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A Search for Single Radio Pulses and Bursts from Southern AXPs

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Abstract. We observed four southern AXPs in 1999 near 1400 MHz with the Parkes 64-m radio telescope to search for periodic radio emission. No Fourier candidates were discovered in the initial analysis, but the recent radio activity observed for the AXP XTE J1810−197 has prompted us to revisit these data to search for single radio pulses and bursts. The data were searched for both persistent and bursting radio emission at a wide range of dispersion measures, but no detections of either kind were made. These results further weaken the proposed link between rotating radio transient sources and magnetars. However, continued radio searches of these and other AXPs at different epochs are warranted given the transient nature of the radio emission seen from XTE J1810−197, which until very recently was the only known radio-emitting AXP.

Keywords: neutron stars, AXPs, magnetars

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INTRODUCTION AND MOTIVATION

The detection of pulsed radio emission from the anomalous X-ray pulsar (AXP) XTE J1810−197 in 2006 [1], and more recently from a second AXP, 1E 1547.0−5408 [2], has renewed interest in searching for radio emission from these objects. In both of these cases, the radio activity is believed to be connected to the X-ray variability of the sources and is transient in nature (or at least highly variable). Given this transient behavior and that both persistent periodic emission and single pulses were detected from both AXPs, renewed searches of archival radio search data of AXPs at different epochs may reveal previously undetected radio signals from these sources.

OBSERVATIONS AND ANALYSIS

Three southern AXPs and one AXP candidate were observed in July and August 1999 with the Parkes 64-m radio telescope. The four targets observed were:

- 1E 1048.1−5937
- AX J1845−0258 (AXP candidate only)
- 1E 1841−045
- 1RXS J170849.0−400910

All observations were conducted with the center beam of the multibeam receiver [3] at a center frequency of 1374 MHz. 288 MHz of bandwidth was split into 96 frequency channels. This is the same observing setup as was used for the Parkes Multibeam Survey [4] and the AXP search observations reported by [5]. None of the four targets was in a state of X-ray outburst at the time of observation.

The data were processed using the PRESTO† suite of pulsar analysis tools [6, 7]. First, the raw data were excised of radio frequency interference (RFI). This is particularly important given the slow rotation rates of the AXPs and the pernicious effect of RFI at low modulation frequencies. Typically, 15-25% of the frequency channels and ~5% of the integration time were discarded in this process. Note that this data excision increases our sensitivity limits by ~10% and is not included in the estimates presented in Table 1. Standard Fourier searches of the data were previously reported [8], but no signals were confirmed in that analysis.

In both the folding search and single pulse analysis reported here, the data were dedispersed at a wide range of dispersion measures (DMs). The DMs ranged from 0 to 4000-8000 pc cm$^{-3}$, depending on the spin period of the AXP. The dedispersed time series were searched for both persistent periodic emission and single pulses and bursts.

To detect periodic emission from these sources, the data were divided into 9 MHz subbands, and each subband was dedispersed at a trial DM of 500 pc cm$^{-3}$. Each subband was then folded at the known neutron star spin period using the X-ray timing ephemeris (where available). In the case of AX J1845−0258, where no

† http://www.cv.nrao.edu/~sransom/presto
Our non-detection of single pulses further weakens the hypothesis that rotating radio transients (RRATs) and magnetars are linked. This has been weakened by two other recent results. First, the X-ray detection of the RRAT J1819–1458 shows that its emission is more typical of middle-aged pulsars than it is of magnetars. Second, the nearby, rotation-powered pulsar PSR B0656+54 would probably have been identified as an RRAT if it were farther away.

We conclude from our results that any periodic or bursting radio emission from the four target AXPs is either very weak (below our detection thresholds), not beamed toward us, or non-existent or sporadic at the epoch of observation. This last possibility is suggested by the connection between the X-ray and radio activity observed for the two known radio-emitting magnetars to date. Continued radio searches of AXPs are therefore warranted given the apparent transient nature of the radio emission. Further details of this work and a more complete discussion of the results are presented in a recent journal article.

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### TABLE 1. Radio Search Parameters and Results

| Parameter                              | 1E 1048.1–5937 | AX J1845–0258\(^∗\) | 1E 1841–045 | 1RXS J170849.0–400910 |
|----------------------------------------|----------------|----------------------|-------------|-----------------------|
| Spin period (s)                        | 6.45           | 6.97                 | 11.77       | 11.00                 |
| Ephemeris reference                    | [13]           | [14]\(^†\)           | [15]        | [16]                  |
| Galactic longitude, latitude (deg)     | 288.26, −0.52  | 29.52, 0.07          | 27.39, −0.01| 346.47, 0.03          |
| \(T_{\text{sky}}\) (K)\(^∗∗\)        | 9.1            | 12.3                 | 13.2        | 16.3                  |
| Observation MJD                        | 51378          | 51391                | 51382       | 51379                 |
| Observation date                       | 1999 Jul 19    | 1999 Aug 1           | 1999 Jul 23| 1999 Jul 20           |
| \(\delta_{1400}\) single (mJy)\(^‡\) | \(\lesssim 0.02\) | \(\lesssim 0.02\)    | \(\lesssim 0.02\) | \(\lesssim 0.02\)    |
| Distance (kpc)\(^∥\)                  | \(\sim 5?\)   | \(\sim 8?\)          | \(\sim 7\)  | \(\sim 8?\)           |
| \(L_{1400}\) (mJy kpc\(^2\))\(^††\) | \(\lesssim 0.5\) | \(\lesssim 1.3\)     | \(\lesssim 1.0\) | \(\lesssim 1.3\)     |
| \(L_{1400}\) single (Jy kpc\(^2\))\(^††\)| \(\lesssim 22-1.3\) | \(\lesssim 62-3.7\) | \(\lesssim 49-2.9\) | \(\lesssim 69-4.1\) |

\(^∗\) AXB candidate only  
\(^†\) No period derivative available  
\(^∗∗\) 1374 MHz sky temperature estimated from [17] assuming a spectral index of \(-2.6\)  
\(^‡\) 1400 MHz flux density limit on pulsed emission estimated using the modified radiometer equation and an assumed duty cycle of 2.7\%  
\(^∥\) Range of single-pulse 1400 MHz flux limits for pulse time-scales 0.25-240 ms  
\(^††\) Range of 1400 MHz luminosity limits on single pulses for pulse time-scales 0.25-240 ms

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