SEARCH FOR A GAMMA-RAY PULSAR IN THE SNR RCW103

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Abstract

Pulsation search for the EGRET gamma-ray data in the direction of the recently identified X-ray pulsar, AXS J161730-505505, in the vicinity of the supernova remnant, RCW103, showing a 69 ms period have been performed. We found no evidence for pulsation and the nature of the RCW103 system remains a puzzle.

1. Introduction

RCW103 (G332.4-0.4) is a supernova remnant with filaments which correspond well to the radio shell. Its distance is estmated to be 3.3 kpc from HI absorption. The GINGA satellite, which is sensitive for 2–30 keV, detected a coherent pulsation at 69 ms from the 2×4 degree^2 field-of-view including RCW103 and 2CG333+01 (Aoki et al. 1992). There is an X-ray point source, 1E161348-5055.1, whose location is marginally coincident with COS B source 2CG333+01. We suspected that 1E161348-5055.1, 2CG333+01 and the GINGA pulsar are all the same source, and it might be a gamma-ray pulsar with a character just between Crab and Vela pulsar. To verify this hypothesis, periodicity search was performed for the EGRET data around the proposed 69 ms period, but we obtained no positive indication (Mori and Ebisawa 1997). Recently, although Gotthelf et al. (1997) failed to find a pulsation of 1E161348-5055.1 with ASCA observation, Torii et al. (1997) discoverd the 69 ms periodicity for another nearby source, AXS J161730-505505, using the ASCA archival data. Thus we have repeated the periodicity search for the EGRET archival data for that position and the result is presented.

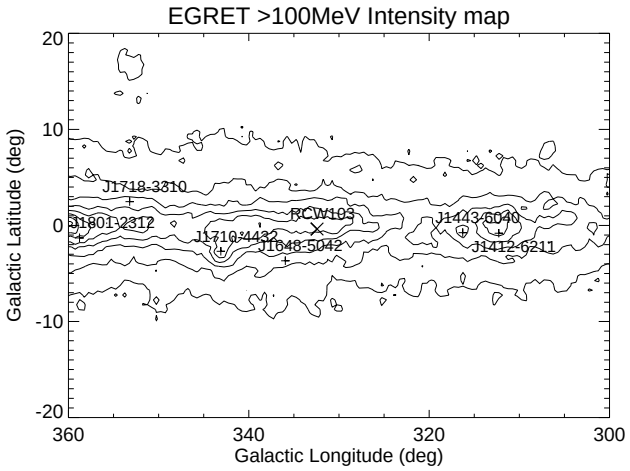

Fig. 1. The gamma-ray sky around the RCW103 observed by EGRET (phase 1, > 100 MeV) shown by intensity contours. The EGRET second catalog sources are marked.

2. Observation

The position of AXS J161730-505505 is only $0^\circ.12$ apart from 1E161348-5055.1 and the exposure is virtually the same as our previous study on the latter source: thus we do not repeat the details here (see Mori and Ebisawa 1997). In summay, the total exposure up to July 1995, which is included in our analysis, is 4.32×10^8 cm^{2}s for > 50 MeV.

3. DC Analysis

For each observation, maximum likelihood analysis (Mattox et al. 1996) is used to test the excess in the direction of RCW103 above the Galactic diffuse background. The RCW103 has been never detected as a "source" (Mori and Ebisawa 1997, see Fig. 1.): nevertheless, one can still have a chance to detect its possible pulsation among possible contamination of source photons immersed in abundant background photons.

4. Periodicity search

The GINGA and ASCA findings are summarized in Table 1. with other SNR/pulsar association candidates.

The period derivative of 1.4×10^{-13} s/s was calculated from the observations seperated by 4 years (Torii et al. 1997): since there is no information about

Table 1. Characteristics of some pulsars associated with SNRs.

SNR	Pulsar	Period (ms)	$\dot{P}$ (s/s)	Age (kyr)
Crab	B0531+21	33.4	4.2×10^{-13}	1.3
CTB80	B1951+32	39.5	5.8×10^{-15}	107
SNR0540-693	B0540-69	50.4	4.8×10^{-13}	1.7
G290.1-0.8	J1105-6107	63.2	1.6×10^{-14}	63
RCW103	AXS J1617-505505	69.3	1.4×10^{-13}	8
Vela	B0833-45	89.3	1.2×10^{-13}	11
G5.4-1.2	B1757-24	125	1.3×10^{-13}	15
G308.8-0.1	J1341-6220	193	2.5×10^{-13}	12
W44	B1853+01	267	2.1×10^{-13}	20

the second derivative, we have searched for the range of $\dot{P} = 0 \sim 2 \times 10^{-13}$ s/s (or $\dot{f} = -\dot{P}/P_0^2 = (0 \sim -4) \times 10^{-11}$ Hz/s).

The program searches the frequency which gives the maximum non-uniformity with the H-test (De Jager et al. 1989) within the given frequency range for each set of frequecy derivative. This test is proved to be powerful for light curves of unknown shape. In order to reduce the number of independent searches to be realistic, only the viewing period showing some excess, though statistically not significant, were processed.

Gamma-rays of energies greater than 50 MeV from within a cone of radius

$$\theta \leq 5.85^{\circ}(E_{\gamma}/100\,\mathrm{MeV})^{-0.534} \tag{1}$$

which is expected to contain 67% of events from the point source are analyzed. These are the standard criteria for EGRET pulsar analysis. The test periods are varied between 69.334 ms and 69.343 ms. Results for three viewing periods are summarized in Table 2. Here *steps* are number of searches in the f–$\dot{f}$ plane, H is the maximum value of H-test statistic during the search, $\mathcal{P}(H)$ is the probability of chance occurrence, f and $\dot{f}$ are those at H, and $\mathcal{P}$ is the overall chance probability after multiplying the number of independent searches. One can see the maximum nonuniformity found is consistent with accidental one and occurrs at significantly different f and $\dot{f}$ for each viewing period. The 95% C. L. upper limits derived from the maximum H found in the search (De Jager 1994) are tabulated in Table 3.

5. Conclusion

We found no evidence for pulsation near the 69 ms period in gamma-rays coming from the direction of RCW103 detected by EGRET. Since the pulsed

Table 2. Results of periodicity search

Vieing period	Events	Steps	Maximum nonuniformity				
			H	$\mathcal{P}(H)$	f (Hz)	$\dot{f}$ (10^{-12}Hz/s)	$\mathcal{P}$
2260	716	33651×40	37.7	9.7×10^{-7}	14.42298	-2.7	~ 1
4210	516	23063×40	32.6	4.4×10^{-6}	14.42230	-4.0	~ 1
4235	819	34042×40	37.2	1.1×10^{-6}	14.42273	-0.4	~ 1

Table 3. Upper limits to the pulsed fraction of gamma-rays above 50 MeV assuming 10% and 50% duty cycles.

Vieing period	Upper limits ($\mathrm{cm^{-2}s^{-1}}$ [erg $\mathrm{cm^{-2}s^{-1}}$], 95% C.L.)	
	10% duty cycle	50% duty cycle
2260	$1.6 \times 10^{-7}[1.3 \times 10^{-11}]$	$4.8 \times 10^{-7}[3.8 \times 10^{-11}]$
4210	$5.3 \times 10^{-7}[4.2 \times 10^{-11}]$	$1.6 \times 10^{-6}[1.3 \times 10^{-10}]$
4235	$2.1 \times 10^{-7}[1.7 \times 10^{-11}]$	$6.4 \times 10^{-7}[5.1 \times 10^{-11}]$

flux of AXS J161730-505505 in X-rays (4×10^{-12} erg $\mathrm{cm^{-2}s^{-1}}$ in the 2–10 keV range; Torii et al. 1997) is smaller than the upper limits above 50 MeV obtained here, we hope more sensitive detectors in near future (for example, GLAST) may detect the gamma-ray pulsation with improved angular resolution reducing the background photons of the Galactic diffuse emission and may probe the nature of the possible pulsar/SNR association.

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6. Title of the Paper

Search for a Gamma-ray Pulsar in the SNR RCW103

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