VP	Target	count rate (ct/s)	freq search (Hz)	pulse fract (% rms)	pulse flux (***)

TABLE 1 — ISOLATED PULSARS (continued)

23	PSR 1509-58	431.6	2 - 62.5	< 0.17	< 0.52
24.5	G Plane 5	169.4	2.5 - 500	< 0.37	< 0.67
24.5	G Plane 5	168.6	14 - 800	< 0.25	< 0.45
24.5	G Plane 5 (off axis SE)	169.4	2.5 - 500	< 0.37	< 0.70
24.5	G Plane 5 (off axis NW)	169.4	2.5 - 500	< 0.37	< 0.70
24.5	G Plane 5 (offset SW)	87.3	2 - 500	< 0.83	< 1.54
24.5	G Plane 5 (offset NE)	87.6	2 - 500	< 0.57	< 1.06
34	Cas A	109.8	2 - 500	< 0.27	< 0.32
34	Cas A (off axis SW)	109.8	2 - 500	< 0.27	< 0.33
34	Cas A (off axis NE)	109.8	2 - 500	< 0.26	< 0.32
34	Geminga	166.3	2 - 62.5	< 0.20	< 0.35
208	NGC 6814	100.8	2 - 500	< 0.29	< 0.31
218	SN 1993J	101.0	2 - 1000	< 0.30	< 0.32
222	MCG +8-11-11	99.9	2 - 500	< 0.41	< 0.44
222	MCG +8-11-11 (o.a. SW)	100.5	2 - 500	< 0.34	< 0.38
227	SN 1993J	213.4	2.5 - 1000	< 0.18	< 0.41

TABLE 2 — BINARY PULSARS

24.5	G Plane 5	178.5	2 - 500	< 1.54	< 2.92
24.5	G Plane 5 (offset)	87.6	2 - 500	< 2.87	< 5.35
24.5	G Plane 5 (offset)	88.4	2 - 500	< 2.38	< 4.48
13.0	G Plane 25	136.8	2 - 500	< 1.29	< 1.88
13.0	G Plane 25 (offset)	68.4	2 - 500	< 2.12	< 3.09
13.0	G Plane 25 (offset)	75.2	2 - 500	< 1.83	< 2.93
19	G Plane 58.1	87.2	2 - 500	< 1.50	< 1.39
19	G Plane 58.1 (offset)	42.2	2 - 500	< 2.07	< 1.86
19	G Plane 58.1 (offset)	41.8	2 - 500	< 2.18	< 1.94
23	PSR 1509-58	412.5	2 - 62.5	< 0.67	< 1.96
222	MCG +8-11-11	99.6	2 - 500	< 1.11	< 1.18
18	PSR 1929+10	294.0	2 - 62.5	< 0.74	< 1.16
34	Cas A	109.4	2 - 500	< 1.44	< 1.68
34	Geminga	165.2	2 - 62.5	< 0.98	< 1.72
208	NGC 6814	101.5	2 - 500	< 1.32	< 1.43
227	SN 1993J	217.3	2 - 1000	< 0.97	< 2.24
4	3C 111	121.7	2 - 500	< 1.25	< 1.62

*** 10^{-3} γ s^{-1} cm^{-2}

PHASE LOCATION OF THE PULSED PEAK DETECTED IN GEMINGA WITH THE FIGARO II EXPERIMENT.

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ABSTRACT

The gamma-ray source Geminga was observed on July 9th, 1990 in the low-energy gamma rays with the FIGARO II experiment. A first analysis provided evidence of a pulsed emission characterised by a broad peak (Massaro et al, 1993). A new folding of the data with improved pulsar ephemerides (Mayer-Hasselvander et al, 1992) shows that the feature is located in the off-pulse region. The presence of a possible emission of the source outside of the pulsed region is discussed in relation with the light curves in other energy bands.

INTRODUCTION

On July 9th 1990, the large area (3600 cm^2) gamma-ray experiment FIGARO II (Agnetta et al., 1989), on board of a stratospheric balloon, was pointed in the Crab Pulsar direction for more than seven hours (7:06 - 14:28 U.T.). Because of the large field of view of the experiment, the gamma-ray source Geminga was also observed with an average fractional exposed area of 0.89.

The folding of the data with the Geminga pulsar parameters (Mattox et al., 1992) provided evidence of a pulsed emission characterised by a broad peak in the energy range 0.14 - 0.48 MeV, and corresponding to a flux of (2.7 ± 0.9) 10^{-4} photons cm^{-2} s^{-1} (Massaro et al., 1993). The

statistical strength of the detection corresponds to a probability of a chance occurrence smaller than 10^{-3}. The time distance between the FIGARO and EGRET observations, however, is so large that it was impossible to compute the absolute phase location of the detected peak.

Afterwards Mayer-Hassewander et al. (1992) released more accurate ephemerides of Geminga, valid for the interval 1990.3 - 1993.7 with a phase uncertainty of 0.1. Using these improved parameters we performed a new folding of the FIGARO data and obtained the absolute phase of the peak. In this contribution we present this new result and discuss its relation with the other light curves in the x and gamma-ray bands.

THE FIGARO II RESULT AND THE GEMINGA LIGHT CURVE

The FIGARO light curve of Geminga, in the energy range 140 - 480 keV and ten phase bins, is plotted in Fig. 1a: a single broad feature is evident with a phase width of 0.3. The centre of this peak is at a phase distance of -0.19±0.1 with respect to peak 1 of the EGRET light curve (fig 1b, Bertsch et al. 1992), and so the whole signal detected by FIGARO lies outside the interval bounded by the two main peaks. This finding indicates that the signal detected by FIGARO does not appear to be related to the emission at higher energies and therefore should be a manifestation of a different component.

As it will be discussed in the following, the phase structures of the Geminga pulse profiles from x to gamma-rays are much different for different energies, and point to a rather complex scenario, in which a possible interpretation of the feature detected by FIGARO can be found.

A new visitation of the COS-B data (Grenier et al., 1993) showed that Geminga can be detected as a point source in the high energy gamma-rays also in the phase interval following peak 2 and preceding peak 1, (0.02 - 0.35) in Fig.1. The signal in this interval (called in the quoted paper Interpeak 2) is characterised by a very soft spectrum above 50 MeV. This finding was confirmed by the analysis of the EGRET data (Mayer-Hasselwander et al., 1993) even if the value of the spectral index is different.

The temporal and the spatial analysis of the COMPTEL data (Hermsen et al., 1993) indicated the presence of pulsed emission between 10-30 MeV only in the Interpeak 2 region (Fig. 1c), coincident with the peak observed by FIGARO.

Finally the pulse profile of the ROSAT observation (Halpern and Ruderman, 1993) in the band 0.53 - 1.5 keV (Fig. 1d) shows again a single broad peak, but at a phase different from all the previous features: it is located in the Interpeak 1 region just before peak 2 of the high energy light curve. It is remarkable that the phase difference between this feature and that observed by us in the low-energy gamma rays is 0.5, as the two main peaks at higher energies.

A POSSIBLE INTERPRETATION

A simple geometric explanation of such patterns is that the x and gamma-ray emission of Geminga is a superposition of several components originated in different regions of the magnetosphere and having different energy spectra, as proposed by Halpern and Ruderman (1993).

These authors consider an outer-gap model with an inclination angle of the magnetic axis to the rotation axis close to 90 degrees: the high energy peaks are emitted in the acceleration zone rather close to the light cylinder, while the ~1 keV feature seen by ROSAT comes directly from the polar cap. Halpern and Ruderman expect, therefore, a low energy pattern with two peaks with a phase separation of 0.5, but, because only one is present in the ROSAT data, they suggest that the magnetic field configuration is highly asymmetric, with the dipole centre close to the neutron star surface, quite similar to a sunspot.

The FIGARO data indicate the presence of a further feature at the right phase distance from that of ROSAT and of a comparable phase width. It could be the emission coming from the other polar cap as expected for a centred dipole field. The symmetry, however, cannot be rigorous because of the very large difference in energy (two orders of magnitude) between the two signals. Tentatively, one could explain it by assuming that the polar magnetic field near the star surface is distorted by higher multipole components and that the lines of sight to the two poles cross regions with different field strength or curvature.

In conclusion the FIGARO results reinforce the COMPTEL detection and provide evidence of a missing element in the emission pattern of Geminga. The statistical confidence is not compelling and is very important to try to confirm this finding in the near future. We have another observation made during an earlier balloon flight on July 11th, 1986. The present knowledge of the pulsar parameters, however, does not allow to keep the phase coherence from 1986 to 1990. More precise ephemerides can be obtained by relating together all the available high-energy observations: SAS 2, COS B, GAMMA 1, and EGRET (Mattox et al.,1993).

REFERENCES

Agnetta G. et al., 1989, Nucl.Instr.Meth. **A 281**,197
Bertsch D.L. et al., 1992, Nature, **357**, 306
Grenier I. et al. ,1993, Ap. J. Suppl., in press
Halpern J.P. and Ruderman M., 1993, Ap.J., submitted
Hermsen W. et al., 1993, Ap. J. Suppl., in press
Massaro E. et al., 1993, AIP Conf. Proc. 280: Compton Symp., St. Louis, MO 1992.
Mayer-Hasselwander H. et al. 1992, I.A.U. circ. 5649
Mayer-Hasselwander H. et al. 1993, Ap.J. submitted
Mattox J.R. et al., 1992, I.A.U. circ. 5583
Mattox J.R. et al., 1993, this Symposium

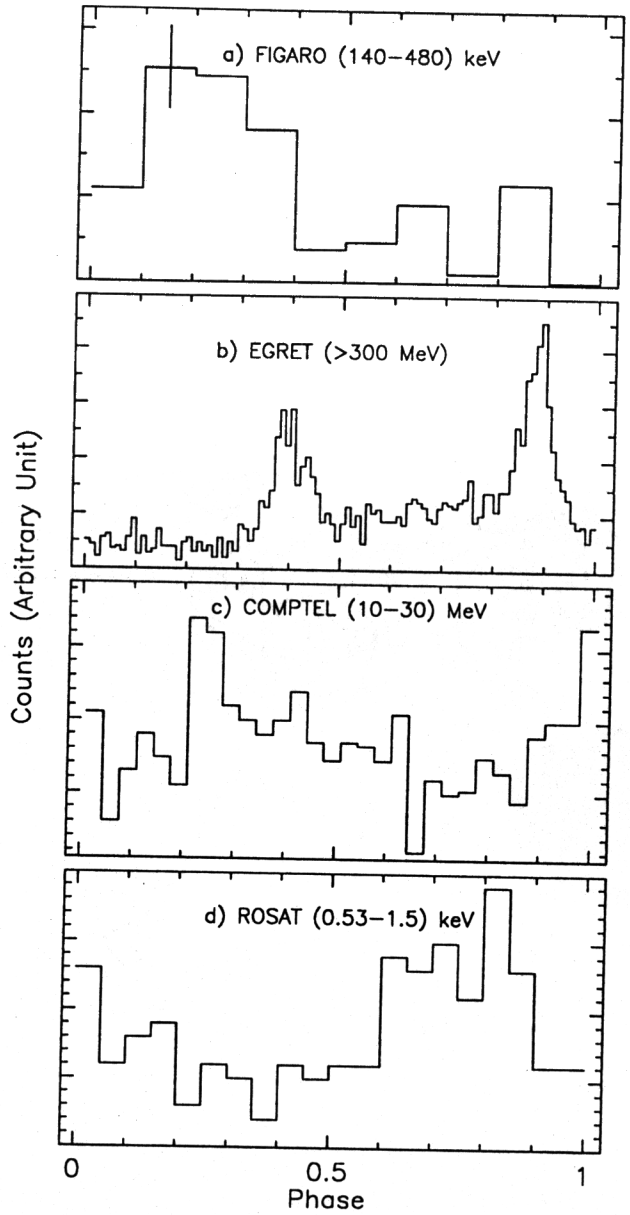

Fig. 1 Phase histograms of Geminga in several energy bands

NUCLEOSYNTHESIS