AXPs in the Optical and Infrared: New Developments

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Abstract:

Here I review the current set of detections of Anomalous X-ray Pulsars (AXPs) in the optical and infrared, including new detections of 1E 1048.1-5937 and CXOU J010043.1-721134 and upper limits on 1E 1841-045. I discuss the implications of this suite of data points in the light of uncertainties on the reddening to the objects. As a possible solution to the latter, I present a simple but robust method to determine the reddening versus distance relationship towards the AXPs.

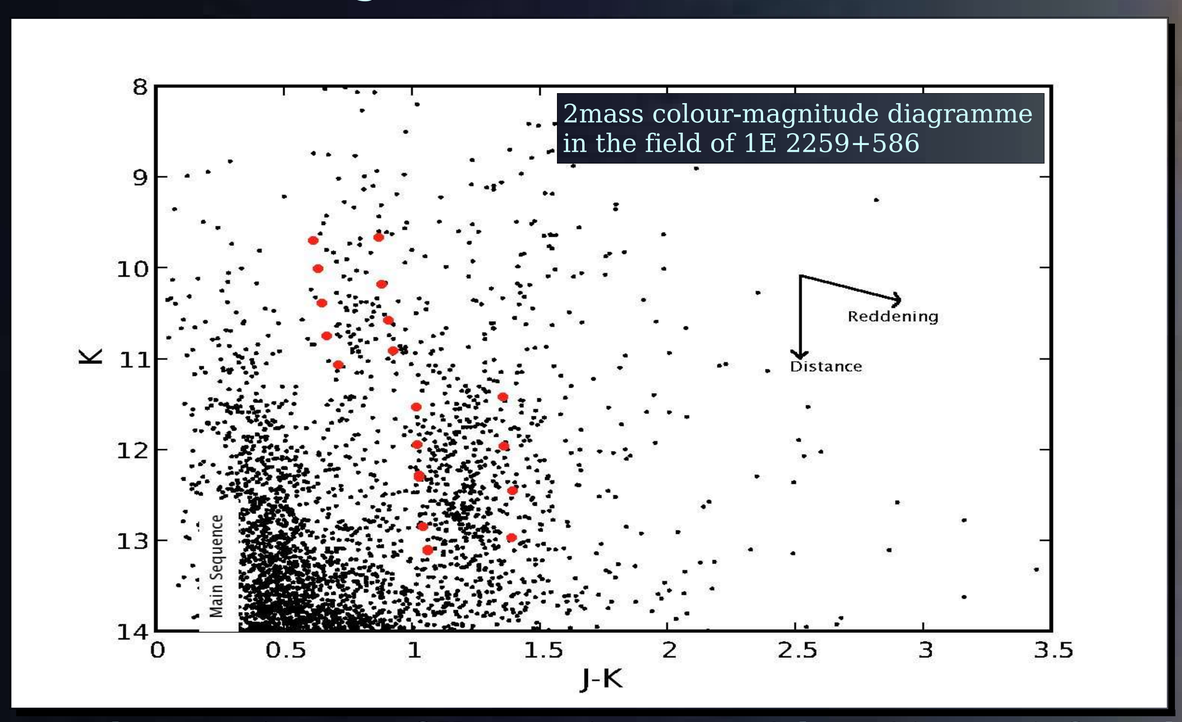
Reddening

Being confined to the Galactic Disc and being at large distances, all the AXPs bar one lie behind substantial amounts of dust extinction. The amount of dust reddening assumed vitally affects the spectral energy distributions derived from optical and infrared detections.

For example, in comparing the spectra of 1E1048.1-5937 and 4U0142+61 (Durant & van Kerkwijk, 2005a), one finds that they are inconsistent under the assumed value for reddening taken from fits to the X-ray spectra. Stellar clusters and an external galaxy in the direction of 4U0142+61 would argue for a much lower extinction towards this object, and the spectra could in reality be consistent.

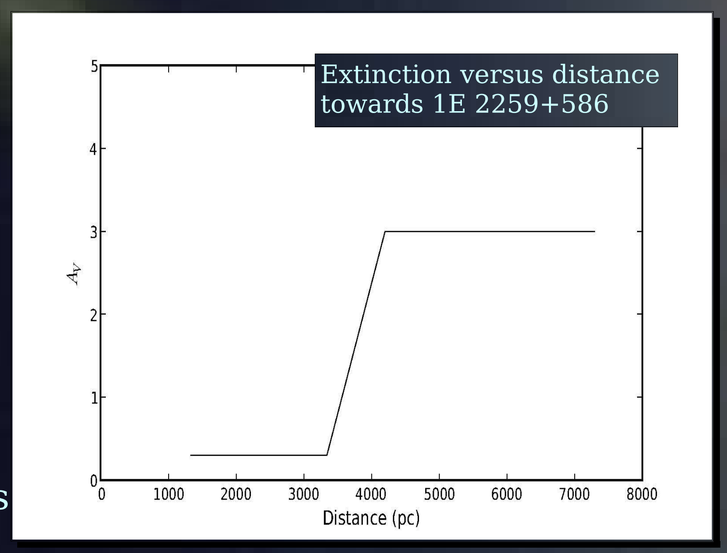
It is important to note that the extinction column as derived from X-ray spectral fits is sensitive only to the low-energy end. Here the count rates are small compared to the background. A method for estimating reddening with the minimum of assumptions would be invaluable..

Infrared Colour-Magnitude Method



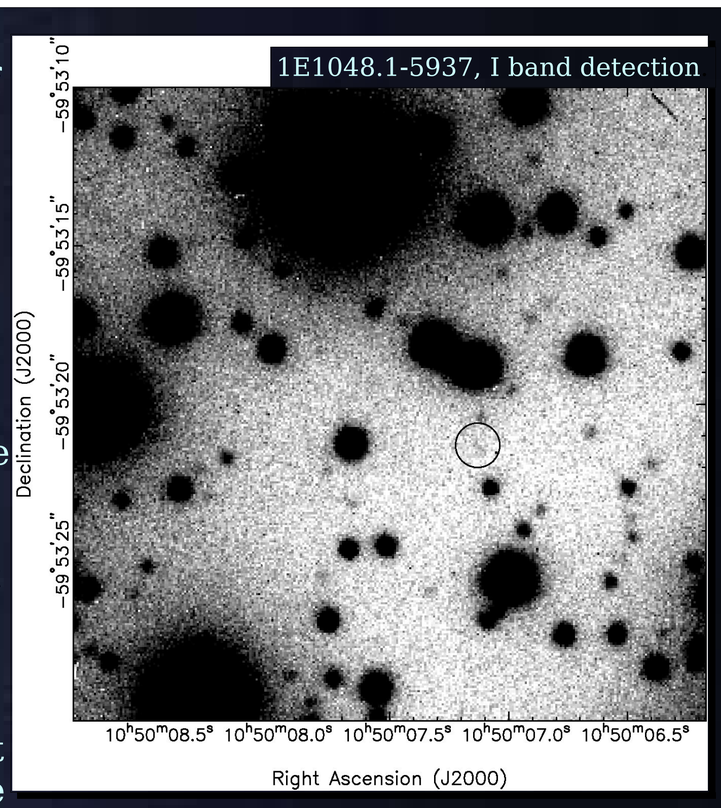
Due to the prominence of K-type giants as a 'clump' in any infrared colour-magnitude diagramme, it is possible to deduce the run of reddening with distance in a given field of view by identifying this population at various distances (Cabrera-Lavers, 2005). Infrared magnitudes can be found from 2mass, for example (see Figures for 1E2259+598).

The justification in assuming the stars in the stripe on the diagramme are the same intrinsically is simply in its coherence to great distance.

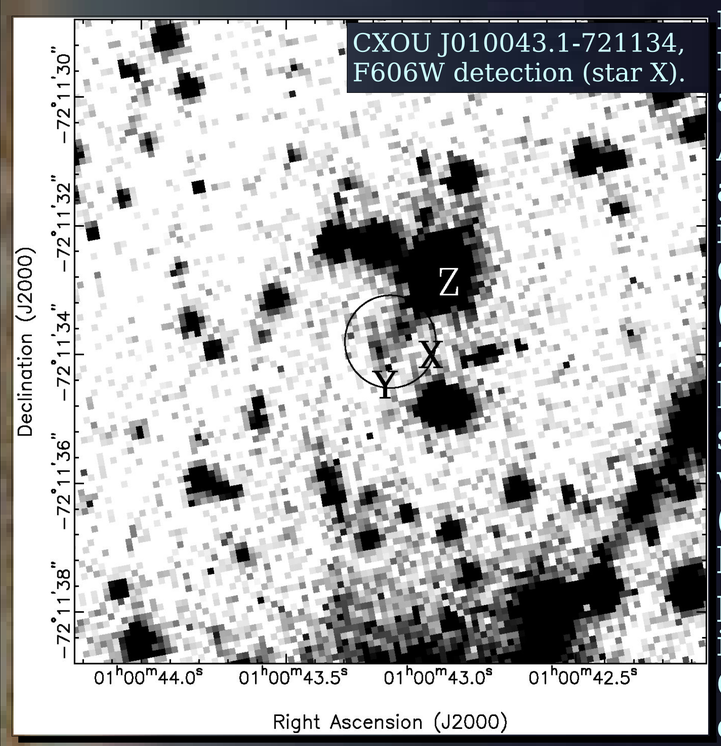


Detections

Since the first detection of an AXP in the infrared (Hulleman et al, 2000), there has been a huge surge of activity to find other optical and infrared counterparts. This has been hampered by the large extinction towards the objects, and indeed the search has been more successful in the infrared. The AXPs are all very faint in this part of the spectrum by any standards.

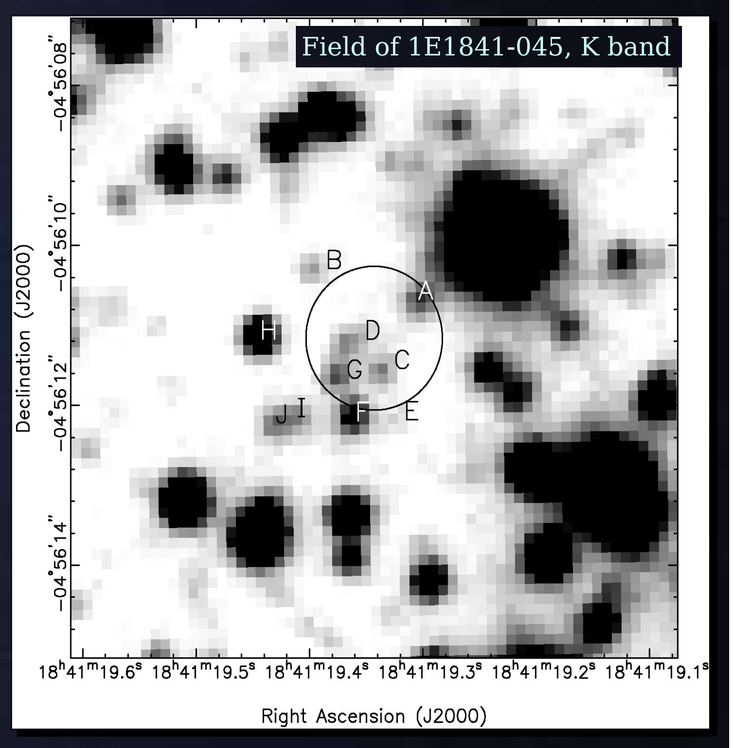


Recent additions to the set of detections include those of 1E1048.1-5937 (Durant & van Kerkwijk, 2005a), at much fainter magnitudes than originally detected by Wang & Chakrabarty (2002): Ks=21.3(3), J=23.4(4), I=26.2(4). These represent about the deepest that can be achieved from the ground. The detections raised a number of questions regarding the variability, spectral energy distribution and extinction of this object, as well as on the remarkable consistency of X-ray to infrared flux ratios across all the AXPs.



A recent and promising addition to AXP counterparts is the likely detection of CXOU J010043,1-721134 (Durant & van Kerkwijk, 2005b). This was found to have M_{F606W}=24.19(15) on a single HST/WFPC2 image, with only a very small (<1.5%) chance of the signal being due to some non-physical source. This AXP is in the Small Magellanic Cloud, and so afford the chance of observations not obscured by a large dust column. Unfortunately a nearby much brighter star (Z on the left-hand image) makes observations from the ground tricky.

Finally, a deep infrared photometric search was undertaken to find 1E1841-045 (Durant, 2005). Under excellent conditions, several sources were found within the X-ray positional error circle, yet none of them showed unambiguously the characteristic non-stellar colours of an AXP. The main limit on the detection comes from the crowding in the field, where none of the sources can be discounted as the counterpart with certainty; if one assumes that they are all ordinary stars, then magnitude limits of J=22.1, H=20.7, Ks=19.9 are reached.



It is fair to say that the very limits of photometry have been reached in the field of AXP research. .

References:

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