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ORIGINAL ARTICLE

A new look at the origin of the 6.67 hr period X-ray pulsar 1E 161348-5055

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Abstract The point X-ray source 1E 161348-5055 is observed to display pulsations with the period 6.67 hr and $|\dot{P}| \leq 1.6 \times 10^{-9}\,\mathrm{s\,s^{-1}}$. It is associated with the supernova remnant RCW 103 and is widely believed to be a ~ 2000 yr old neutron star. Observations give no evidence for the star to be a member of a binary system. Nevertheless, it resembles an accretion-powered pulsar with the magnetospheric radius ~ 3000 km and the mass-accretion rate $\sim 10^{14}\,\mathrm{g\,s^{-1}}$. This situation could be described in terms of accretion from a (residual) fossil disk established from the material falling back towards the star after its birth. However, current fall-back accretion scenarios encounter major difficulties explaining an extremely long spin period of the young neutron star. We show that the problems can be avoided if the accreting material is magnetized. The star in this case is surrounded by a fossil magnetic slab in which the material is confined by the magnetic field of the accretion flow itself. We find that the surface magnetic field of the neutron star within this scenario is $\sim 10^{12}$ G and that a presence of $\gtrsim 10^{-7}\,\mathrm{M_\odot}$ magnetic slab would be sufficient to explain the origin and current state of the pulsar.

Keywords Stars: magnetic field · Stars: pulsars: individual 1E 161348-5055 · Stars: supernovae: individual: RCW 103 · X-rays: stars

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1 Introduction

The point X-ray source 1E 161348-5055 (hereafter 1E1613) is observed to display pulsations with the period $P_* \simeq 6.67$ hr (de Luca et al. 2006; Esposito et al. 2011). It is located near the center of the supernova remnant RCW 103 (Tuohy and Garmire 1980) of the age $\tau_* \sim 2000$ yr (Nugent et al. 1984; Carter et al. 1997) situated at the distance of 3.3 kpc (Caswell et al. 1975; Reynoso et al. 2004). The X-ray luminosity of the pulsar varies in the interval $L_X \simeq 10^{33}$–$10^{35}\,\mathrm{erg\,s^{-1}}$ on a timescale of a few years. The X-ray emission comes from a local ($a_p \sim 600$ m) region heated up to a temperature $kT \sim 0.6$–0.8 keV (Gotthelf et al. 1997, 1999; de Luca et al. 2006; Esposito et al. 2011). The upper limit on derivative of the period of pulsations $|\dot{P}| \leq 1.6 \times 10^{-9}\,\mathrm{s\,s^{-1}}$ has recently been reported by Esposito et al. (2011).

It is widely adopted that 1E1613 is a young (~ 2000 yr) neutron star. In X-rays it resembles an accretion-powered pulsar (Gotthelf et al. 1999) which accretes material at the rate (see e.g. Lamb et al. 1973)

$$\dot{\mathfrak{M}}_* \simeq 5 \times 10^{13}\, m^{-1}\, R_6\, L_{34}\ \mathrm{g\,s^{-1}} \quad (1)$$

and is surrounded by the magnetosphere of the radius

$$r_{\rm mag} \simeq 3 \times 10^8\, R_6^3 \left(\frac{a_p}{600\ \mathrm{m}}\right)^{-2} \mathrm{cm}. \quad (2)$$

Here $R_6 = R_{\rm ns}/10^6$ cm and $m = M_{\rm ns}/1.4\,\mathrm{M_\odot}$ are the radius and mass of the neutron star, and L_{34} is the average X-ray luminosity of the pulsar in units of $10^{34}\,\mathrm{erg\,s^{-1}}$.

Observations give no evidence for 1E1613 to be a close binary system (Wang et al. 2007). Nevertheless, Li (2007) have argued that the source of the accreting material can be