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X-ray observations of the high magnetic field radio pulsar PSR J1814−1744

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Abstract. We present X-ray observations of PSR J1814−1744, a 4 s radio pulsar with inferred surface dipole magnetic field strength 5.5×10^{13} G recently discovered in the on-going Parkes multibeam survey. This pulsar's spin parameters are very similar to those of anomalous X-ray pulsars (AXPs). X-ray emission is not detected from the position of the radio pulsar in observations with *ROSAT* and *ASCA*. The derived upper flux limit implies an X-ray luminosity significantly smaller than those of all known AXPs. These results argue that magnetar mechanism invoked to explain X-ray emission from AXPs must depend on more than merely the inferred surface magnetic field strength as estimated from P and $\dot{P}$.

Recently, PSR J1814−1744, an isolated radio pulsar with period $P = 4$ s and large period derivative $\dot{P} = 7.4 \times 10^{-13}$, was discovered (Camilo et al. 1999) in an ongoing survey of the Galactic Plane for radio pulsars (Lyne et al. 1999). The pulsar's surface magnetic field strength B is 5.5×10^{13} G, inferred under the assumption of a dipole rotating *in vacuo*. This pulsar's properties are interesting because they are similar to those of anomalous X-ray pulsars (AXPs), in particular to 1E 2259+586 which has $P = 7$ s and $\dot{P} = 4.9 \times 10^{-13}$ (Fahlman & Gregory 1981). The X-ray luminosities of AXPs are typically several orders of magnitude larger than their spin-down luminosities. The leading hypothesis to explain AXP properties is that they are isolated neutron stars with ultra-high magnetic fields, so-called "magnetars" (Duncan & Thompson 1992). In this model, the X-ray emission is powered either by decay of the large magnetic field (Thompson & Duncan 1996 [TD96]) or neutron star cooling enhanced by the presence of the strong field (Heyl & Hernquist 1997 [HH97]).

The spin parameters, and hence inferred B, of PSR J1814−1744 are extreme in the radio pulsar population and are more typical of AXPs, suggesting that it is a transition object between these populations. Under the magnetar hypothesis, the mechanism responsible for the production of X-rays in AXPs should be present in PSR J1814−1744 if the inferred B is indeed the primary characteristic relevant to the observed magnetar properties.

The pulsar was serendipitously observed with both the *ROSAT* and *ASCA* satellites, and no X-ray emission was detected with either telescope. Given the similarities in spin parameters between the pulsar and 1E 2259+586, the magnetar hypothesis suggests that the pulsar may also share similar X-ray properties.

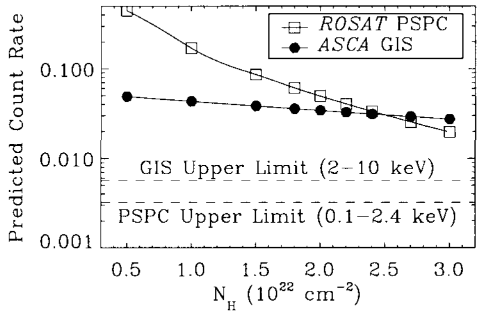

Figure 1. Count rates (counts/s) expected from PSR J1814−1744 for the same spectrum and luminosity as 1E 2259+586 (Rho & Petre 1997). For $N_H = 2.2 \times 10^{22}$ cm^{-2} and $d = 10$ kpc, the expected count rate exceeds the upper limit by a factor of 13 (ROSAT) and 6 (ASCA).

Fig.1 compares the count rate upper limits with those expected if the pulsar has X-ray emission similar to that of 1E 2259+586. The limit on X-ray luminosity from PSR J1814−1744 is significantly below that expected from an AXP.

X-ray emission from AXPs has been explained in the context of the magnetar model by either magnetic field decay (TD96) or neutron star cooling (HH97). In the field decay model, ambipolar diffusion of the magnetic field on time scales of $\sim 10^4$ yr drives the AXP emission (TD96). That no X-rays are seen from PSR J1814−1744 argues that 1E 2259+586 is much younger, even though the characteristic ages indicate otherwise, consistent with the latter's association with SNR CTB 109. This suggests that 1E 2259+586 has had a spin-down history inconsistent with simple dipole braking or that it was born with a long spin period. In the cooling model, photon cooling in young stars ($\sim$1 kyr), enhanced by heavy element envelopes, produces the AXP emission (HH97). The absence of X-rays from PSR J1814−1744 again argues that this neutron star must be much older than 1E 2259+586. Alternatively, PSR J1814−1744 could be equally as young as 1E 2259+586 and may not possess a light-element insulating layer, in spite of the ease with which they are supposed to be formed. These results argue that magnetar mechanism invoked to explain X-ray emission from AXPs must depend on more than merely the inferred B, as estimated from P and $\dot{P}$. For a complete discussion, see Pivovaroff, Kaspi & Camilo (2000).

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