Young Neutron Stars and Their Environments
IAU Symposium, Vol. 218, 2004
F. Camilo and B. M. Gaensler, eds.

Imprints of Neutron Stars in the Interstellar Medium

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Abstract. We have carried out an H I survey towards X-ray central compact objects (CCOs) inside supernova remnants (SNRs), which shows that many of them are placed within local H I minima. The nature of these minima is not clear, but the most likely explanation is that the CCOs have evacuated the neighboring gas. This survey also allowed us to detect a weak, diffuse radio nebula inside the SNR G266.2–1.2, probably created by the winds of its associated CCO.

1. Introduction and Observations

Several X-ray point sources with no radio counterpart, generically called CCOs, have recently been detected near the centers of supernova remnants (SNRs). In most cases, these sources are claimed to be the neutron stars (NSs) left behind after the supernova explosions. One of them, 1E 1207.4–5209, was found to lie at the center of an H I depression (Giacani et al. 2000), raising the question of whether the hot atmosphere of the NS is capable of heating up the neighboring gas and producing the observed depression. We present the results of a search for similar traces in the interstellar gas towards a sample of CCOs in southern SNRs.

The environs of the CCOs RX J0822–4300 in Puppis A, 1E 161348–5055.1 in RCW 103, CXOU J085201.4–461753 in G266.2–1.2 and 1WGA J1713.4–3949 in G347.3–0.5 were observed in the λ21 cm H I line and in continuum using the Australia Telescope Compact Array. The data were combined with single-dish data from the Parkes telescope (McClure-Griffiths et al. 2001).

2. Results and Discussion

RX J0822–4300, the CCO in Puppis A, was found to lie between two opposite lobe-like H I minima (Reynoso et al. 2003). The lobes are aligned with the proper motion of the CCO, assuming that the explosion site of the supernova is given by the optical expansion center measured by Winkler et al. (1988). The lobes are centered at the same systemic velocity previously measured for Puppis A, +16 km s^{-1}. Reynoso et al. (2004) propose that this H I structure is created by the ejection of two opposite jets from the CCO. More X-ray observations towards RX J0822–4300 are needed to search for jets (as are seen around the Vela and Crab pulsars) and measure the CCO's proper motion.

At +3 km s^{-1}, the H I shows another depression coincident with RX J0822–4300, but in this case the morphology and size are similar to the minimum found by Giacani et al. (2000) around the CCO associated with G296.5+10.0. RCW 103 represents the third case in which the associated CCO has created an H I depression (Reynoso et al. 2004). In all three cases, these H I features have sizes of 1 to 3 pc, the CCOs are off-center by ~ 0.3 pc, and the missing masses are estimated to be 0.1 to 0.3 $M_{\odot}$. It is very unlikely that these depressions are due to self-absorption, since the involved temperatures would be ~ 100 K, too low for a SNR interior. Most probably, the CCOs swept up the surrounding gas (Reynoso et al. 2004). In all cases, the measured H I column densities favor blackbody rather than power law fits to the X-ray spectra.

For G347.3–0.5, a preliminary analysis of our data did not allow us to find any feature suggestive of being associated with the CCO down to a limit of $\Delta T = 5$ K (3σ). At a velocity compatible with the distance proposed to this SNR, there appears a tiny depression, marginally enclosing the CCO, but it does not look different than many other spots in the image.

Finally, the radio continuum data towards the SNR G266.2–1.2 ("Vela Junior") reveal an elongated nebula, approximately 30′ in length and 14′ in width, centered at the position of the CCO. In addition, a compact source is found at the location of the CCO. The flux of this compact source is 7.2 mJy $beam^{-1}$, and its size is $\sim 85'' \times 27''$. Polarization and spectral index studies will provide information to confirm if this emission arises from the pulsar wind nebula created by CXOU J085201.4–461753. Such observations are proposed early in 2004.

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