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EXPLORING THE NATURE OF WEAK CHANDRA SOURCES NEAR THE GALACTIC CENTRE

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We present early results from the first near-IR imaging of the weak X-ray sources discovered in the recent Chandra/ACIS-I survey towards the Galactic Centre (GC) (Wang et al. 2002). These ∼800 discrete sources, which contribute significantly to the GC X-ray emission, represent an important and previously unknown population within the Galaxy. From our VLT observations we will identify likely IR counterparts to a sample of the hardest sources, which are most likely X-ray binaries. With these data we can place constraints on the nature of the discrete weak X-ray source population of the GC. Once the data analysis is complete we will discuss our results in the context of binary population synthesis models.

1. *CHANDRA* SURVEY OF THE GALACTIC CENTRE

In July 2001 Wang et al. performed an imaging survey with *Chandra*/ACIS-I of the central 0.8×2 degrees of the Galactic Centre (GC), revealing a large population of previously undiscovered discrete weak sources with X-ray luminosities of $10^{32} - 10^{35}$ ergs s^{-1}. The nature of these ∼800 newly detected sources is as yet unknown. In contrast to the populations of faint AGN discovered from recent deep X-ray imaging out of the Galactic plane, our calculations suggest that the extragalactic contribution to the hard point source population over the entire Wang et al. survey is ≤ 10%, consistent with the log(N)-log(S) function derived from the Chandra Deep Field data (Brandt et al. 2001). The harder (≥3 keV) X-ray sources (for which the softer X-rays have been absorbed by the interstellar medium) are likely to be at the distance of the GC, while the softer sources are likely to be foreground X-ray active stars or cataclysmic variables (CVs) within a few kpc of the Sun. The combined spectrum of the discrete sources shows emission lines characteristic of accreting systems such as CVs and X-ray binaries (XRBs). These hard, weak X-ray sources in the GC are therefore most likely a population of XRBs; candidate classes include quiescent black hole binaries or quiescent low-mass XRBs, CVs, and high-mass wind-accreting neutron star binaries (WNSs).

2. WHAT ARE THESE POINT SOURCES?

Pfahl et al. (2002) have recently considered in detail the likely nature of these Chandra sources and concluded on the basis of binary population synthesis (BPS) models that many, if not the majority, of these systems are WNSs. Depending on the mass of the companions, the WNSs may belong to the "missing" population of wind-accreting Be/X-ray transients in quiescence or the progenitors of intermediate-mass X-ray binaries (IMXBs; $3 \leq M/M_{sun} \leq 7$). The existence of tens of thousands of quiescent Be/XRBs in the Galaxy has been predicted since the early 1980s (Rappaport & van den Heuvel 1982; Meurs & van den Heuvel 1989), while it has only recently been recognized that IMXBs may constitute a very important class of XRBs that had not been considered before (King & Ritter 1999; Podsiadlowski & Rappaport 2000). The Wang et al. *Chandra* survey may contain as many as 10% of the entire Galactic population of WNSs. In addition to the WNSs, Pfahl et al. estimate that a small fraction of the *Chandra* sources could be CVs or transient low-mass XRBs/black-hole binaries.

3. OUR IMAGING PROGRAM

The first step in determining the nature of this population is to identify counterparts to the X-ray sources. These observations must necessarily be done in the infrared due to the high optical extinction in the direction of the GC. We therefore constructed a survey program using the ISAAC IR camera on the VLT, with the goal of obtaining high-resolution JHK-band images in order to identify a statistically significant number of counterparts to the X-ray sources on the basis of the *Chandra* astrometry, which can be refined to a precision between 0.3"-0.8". We imaged 26 fields within the *Chandra* survey region, containing a total of ∼70 X-ray

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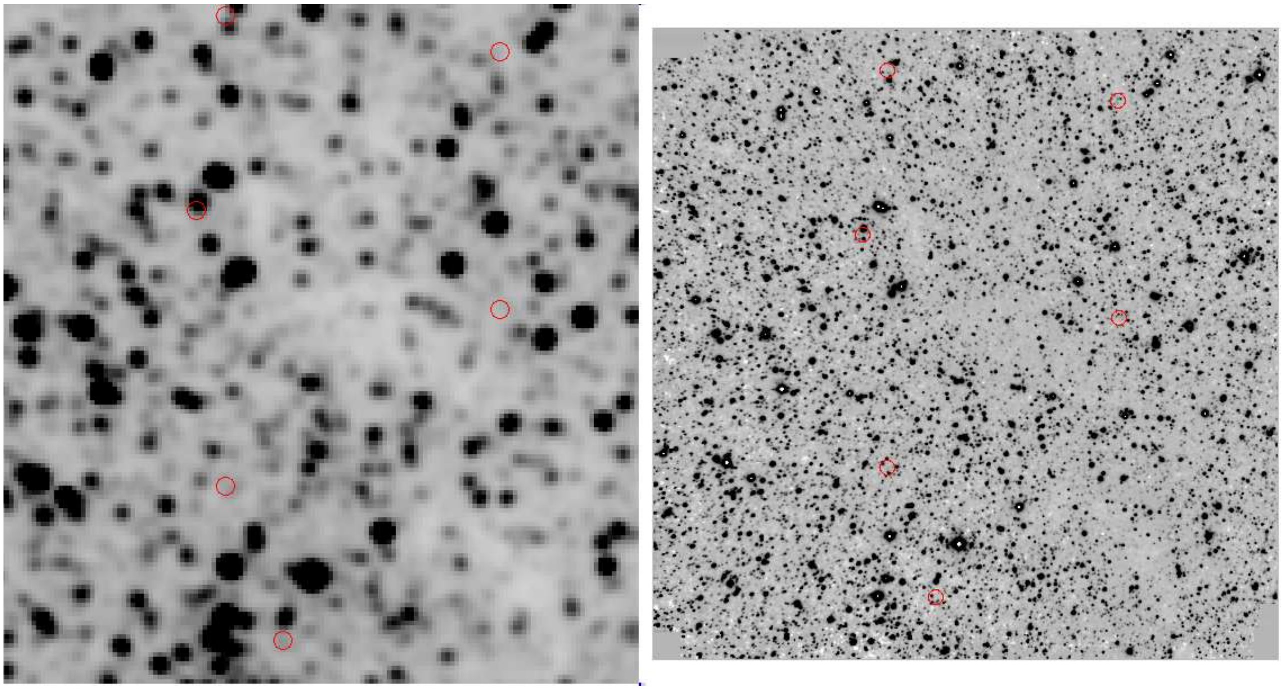

Fig. 1. 2MASS (left) and VLT (right) K-band images of one of our GC fields. The circles (*Chandra* error circles with 1" radius) indicate the positions of X-ray sources. The brightest stars are clearly visible in both the 2MASS and VLT images; however, the VLT image is considerably superior in depth and resolution.

sources . For the early-type donors of the WNSs, we would expect intrinsic magnitudes of K=11-16; these are therefore readily distinguishable from the majority of late-type donors expected for black hole X-ray transients which generally have $K \geq 16$ in quiescence. The average extinction towards the GC is $K \sim 3$; therefore by imaging to a magnitude limit of K=20 we should detect most of the WNSs.

4. THE VLT DATA

The successful achievement of our goals requires astrometric accuracy and high angular resolution to overcome the confusion limit of the crowded GC. There is no archival systematic IR imaging survey towards the GC which we could use for this project. The 2MASS survey has a limiting magnitude of K=14.3, and although the astrometric positions are accurate to 0.2", the survey has a spatial resolution of $\geq$2". As such, the 2MASS data are severely confusion limited in the GC and moreover are of insufficient depth to detect the majority of the expected counterparts (Figure 1). In contrast, our VLT/ISAAC images are clearly not confusion limited and reach a depth of $K \sim$19-20. Furthermore, there are one or more resolved IR sources within each *Chandra* error circle. Thus there are potential IR counterparts in our VLT images for the majority of *Chandra* sources within those fields.

The distribution of X-ray colours suggests that only a small fraction of the *Chandra* sources are foreground objects. The next steps in the analysis of these datasets are (1) to derive accurate astrometric solutions for both the IR and X-ray images; (2) to determine IR colours for the potential counterparts within the X-ray error circles; and ultimately (3) to identify candidates for IR spectroscopic follow-up observations in order to establish accurate spectral types for this population.

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