New techniques for unveiling fundamental parameters in LMXBs harbouring NSs

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Credit: G. Perez (IAC)
Low mass X-ray binary (LMXB)

**Persistent:** bright disc companion not detected

**Transient:** companion detected
Fundamental parameters

The mass of the neutron star: Cubic terms!

\[ f(M_1) = \frac{PK_2^3}{2\pi G} = \frac{M_1 \sin^3 i}{(1 + q)^2} \]

\[ q = \frac{M_2}{M_1} = \frac{K_1}{K_2} \]

The determination of the donor star radial velocity semi-amplitude \((K_2)\) is key.
The classical approach

The orbital velocity of the donor in the line-of-sight ($K_2$).

Classical approach: observations during quiescence:

González-Hernández et al. (2008)
The classical approach

The donor star radial velocity curve:

Shahbaz, Watson & Dhillon (2008)
The classical approach

This technique is not always available:

- Persistent systems: always in outburst:  
  **Sco X-1** (NS)

- A quiescence state with high disc contribution:  
  **Swift J1357.2-0933** (BH)

- Field stars equally bright near the LMXB line-of-sight:  
  **Aql X-1** (NS)
The persistent NS LMXB Sco X-1

NIR K-band spectrum:

Mata Sánchez, D. et al. (2015a)
The persistent NS LMXB Sco X-1

Bowen blend

Bowen blend:
NIII 4634, 4641-2
CIII 4647, 4650-1

McClintock et al. (1975)
The persistent NS LMXB Sco X-1

Bowen technique

Steeghs & Casares (2002)
The persistent NS LMXB: Sco X-1

Monte Carlo analysis

Fundamental parameters:

\[ M_1 < 1.73 M_\odot \]
\[ 0.28 < q < 0.51 \]
\[ 0.28 M_\odot < M_2 < 0.70 M_\odot \]

Mata Sánchez et al. (2015a)
The loud quiescence of Swift J1357

Mata Sánchez, D. et al. (2015b)
The loud quiescence of Swift J1357

K2 - FWHM (Hα) correlation

Reveals a massive BH: $M_{\text{BH}} > 9.3 \, M_\odot$ (Mata Sánchez et al. 2017a)
The crowded field of Aql X-1

Aquila X-1 finding chart field

Aquila X-1 is star e, only 0.4″ away from the interloper a

Chevalier et al. (1999)
The crowded field of Aql X-1

SINFONI (VLT) + Adaptive optics module

NIR spectroscopy on Aql X-1 for the first time

Mata Sánchez, D. et al. (2017a)
The crowded field of Aql X-1

We find K4V donor star absorption features

Mata Sánchez, D. et al. (2017a)
The crowded field of Aql X-1

The radial velocity curve

Fundamental parameters:

\[ f(M_1) = 0.21 \pm 0.02 \, M_{\odot} \]
\[ K_2 = 136 \pm 4 \, \text{km/s} \]
\[ 36^\circ < i < 47^\circ \]
\[ d = 6 \pm 2 \, \text{kpc} \]

Mata Sánchez, D. et al. (2017a)
Conclusions

New approaches to carry out dynamical studies:

• Persistent systems: always in outburst:
  The Bowen technique
  Mata Sánchez, D. et al. (2015a)

• A quiescence state with disc contribution:
  K2 - FWHM correlation
  Mata Sánchez, D. et al. (2015b)

• Field stars equally bright near the LMXB line-of-sight:
  NIR integral field spectroscopy
  Mata Sánchez, D. et al. (2017a)
Thank you

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