A SEARCH FOR HIGH-ENERGY γ-RAYS FROM PULSARS

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Abstract. The 10-m optical reflector at Mt. Hopkins, Ariz., was used to search for cosmic γ radiation from pulsars by detection of atmospheric Čerenkov light generated by energetic particle showers. In the energy region of 10^{11}–10^{12} eV, no evidence of pulsed γ-ray emission was found from either NP0532 (Crab Nebula) or CP1133.

1. Introduction

Two pulsating radio sources (pulsars), NP0532 (Crab Nebula) and CP1133, have been investigated for pulsed γ-ray emission in the energy region from 10^{11} to 10^{12} eV. Such radiation could be produced at the pulsar source by Compton scattering between high-energy electrons and their synchrotron-emitted photons or by high-energy proton collisions. In either case, detection of γ radiation from pulsars would support the theory that these objects are the origin of cosmic radiation in the Galaxy.

2. Observations

At energies above 10^{11} eV, cosmic γ-rays produce high-energy particle showers in the atmosphere; these showers can be detected with ground-based instruments by the Čerenkov light bursts they produce.

The 10-m light reflector at Mt. Hopkins, Ariz., has been used to search for such γ-ray emission from pulsars. The detector has been described in another paper in this symposium (Fazio *et al.*, 1969).

For each source, the reflector, operating in the coincidence mode, was moved in order to track the source for periods of 45–90 min. While the source was being tracked, each coincidence pulse was recorded on one track of a magnetic tape. On a parallel track, timing pulses (typically 10 kHz) from the clock at the satellite-tracking station on Mt. Hopkins were recorded. The frequency stability of the clock pulses was 1 part in 10^{10}. The magnetic tapes were analyzed on a 100-channel pulse-height analyzer operating in the multiscaler mode. The analyzer was recycled after two pulsar periods, with the channel advance and the recycle signal generated from a vernier scaler system driven by the clock pulses (Horowitz, 1969). Thus, the arrival time of each Čerenkov pulse was sorted into time intervals corresponding to the phase of one pulsar period. A monitor was constructed to detect any loss of clock pulses when the magnetic tape was replayed. The analyzer was stopped when a single missing pulse was detected. The pulsar periods were corrected for earth orbital and axial rotation.

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TABLE I

Summary of data and results

Source	Date (GMT)	Observation time (min)	Apparent period (sec)	Time interval (msec/channel)	Energy threshold (10^{11} eV)	Flux upper limit (10^{-10}/cm^2 sec)
NP0532	2/10/69	37.4	0.033097092	0.7	1.2	1.4
		37.8	0.033097104			
NP0532	2/10/69	37.4	0.033097092	2.1	1.2	2.6
		37.8	0.033097104			
CP1133	3/16/69	82.5	1.18795000	24	1.4	0.90
CP1133	2/10/69	30.4	1.18785700	24	10	0.12

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3. Results

No evidence of periodic high-energy (10^{11}–10^{12} eV) γ-ray emission was detected from either NP0532 or CP1133. The results are summarized in Table I. The calculated upper limit to the flux was based on the largest positive fluctuation observed in the total number of pulses stored in each time interval. To the corresponding number of standard deviations in this channel, three standard deviations were added to compute

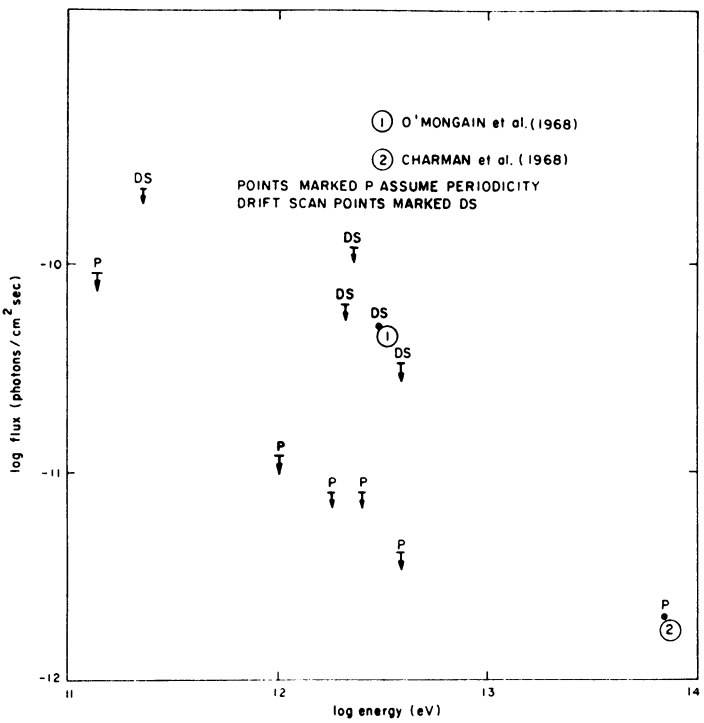

Fig. 1. Summary of results from CP1133. The drift-scan upper limits (DS) are from the results of Fazio *et al.* (1968), modified by the results of Rieke (1969). The periodicity (P) upper limits are from the results of this work, Rieke (1969), and Fazio *et al.* (1968).

the number of Čerenkov pulses per unit time above the background rate. When the results from two tapes were combined, e.g., NP0532, the upper limit was based on the sum of the maximum fluctuation in each case.

The results from several experiments are shown in Figure 1. This experiment does not confirm possible evidence for periodic γ-ray emission from CP1133 previously reported by Charman *et al.* (1968) at 7×10^{13} eV. O'Mongain *et al.* (1968) reported possible evidence for a continuous flux from CP1133 at 4.5×10^{12} eV. Our previous work (Rieke, 1969; Fazio *et al.*, 1968) did not support this result, and the present results do not indicate that the flux occurs in bursts at the pulsar frequency.

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References

Charman, W. N., Jelley, J. V., Orman, P. R., Drever, R. W. P., and McBreen, B.: 1968, *Nature* **220**, 565.
Fazio, G. G., Helmken, H. F., Rieke, G. H., and Weekes, T. C.: 1968, *Nature* **220**, 892.
Fazio, G. G., Helmken, H. F., Rieke, G. H., and Weekes, T. C.: 1970, this volume, p. 192.
Horowitz, P.: 1969, *Rev. Sci. Instr.* **40**, 369.
O'Mongain, E. P., Porter, N. A., White, J., Fegan, D. J., Jennings, D. M., and Lawless, B. G.: 1968, *Nature* **219**, 1348.
Rieke, G. H.: 1969, Smithson. Astrophys. Obs. Spec. Rep. No. 301.