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RADIO QUIET PULSAR CANDIDATES AMONG UNIDENTIFIED GAMMA-RAY SOURCES

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RESUMEN

La identificación de Geminga, la segunda fuente más brillante en el cielo por encima de 100 MeV, como un pulsar radio silencioso abre una nueva ventana para el estudio de las estrellas de neutrones. Aquí resumimos observaciones multifrecuencias de dos fuentes EGRET candidatos a pulsar radio silenciosos: 2EG J2020+4026 (γ-Cyg) y 2EG J0008+73 (CTA 1).

ABSTRACT

The identification of Geminga, the second brightest source in the sky above 100 MeV, as a radio quiet pulsar opened a new window of study for neutron stars. Here we summarize multiwavelength observations of two radio quiet pulsar candidates among unidentified EGRET sources: 2EG J2020+4026 (γ-Cyg) and 2EG J0008+73 (CTA 1).

Key Words: **GAMMA-RAYS: OBSERVATIONS — PULSARS: GENERAL**

1. INTRODUCTION

In previous work we provided evidence that the EGRET sources 2EG J2020+4026 (Brazier et al. 1996) and 2EG J0008+7307 (Brazier et al. 1998) are good radio quiet pulsar candidates. In here we investigate the radio quiet pulsar hypothesis in terms of available optical data.

2. THE γ-CYGNI SOURCE 3EG J2020+4017

This bright *COS-B* and EGRET source is inside the supernova (G78.2+2.1) remnant G78.2+2.1, known also as the γ-Cygni remnant due to its proximity with this star. X-ray imaging of the region shows a single point source, RX J2020.3+4026, close to the centre of the remnant. Optically coincident with this X-ray source is a $15^{\rm th}$ magnitude K0 star, unlikely to be the source of X-rays and discarted by us as the γ-ray source. The association between the X-ray source and the K0 star, which would require a high level of coronal activity, is judged unlikely. In Brazier et al. (1996) we proposed a radio quiet pulsar as the most probable the source of X-rays and γ-rays. Additional support is given by the presence of diffuse X-ray emission surrounding the point

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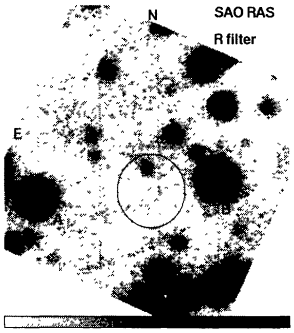

Fig. 1. R image of the region surrounding RX J0007.0+7302 taken with the BTA 6 m telescope. The circle indicates the *ROSAT* error box. An object with $R \sim 23$ is present inside.

source. With the exception of the Crab pulsar, isolated neutron stars are very faint in the optical and deep exposures with large telescope ($\gtrsim$ 4m) are needed to reveal these objects.

An unexplored possibility, which we address here, is whether the radio silent pulsar could actually form a binary system with the K0V star. This binary scenario requires a non accreting system, to be consistent with the level of X-ray luminosity. Therefore, the K0V star must not fill its Roche lobe, $R_1 \leq R_L = 0.462(q/1+q)^{1/3}\, a$ where a is the major semiaxis and $q = m_1/m_2$ is the ratio of masses (Frank, King & Raine 1992). Given the theoretical model mass of K0V stars ($m_1 \approx 0.79\, M_\odot$) and neutron stars ($m_2 \approx 1.44\, M_\odot$), we constrain the orbital period, assuming a circular orbit, to $P \geq 10^3$ s.

From the apparent and absolute magnitudes of the K0V star we obtain a distance of 660 pc, a factor of 2.5 lower than that estimated to the X-ray remnant by Dermer & Sturner (1995). At the SNR distance the γ-ray flux ($E > 100$ MeV) translates to a luminosity of $\sim 1.0 \times 10^{34}\, \mathrm{erg\, s^{-1}}$, assuming isotropic emission, comparable to that of observed γ-ray pulsars. From the age of the remnant one could estimate expected values for P and $\dot{P}$.

3. 3EG J0010+7309, IN THE CTA 1 SNR

In Brazier et al. (1998) we presented an analysis of a *ROSAT* HRI X-ray image of the region of CTA 1, in which the point source RX J0007.0+7302 was showed to be the most likely X-ray counterpart of the EGRET source 3EG J0010+7309 (also 2EG J0008+7307).

More recently we made observations with the BTA 6 m telescope where a $R \sim 23.5$ magnitude object was found. In fact the same object is present in the images shown in Brazier et al. (1998), but below the 3σ level set as detection threshold. The BTA image further shows that there is no other object in the *ROSAT* error down to $R \approx 24.5$. We propose four possibilities for this object: (i) an unrelated Galactic object, like a low-mass star; (ii) an unrelated extragalactic object: a normal or Seyfert galaxy would be rejected as the source of γ-rays; (iii) a blazar: the lack of radio emission is inconsistent with the γ-ray source; (iv) a bright neutron star: given that the Crab pulsar is $V \sim 16$ this object could be a neutron star with relatively large optical magnetospheric emission. In this case a search for pulsations through optical observations with large telescopes might be feasible. In any case, and given the lack of blazar-type radio emission, the Geminga-type pulsar hypothesis stands strong and a search for pulsations in higher S/N X-ray or optical data should be pursued.

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