2.17 SEARCH FOR PULSED HIGH ENERGY GAMMA RADIATION FROM NP 0532

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Abstract. During winter 1969 the 10 m optical reflector at Mt. Hopkins, Arizona, was used to search for periodic gamma ray emission above 10^{11} eV from NP 0532. Based on predicted optical period and phase, approximately 57 h of data were summed together. No evidence of pulsed radiation was found.

1. Introduction

A search with long integration times was undertaken from 11 December 1969 to 14 January 1970 for periodic gamma ray emission from NP 0532. Theoretical predictions for the existence of this radiation are based on inverse Compton scattering by electrons and high energy proton interactions. Above 10^{11} eV, gamma rays are detected from the Čerenkov light pulse emitted by their atmospheric electromagnetic cascade. Cosmic ray protons also give rise to many, more numerous cascades with similar light pulses. For pulsar search, the time of arrival of each Čerenkov light pulse is recorded and sorted into bins according to the period of the object under investigation. Best previous upper limits (Fazio *et al.*, 1970) to the gamma ray flux were based on 1 hour runs.

2. Techniques

The 10 m optical reflector at Mt. Hopkins, Arizona, was used for the collection of the Čerenkov light. The reflector has a collecting area of 1.3×10^4 m^2 and a zenith energy threshold of 9×10^{10} eV. Two 5″ RCA 4522 phototubes separated by approximately 2.4° were placed at the prime focus of the reflector. Each phototube successively tracked 'on' the pulsar direction for 9 min. One additional minute was allowed for slewing the reflector to interchange the 'on' phototube. Each phototube was light servoed to give a constant current response.

Each event from the 'on' phototube was recorded on one track of a stereo tape recorder for periods up to 115 min. On the adjacent stereo track, a 5 kHz timing signal from the clock at the satellite-tracking station on Mt. Hopkins was recorded. Frequency stability of the clock was 1 part in 10^{10}. Preceding each event record were two known minute time marks. Absolute phase of the pulsar was referenced to these time marks. During the playback of each tape the time of each event, to the 5 kHz clock accuracy, was recorded on a digital stepping recorder. A 2 period analysis into 100 channels was made with the CDC 6400 computer and the predicted phase normalized the 'peak' to channels 10 and 60. Period and phase predictions were based on the optical ephemeris compiled at the Harvard Agassiz Station by Horowitz and Papaliolios (1971). Verification of the predicted phase was achieved at Mt. Hopkins

Davies and Smith (eds.), The Crab Nebula, 160–161.

by observing the optical pulsar with the No. 2 Kitt Peak 36″ reflector and telemetering the individual pulses to Mt. Hopkins, some 40 miles distant. The telemetry system had a 4 MHz bandwidth to ensure good pulse response.

In the digital analysis, a free running 5 kHz clock was phase locked with the recorded 5 kHz signal. Thus a missing pulse due to tape dropout would be correctly reinserted. The recorded tapes had an additional set of minute marks at the end of a run and thus verified that the synthesized clock neither added nor deleted clock pulses.

3. Results

Three sums for each month's operations were made. The first summed the entire month's data, the second only those runs in which the average zenith angle of NP 0532 was less than 30°, the third for those with average zenith angle greater than 30°. Finally, the data from both months' observations were summed together.

In 57 hours of combined data, no excess was seen at the expected channel or at any other channel. The high energy pulsed gamma ray emission was assumed to occur over just one channel width, i.e., 0.6 msec. The flux that could have been detected was taken as the effect in the predicted channel plus three standard deviations. Thus the upper limits to the pulsed gamma radiation emitted in phase with the optical pulsations for the period December 1969 to January 1970 are:

Data	Energy threshold (eV)	Upper limit photons cm^{-2} sec^{-1}
All zenith angles	$2.2 \times 10^{+11}$	6.0×10^{-12}
Zenith angles less than 30°	$1.2 \times 10^{+11}$	2.3×10^{-11}
Zenith angles greater than 30°	$3.2 \times 10^{+11}$	3.5×10^{-12}

References

Fazio, G. G., Hearn, D. R., Helmken, H. F., Rieke, G. H., and Weekes, T. C.: 1970, in L. Gratton (ed.), 'Non-Solar X- and Gamma-Ray Astronomy', *IAU Symp.* **37**, 192.
Horowitz, P. and Papaliolios, C.: 1971, to be published in *Nature*.

Discussion

F. C. Michel: Is the A. C. flux limit a mean flux or a peak flux?

H. Helmken: The periodic result is the upper limit to the flux per second at the expected position of the pulse for a mean pulse width of 0.6 msec.

N. Visvanathan: You reported 113 hours observing but have only reported results from 57 hours.

H. Helmken: The analysis is incomplete.