GEOMETRY OF GEMINGA ROTATION ACCORDING TO LIGHT CURVES IN GAMMA-REGION

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ABSTRACT. Light curves and spectrum of Geminga in a hard gamma region are investigated in this paper and their properties are discussed. The geometric parameters of pulsar rotation, such as the inclination angle of rotational axis, the angle between rotational and magnetic axes and the cone spread angle of gamma radiation are evaluated. All the results are based on the data of EGRET instrument.

Key words: Pulsar, Geminga, rotation, gamma-radiation

Energy radiation and light curves

EGRET mission has been launched in April, 1988. Now we have at least 9 periods of observations where Geminga was at a distance less than $R = 30°$ from the center of a view field.

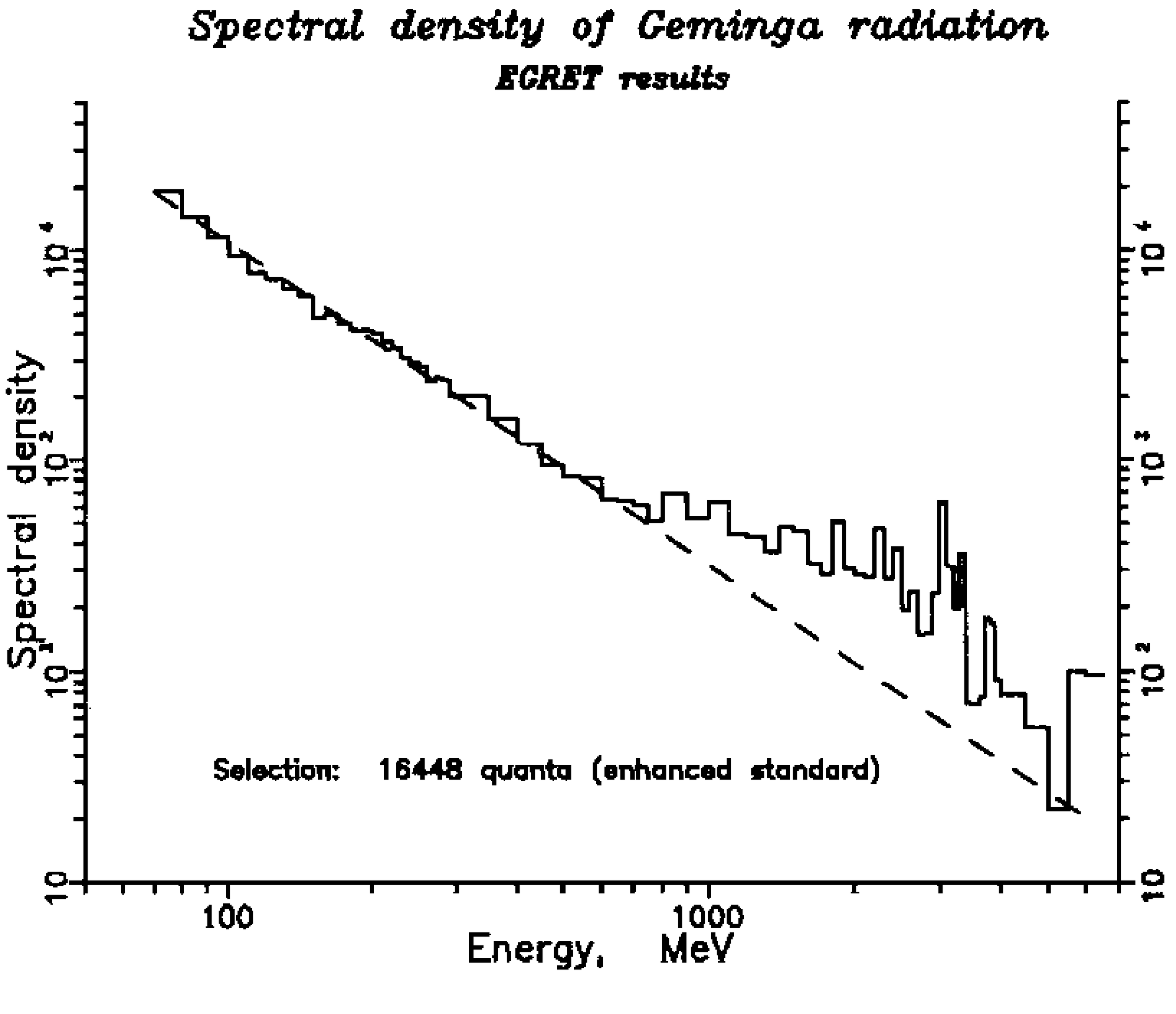

Figure 1: Geminga spectrum with a background after a rough corection over the instrumental effects

The spectrum of Geminga after rough correction over the instrumental effects is presented in Fig. 1. Every narrow stair includes full energy, radiated by the pulsar in appropriate energy band divided by the width of the stair. The energy refers to the sensitive area $S = 800$ cm^2 during the total observation time.

The hump in spectrum for $E > 850$ MeV means that we observe a pulsar above the background. The pulsar power in this spectral hump is

$$W = 1.9 \cdot 10^{31} \cdot \left(\frac{R}{50\,\mathrm{ps}}\right)^2 \ \mathrm{erg/s}, \qquad (1)$$

where R is a distance, expressed in parsecs. It is the lowest estimation of pulsar power.

The pulsar light curve has two-peak shape (Fig. 2). But, the higher is the energy band, the lower is the left hand peak with respect the the right one and both peaks become more narrow. At $E \approx 3500$ MeV the right hand peak has the width of 0.11 of a period, the left hand peak is totally disappeared. Poor statistics does not spoil this conclusion, because right hand peak still contains more than 20 quanta of 38.

φ, deg.	α, deg.	i, deg.
19.8	80.1	9.9
19.9	79.1	9.0
20	78.5	8.5
21	75.9	6.9
22	74.1	6.1
23	72.5	5.5
24	71.1	5.1
25	69.7	4.7
26	68.4	4.4
27	67.1	4.1
28	65.9	3.9
29	64.7	3.7
30	63.5	3.5
31	62.3	3.3
32	61.2	3.2
34	58.9	2.9
36	56.6	2.6
38	54.4	2.4

Table 1: Possible solutions for φ, α and i when $E =$ 3500 MeV

Pulsar rotation

The structure of the light curves can be explained by the geomery of pulsar rotation. The main geometric parameters are presented in Fig. 3.

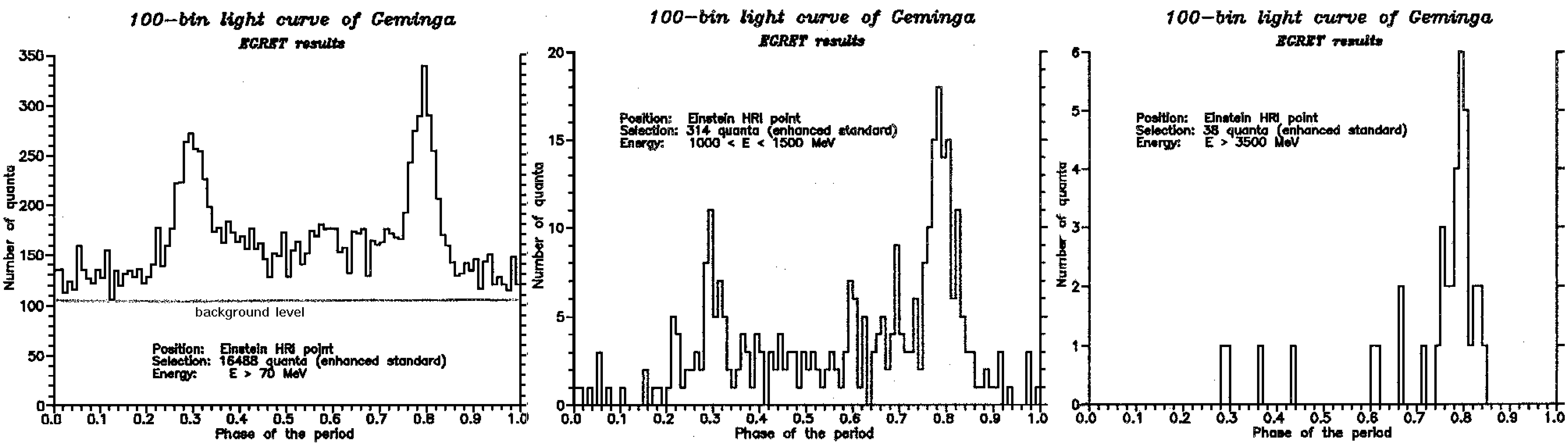

Figure 2: Light curve of Geminga, in different spectral bands

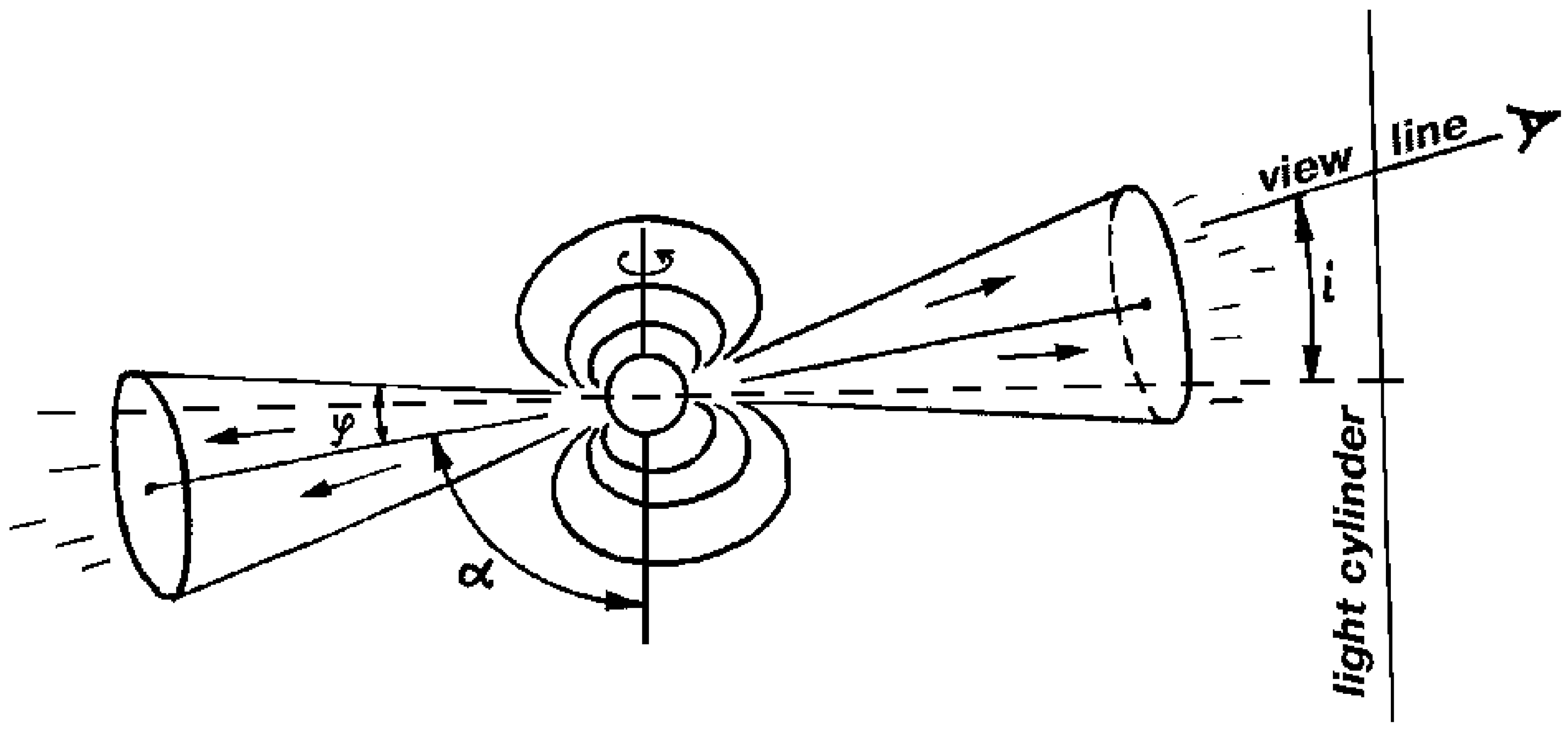

Figure 3: Geometry of pulsar rotation

The situation looks like the primary high energetic γ-quanta are generated in magnetic pole caps close to the surface, then they fly out the pulsar in narrow cone, but, scattering in pulsar magnetosphere, some of them loose the energy and, deviating after Compton scattering, they encrease the cone spread angle 2φ. The cone widening mechanism can have another nature (it may be connected with γ-quanta generation), but the main conclusion is the same: the cone spread angle depends on the quanta energy.

If the observer is not in the equtorial plane, and the cone spread angle does decrease when the energy encreases, then we are to come to position when a view line slips along the forming line of one of the cones. At that marginal position one cone becomes invisible and the observer can see for the first time only one peak in light curve.

Simplifying the geometry, we come to the following corespondence between the angles

$$\left\{ \begin{array}{lcl} \sin^2(i+\alpha)\tan^2\varphi - \cos^2(i+\alpha) & = & \tan^2\delta_1 \\ \sin^2(i-\alpha)\tan^2\varphi - \cos^2(i-\alpha) & = & \tan^2\delta_2 \end{array} \right. \qquad (2)$$

where δ_1 and δ_2 are the half-part of a period in the interval $[0, 2\pi]$ when the observer is inside the appropriate cone. For $E = 3500$ MeV $\delta_2 = 0$, $\delta_1 = 2\pi \cdot (0.11/2) \approx 0.35$ and $\tan^2\delta_1 = 0.1296$.

We have two equations for three variables and the system cannot be solved directly. But, for every fixed value of φ angle we can obtain a solution for α and i. A number of possible solutions for the system (2) is summarized in Table ??.

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References

Bignami G.F., Caraveo P.A.: 1992, *Nature,* **357**, 287.
Thompson D.J. et al.: 1993, *Ap.J.S.*, **86**, 629.