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**Recommended Citation**
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BOWEN FLUORESCENCE FROM COMPANION STARS IN X-RAY BINARIES

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ABSTRACT

This paper will review a new technique of detecting companion stars in LMXBs and X-ray transients in outburst using the Bowen fluorescence NIII lines at 4634-4640. These lines are very efficiently reprocessed in the atmospheres of the companion stars and, thereby, provide estimates of the $K_2$ velocities and mass functions. The method has been applied to Sco X-1, X1822-371 and GX339-4 which, in the latter case, provides dynamical evidence for the presence of an accreting black hole. Preliminary results from a VLT campaign on V801 Ara, V926 Sco y XTE J1814-338 are also presented.

Key Words: ACCRETION, ACCRETION DISCS — X-RAYS: BINARIES — X-RAYS: STARS

1. INTRODUCTION

The Galaxy is populated with just over 100 known persistent Low Mass X-ray Binaries (LMXBs hereafter) whose optical emission is triggered by X-ray reprocessing into the gas surrounding the compact object, mainly the accretion disc. The companion star is ~ $10^8$ times fainter than the optical disc and hence completely undetected. This has hampered dynamical studies of LMXBs which have been restricted so far to radial velocity studies of X-ray transients in quiescence. In several cases, the quiescent companion spectrum is just too faint for current instrumentation (e.g. GX339-4, N. Oph 93) or the target is contaminated by a bright line-of-sight star (e.g. Aql X-1, 4U 2129+47). Dynamical studies and mass determination of compact stars in LMXBS has paramount implications in astrophysics since it may yield new black hole discoveries and the first massive neutron stars. The latter would rule out soft equations of state and will prove LMXBs are indeed the progenitors of millisecond pulsars, spun up by accretion.

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narrow (i.e. $FWHM = 50$ km s$^{-1}$, the instrumental resolution), and (2) move in anti-phase with the wings of the He II $\lambda 4686$ line (which trace the motion of the compact star). Furthermore, the radial velocity curve is very sinusoidal indicating a fixed structure in the binary frame. This work represents the first detection of the companion star in Sco X-1 and opens a new window to extract dynamical information in a population of $\simeq 20$ LMXBs with optical counterparts.

**3. GX339-4 AND X1822-371**

The Bowen fluorescence diagnostic is a powerful technique also for transient sources as we have clearly demonstrated in Hynes et al. (2003). GX339-4 has been a black hole candidate for decades based on its X-ray properties but no dynamical proof could be provided. In summer 2002 we used the opportunity of a new outburst episode to obtain AAT, NTT and VLT spectroscopy which revealed (1) He II velocities modulated with an orbital period of 1.76 d, and (2) narrow N III Bowen components from the companion star with a velocity semi-amplitude of $317 \pm 10$ km s$^{-1}$. The implied mass function is $5.8 \pm 0.5 M_\odot$ and hence a robust evidence for an accreting black hole.

The next obvious target is X1822-371 because, at $B=16$ it is one of the brightest LMXBs. It is also a key system because (1) is eclipsing hence the inclination is well constrained (2) is an X-ray pulsar and therefore the orbit of the neutron star is known to great accuracy. In summer 2002 we obtained AAT spectroscopy but the moderate $S/N$ prevented identification of the narrow fluorescence components in individual spectra (see Casares et al. 2003). However, we exploited the Doppler Tomography technique which uses all the information contained in the phase-resolved emission profiles at once to reconstruct the emissivity distribution in velocity space.

**4. VLT SURVEY**

We have started a VLT survey of LMXBs to target new candidates with strong Bowen emission for future studies. These are MM Ser, X1957-115, LU TrA, V926 Sco, GX9+9, GR Mus, V801 Ara and X0614+091. In summer 2003 we observed V926 Sco, V801 Ara and the newly discovered transient millisecond pulsar XTE J1814-338 using VLT+FORS2. Our Doppler tomograms enables us to detect the companion star in N III $\lambda 4640$ and derive lower limits to their $K$-velocities of 223, 282 and 345 km s$^{-1}$ respectively (Casares et al. 2004a,b in preparation).

**REFERENCES**