta = \alpha + \beta$, and $\beta$ is the line of sight impact parameter.

In a relativistic flow, the emitted radiation is beamed in the direction of field line tangent $\hat{\mathbf{b}}$, so at any instant the observed radiation comes from a spot in the magnetosphere where the tangent vector points in the direction $\hat{\mathbf{n}}$ of observer. For receiving such radiation the semi opening angle of emission beam $\Gamma = \arccos(\hat{\mathbf{n}}.\hat{\mathbf{m}})$ must be approximately equal to the opening angle of field lines $\tau = \arccos(\hat{\mathbf{b}}.\hat{\mathbf{m}})$. Therefore, the magnetic *colatitude* ($\theta$) is given by

$$\cos(2\,\theta) = \frac{1}{3}\left(\cos\Gamma\,\sqrt{8+\cos^2\Gamma} - \sin^2\Gamma\right)\,, \qquad -\pi \le \Gamma \le \pi\,. \tag{1}$$

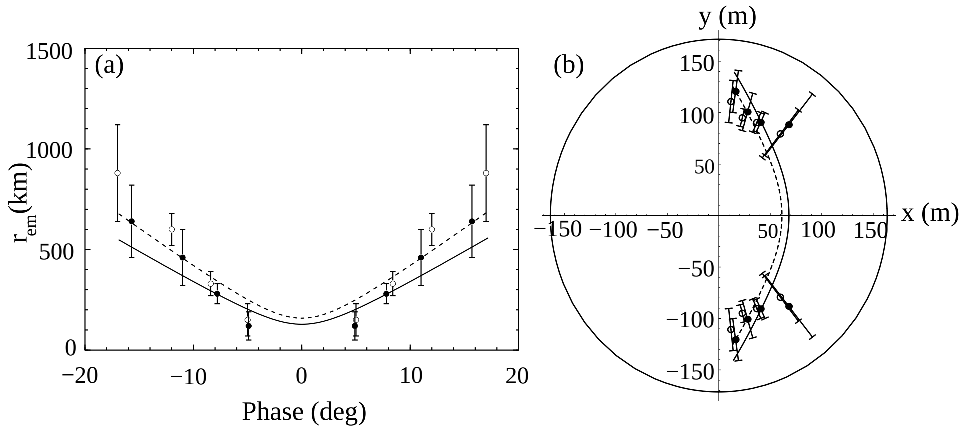


Figure 1. (a) Emission heights in PSR B0329+54: solid and dashed line curves are for the emissions at 606 MHz and 325 MHz, respectively. The emission heights estimated from aberration-retardation phase shift are superposed: the points marked with $\circ$ for 325 MHz and $\bullet$ for 606 MHz. (b) Polar cap with foot of emission associated field lines.

Next, the magnetic *azimuth* ($\phi$) of the emission point can be obtained by finding $\hat{\mathbf{b}}$ which is parallel to $\hat{\mathbf{n}}$ :

$$\sin\phi = -\sin\zeta\,\sin\phi'\csc\Gamma. \tag{2}$$

For $\beta > 0$, on leading side the maximum value for $\phi$ allowed by the viewing geometry is $\pi/2$, which in turn allows to find the maximum pulse window $W = 2\phi'$, where $\phi'$ is the pulse phase at which $\phi$ approaches $\pi/2$. Using $\alpha = 30^\circ$ and $\beta = 2.1^\circ$ for PSR B0329+54, we find $\theta_{\rm max} \sim 8^\circ$, $\Gamma_{\rm max} \sim 12^\circ$ and $W \sim 46^\circ$.

Pulsar radio emission is generally believed to be coherent curvature radiation by secondary pair plasma streaming along the dipolar magnetic field lines. The curvature emission peaks at the characteristic frequency (e.g., Eq. 45, Ruderman & Sutherland 1975). For a given frequency and a Lorentz factor $\gamma$, we can estimate the radius of curvature $\rho$, which in tern allows to find the field line constant. So, using $\gamma = 340$ and 390 we estimated the emission height (see, Fig. 1a) of radiation at 325 MHz and 606 MHz, respectively. On the other hand by accepting the emission heights derived from the aberration-retardation phase shift, we estimated $\gamma$ and $\rho$ expected: $0.15 \leq \rho/r_{\rm LC} \leq 0.33$, $286 \leq \gamma \leq 370$ for 325 MHz emission, and $0.12 \leq \rho/r_{\rm LC} \leq 0.26$, $328 \leq \gamma \leq 420$ for 606 MHz.

The polar cap with foot location of emission associated field lines is given in Fig. 1b, where $z-$axis is chosen to be parallel to $\hat{\mathbf{m}}$ and x to lie in the $\hat{\mathbf{\Omega}}$-$\hat{\mathbf{m}}$ plane. It is nearly elliptical with radius of 164 m and 171 m in x and y directions.

## References

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