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Discovery of a supernova remnant with a central X-ray source: AX J184453.3−025642 in G 29.6+0.1

E. V. Gotthelf[1], G. Vasisht[2], B. Gaensler[3], K. Torii[4]

[1] *Columbia U.;* [2] *Caltech/JPL;* [3] *MIT;* [4] *NASDA*

Abstract. We report preliminary results from our follow-up X-ray and radio study of AX J1845−0258, the 7-s X-ray pulsar whose characteristics are similar to those found for the anomalous X-ray pulsars (AXPs). We have located a faint X-ray source within the pulsar's error circle implying a dramatic reduction in flux, however, the source is too faint to provide a confirmation of the expected pulsations. Centered on this X-ray source is a newly discovered supernova remnant, evident in both radio and X-ray emission. This is the third example of an AXP-like object associated with a supernova remnant.

1. Introduction

We have obtained new X-ray and radio observations of the field containing the 7-s pulsar AX J1845−0258. This pulsar was discovered during an automatic search of the ASCA archival data and was classified as an anomalous X-ray pulsar (AXP) based on its spectral and timing properties (Gotthelf & Vasisht 1998; Torii et al. 1998). The goal of these new observations was to confirm or repudiate the AXP hypothesis by measuring the spin-down rate of the pulsar and searching for an associated radio supernova remnant (SNR).

Figure 1 displays the 64 ks image of the AX J1845−0258 field acquired on March 28-29, 1999 UT with the two solid-state imaging spectrometers (SISs) on-board the ASCA observatory. The SIS is sensitive to photons in the $\sim 1-10$ keV energy range and has a spatial resolution $\sim 1'$. Instead of the expected re-detection of the pulsar we found a faint $\sim 5\sigma$ source within the $\sim 3'$ radius error circle for AX J1845−0258. This source, referred to as AX J184453.3−025642 (Vasisht et al. 2000), has a revised uncertainty in position of $20''$ in the new on-axis SIS observation. The pulsars has evidently undergone a massive change in flux of at least an order-of-magnitude since the original detection, assuming the spectrum form has remained the same. The lack of photons from the faint source prohibits a proper spectral analysis or search for pulsations, which might allow positive identification with AX J1845−0258.

A 6 hr radio observation of the region obtained with the Very Large Array (VLA) on 1999 March 26 reveals a clumpy shell of emission, $\sim 5'.0$ in diameter, with properties characteristic of a supernova remnant (G 29.6+0.1; Gaensler et al. 1999). This radio shell is centered on the new X-ray source, whose overlap is most unlikely to be a chance superposition, suggesting that the two are related. Furthermore, we also see X-ray emission from the southeast quadrant of the radio

shell, overlapping the sector where the measured non-thermal radio emission is the strongest. The X-ray results also suggest a young remnant, as inferred for G 29.6+0.1, with an age upper limit of 8000 yrs.

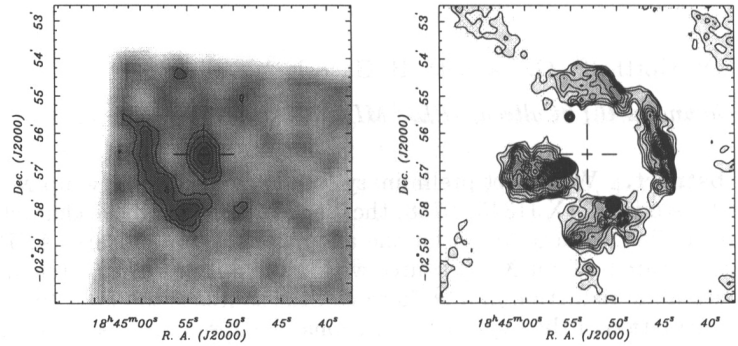

Figure 1. Discovery of a new supernova remnant, G 29.6+0.1, and central X-ray source, AX J184453.3−025642, within the error box of the X-ray pulsar AX J1845−0258. **(LEFT)** The ASCA SIS X-ray image centered on AX J184453.3−025642, marked by the cross. An arc of emission is evident surrounding the point source overlapping the radio shell shown in the next panel. **(RIGHT)** The 5 GHz VLA radio map of the same region, which reveals a clumpy shell, whose spectral index is consistent with a SNR hypothesis.

The lack of a bright pulsator in the new ASCA observation of AX J1845−0258 is quite surprising. The spectral and temporal properties of this pulsar had strongly implied an AXP interpretation. Indeed the discovery of a young radio remnant coincident with the pulsar is consistent with the AXP hypothesis. Conversely, the detection of an X-ray point source in the center of the SNR is in itself indicative of a neutron star candidate associated with the remnant. This new source is exactly where we would expect the AXP to be, to within errors, consistent with this interpretation. We therefore suggest that AX J184453.3−025642 is indeed the pulsar, but at a much reduced X-ray flux. This system is likely similar to that of RCW 103, another AXP-like object whose central source displays low/high flux states, but no pulsations (Gotthelf, Petre, & Vasisht 1999). Conversely, this provides further evidence that RCW 103 may be an AXP with unseen pulsations, perhaps due to unfavorable beaming geometry.

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