New techniques for unveiling fundamental parameters in LMXBs harbouring NSs

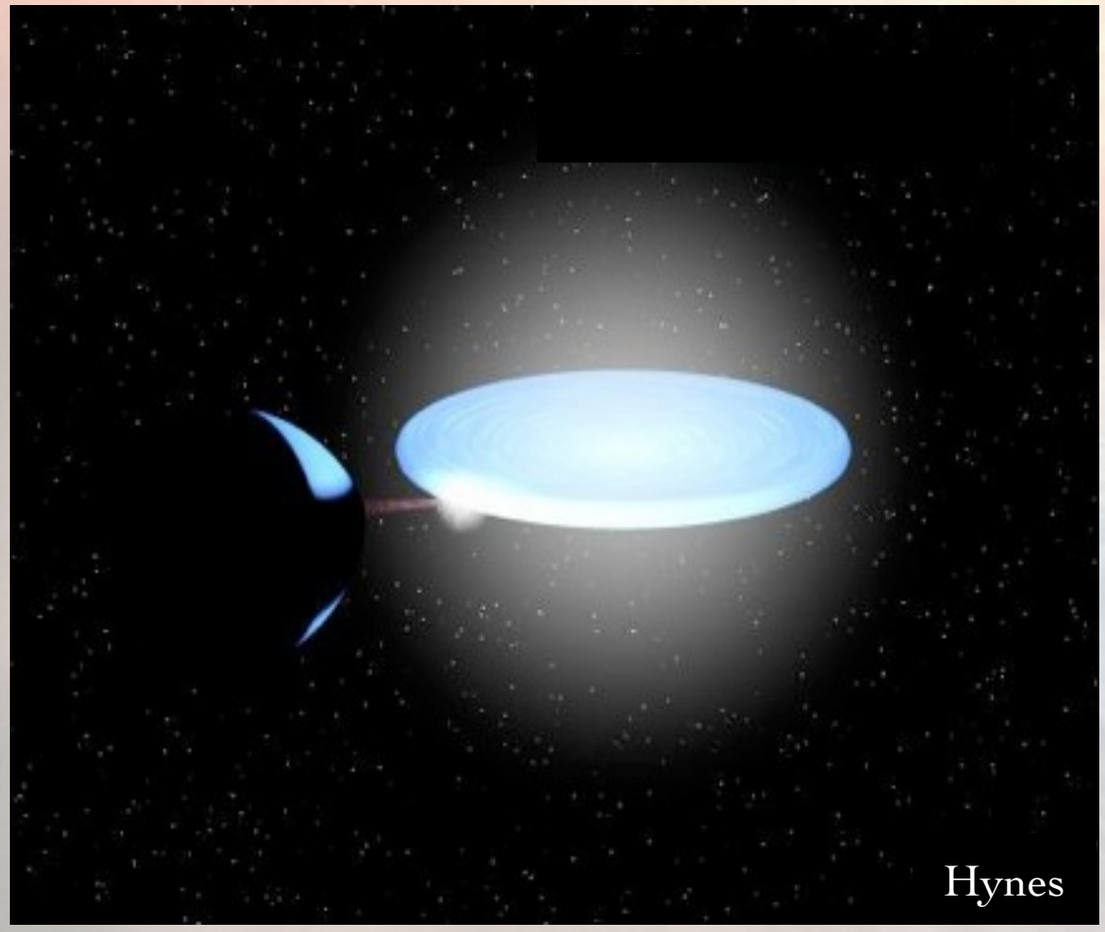
Daniel Mata Sánchez

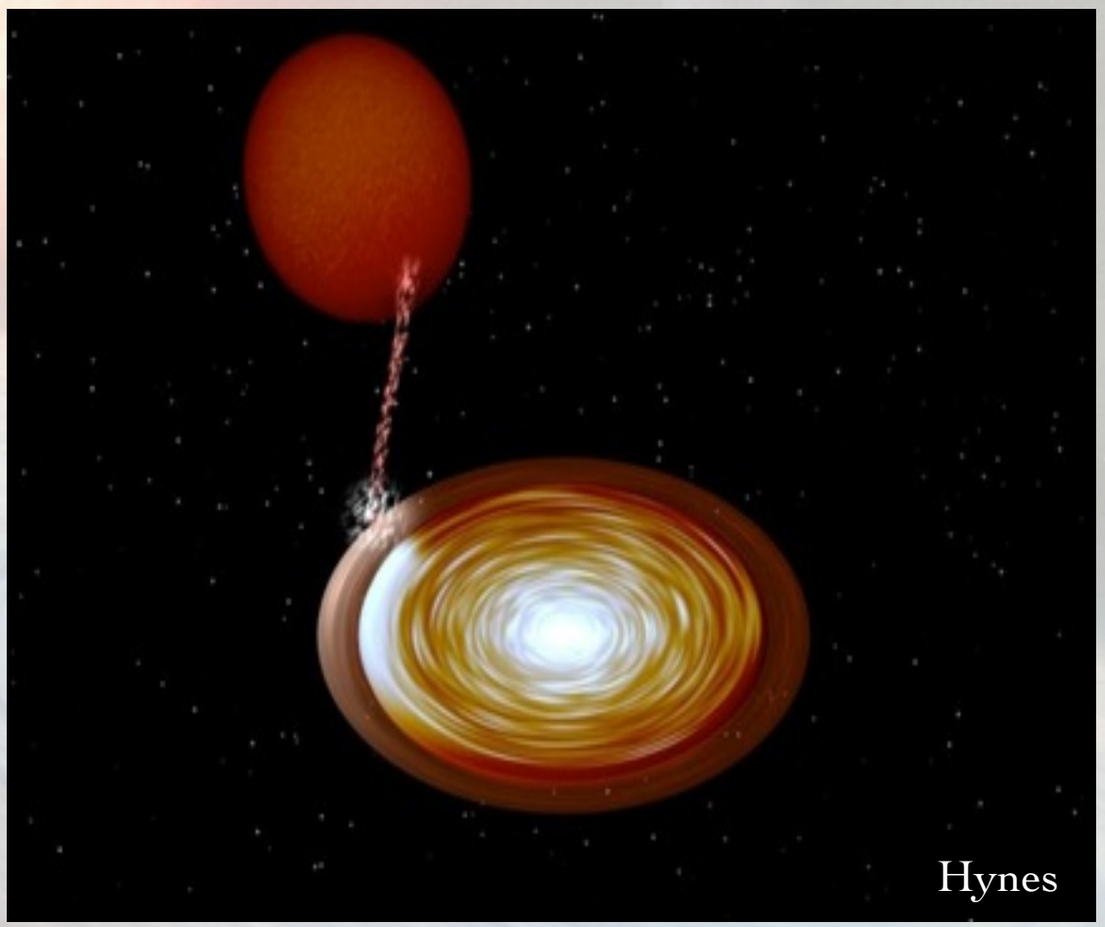
Supervisors:
T. Muñoz-Darias, J. Casares

PNS 2017 - St. Petersburg, Russia

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!**

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

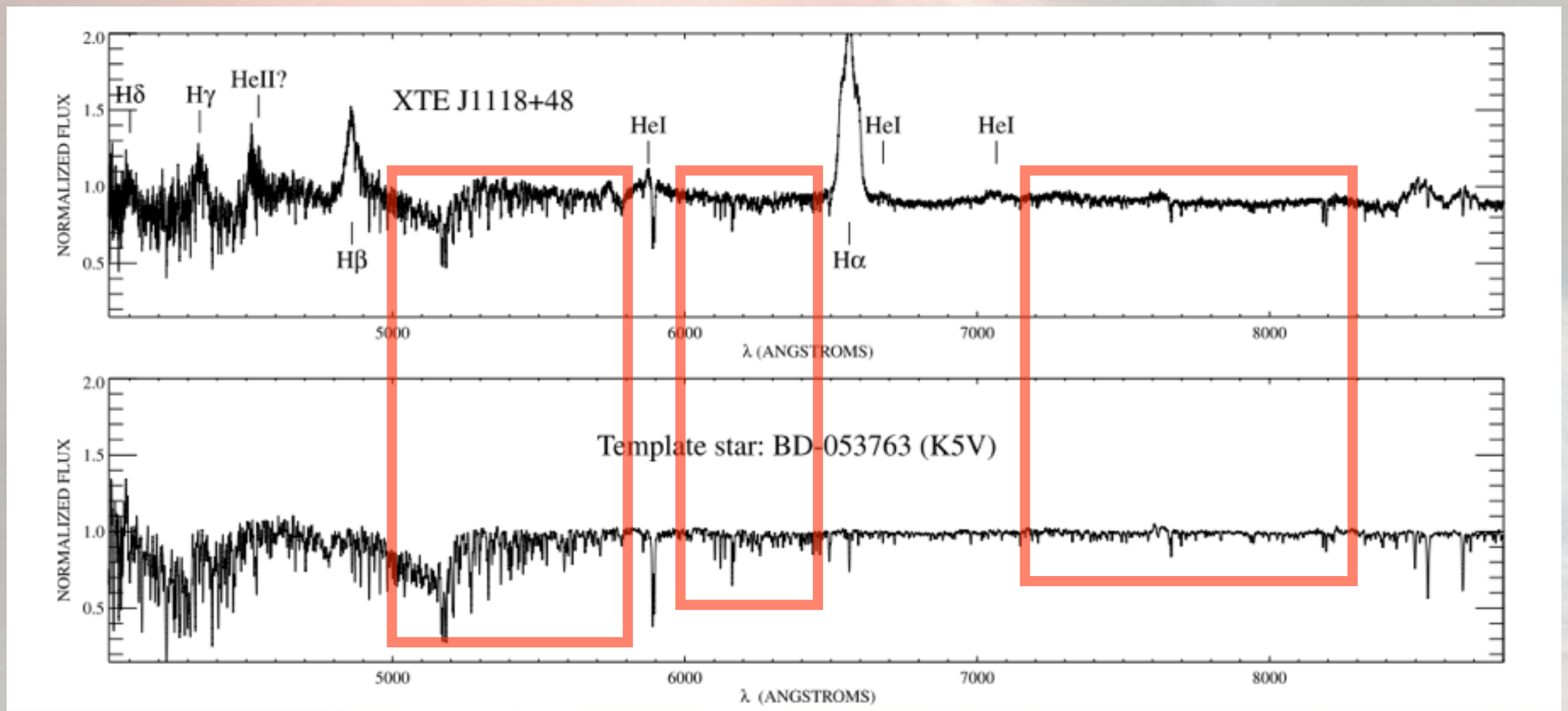
$$q = \frac{M_2}{M_1} = \frac{K_1}{K_2}$$

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).**

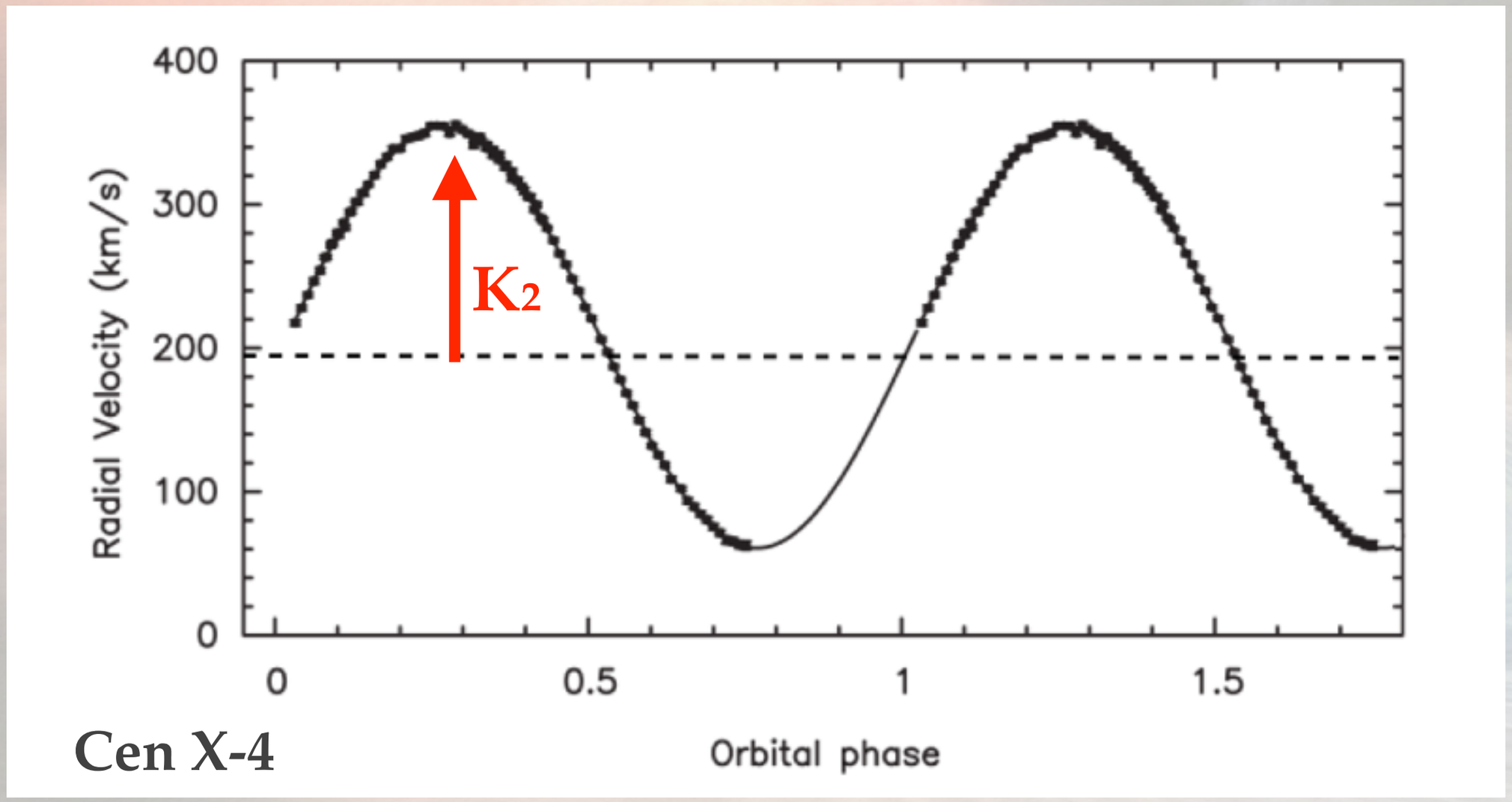
Classical approach: observations during **quiescence:**



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:

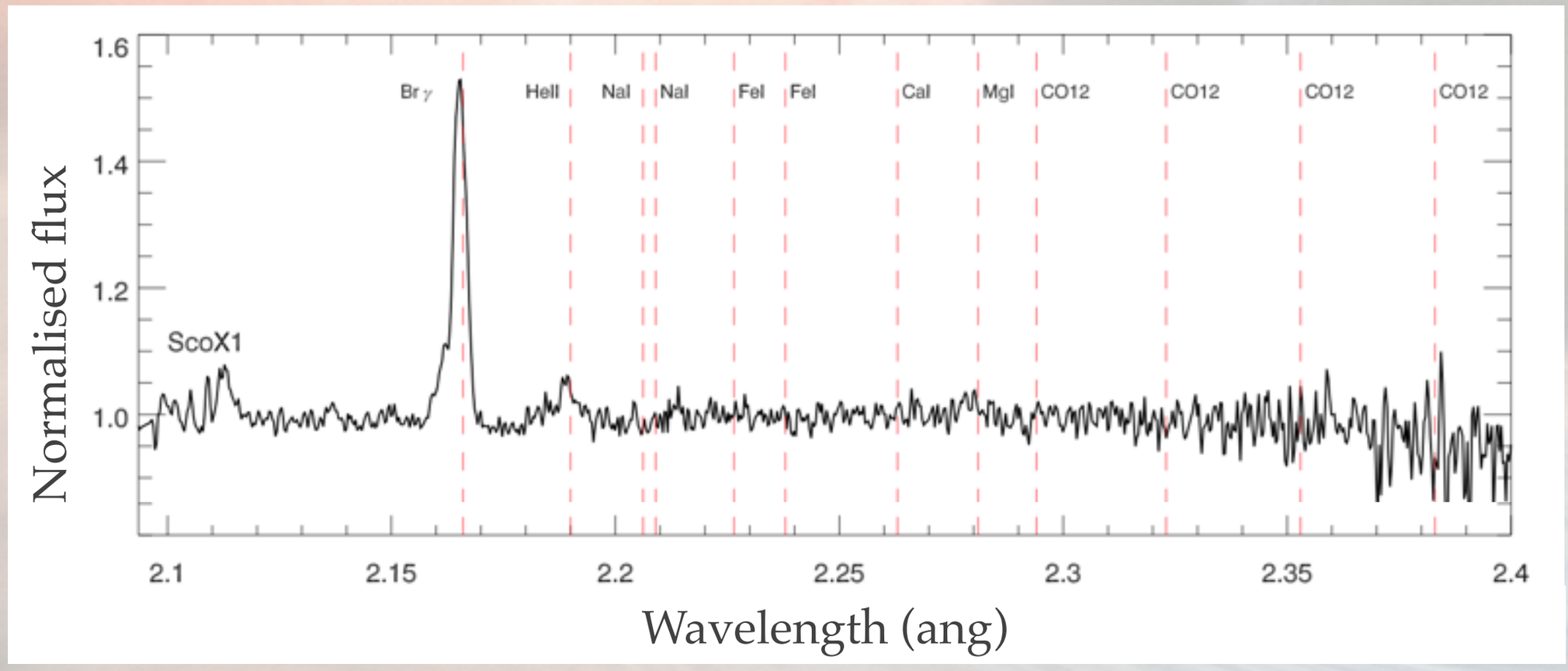
- Persistent systems: always in outburst:
  Sco X-1 (NS)

- 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

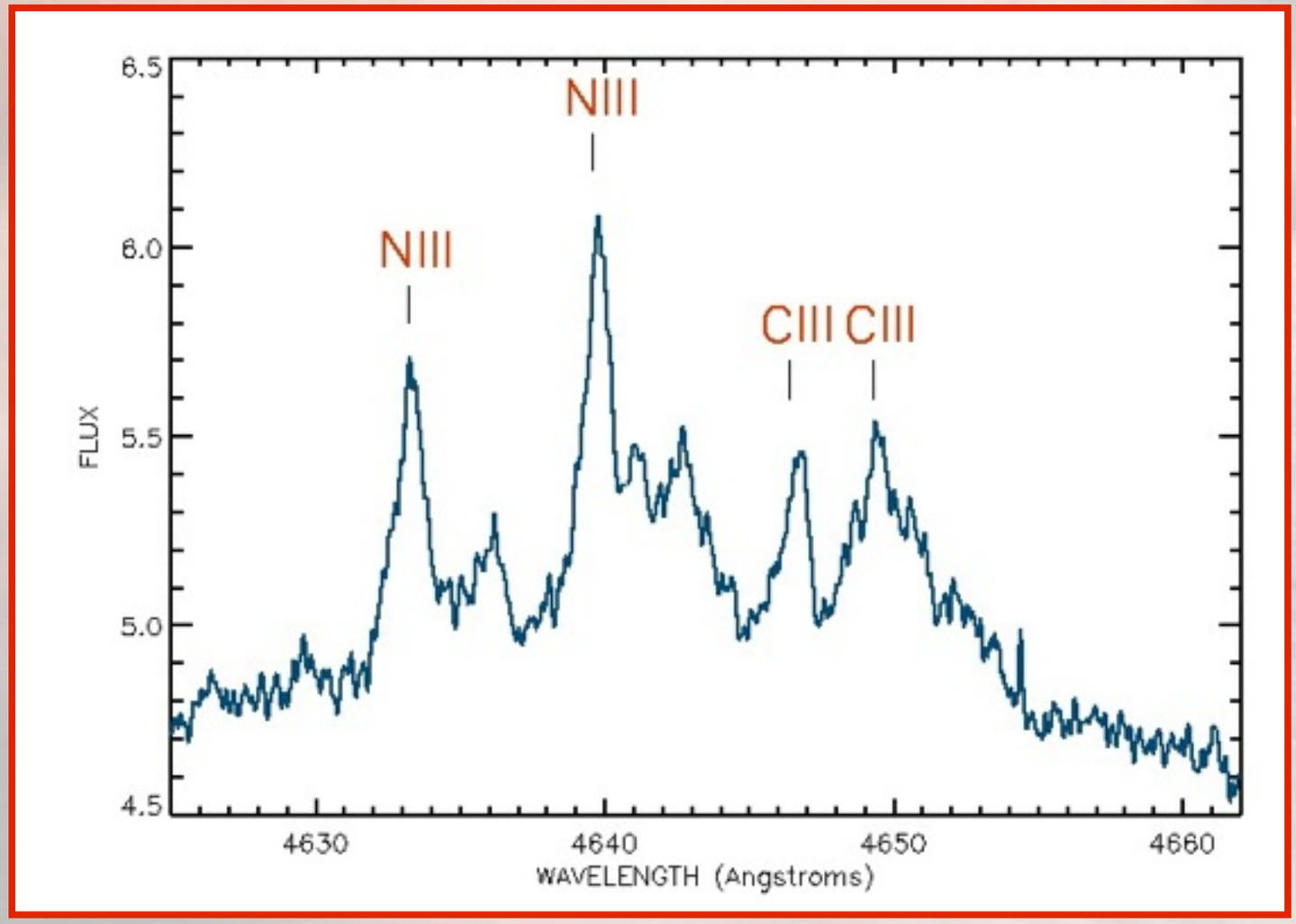
NIR K-band spectrum:



Mata Sánchez, D. et al. (2015a)

The persistent NS LMXB Sco X-1

Bowen blend



Bowen blend:

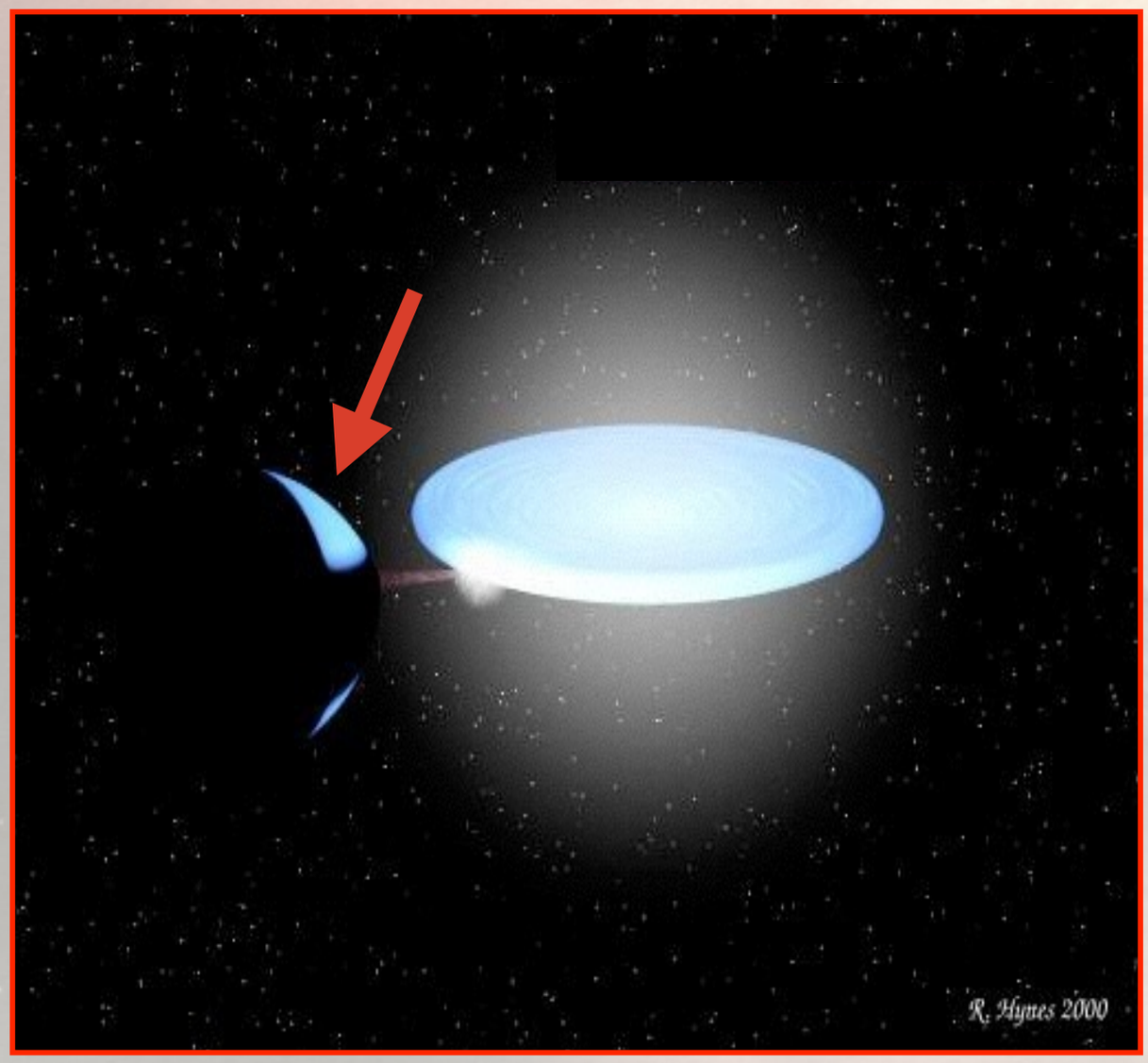
NIII 4634, 4641-2

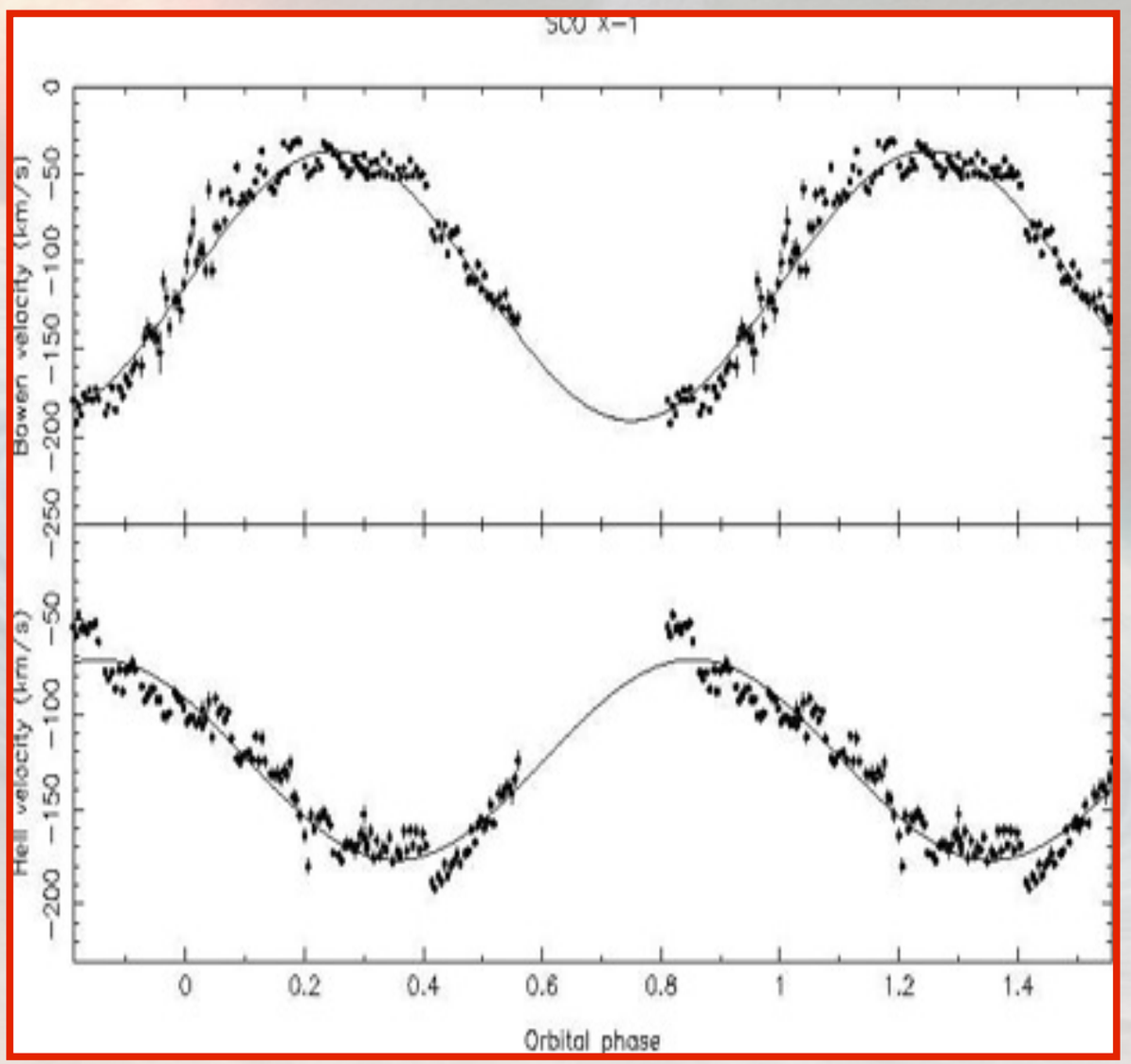
CIII 4647, 4650-1

McClinctock et al. (1975)

The persistent NS LMXB Sco X-1

Bowen technique





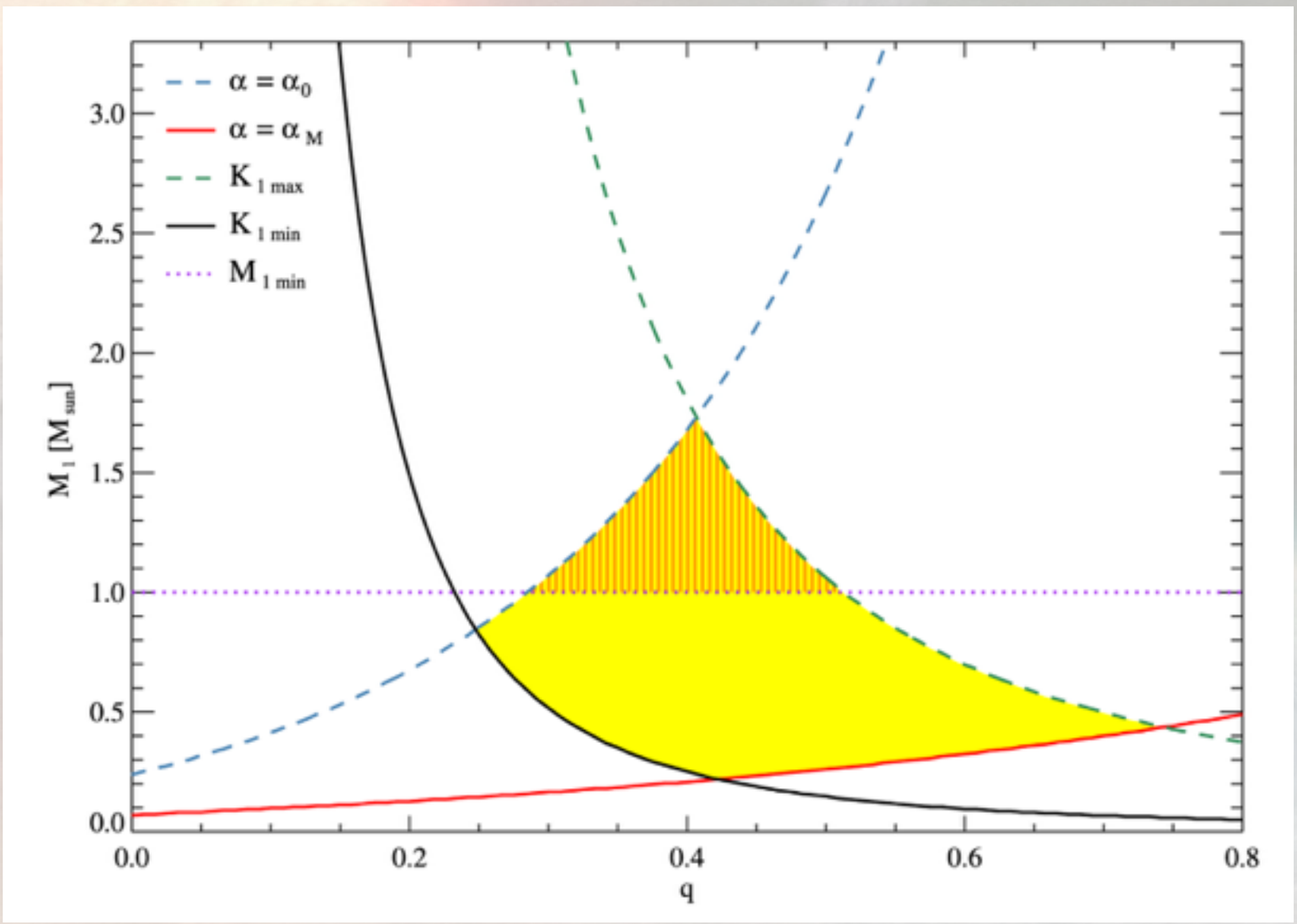
Steeghs & Casares (2002)

The persistent NS LMXB: Sco X-1

Monte Carlo analysis

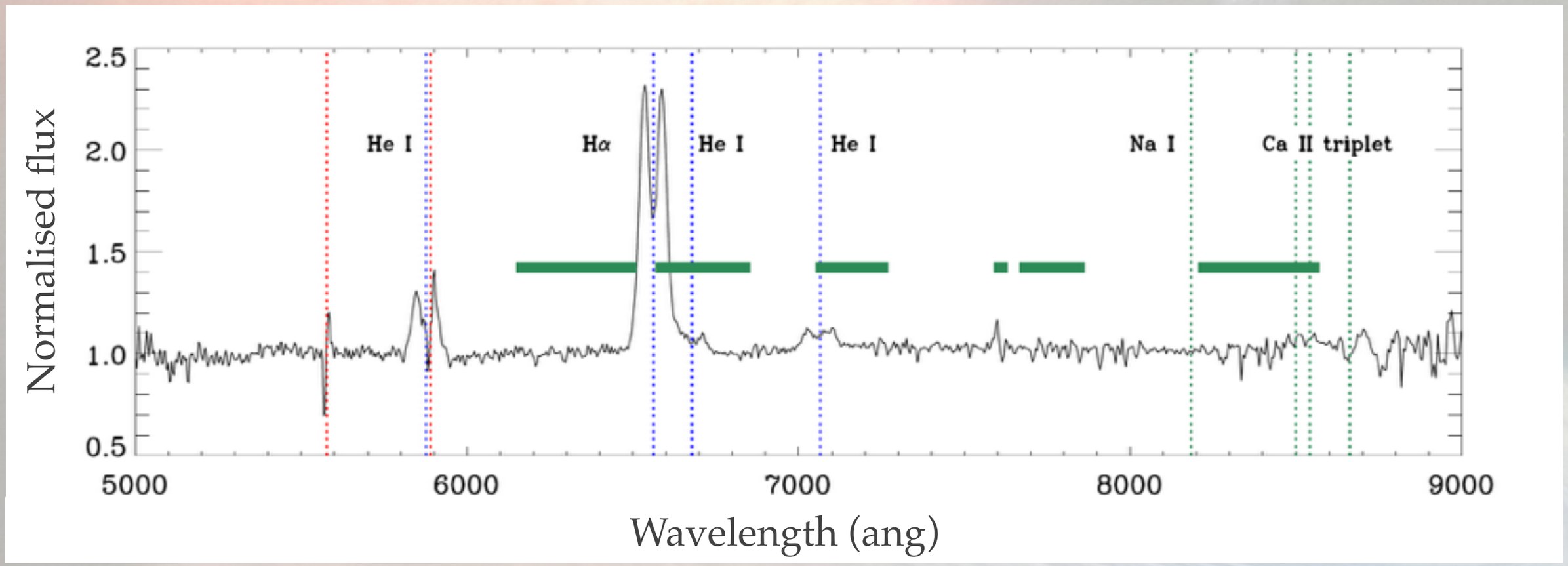
Fundamental parameters:

$$M_1 < 1.73\, M_\odot$$
$$0.28 < q < 0.51$$
$$0.28\, M_\odot < M_2 < 0.70\, M_\odot$$



Mata Sánchez et al. (2015a)

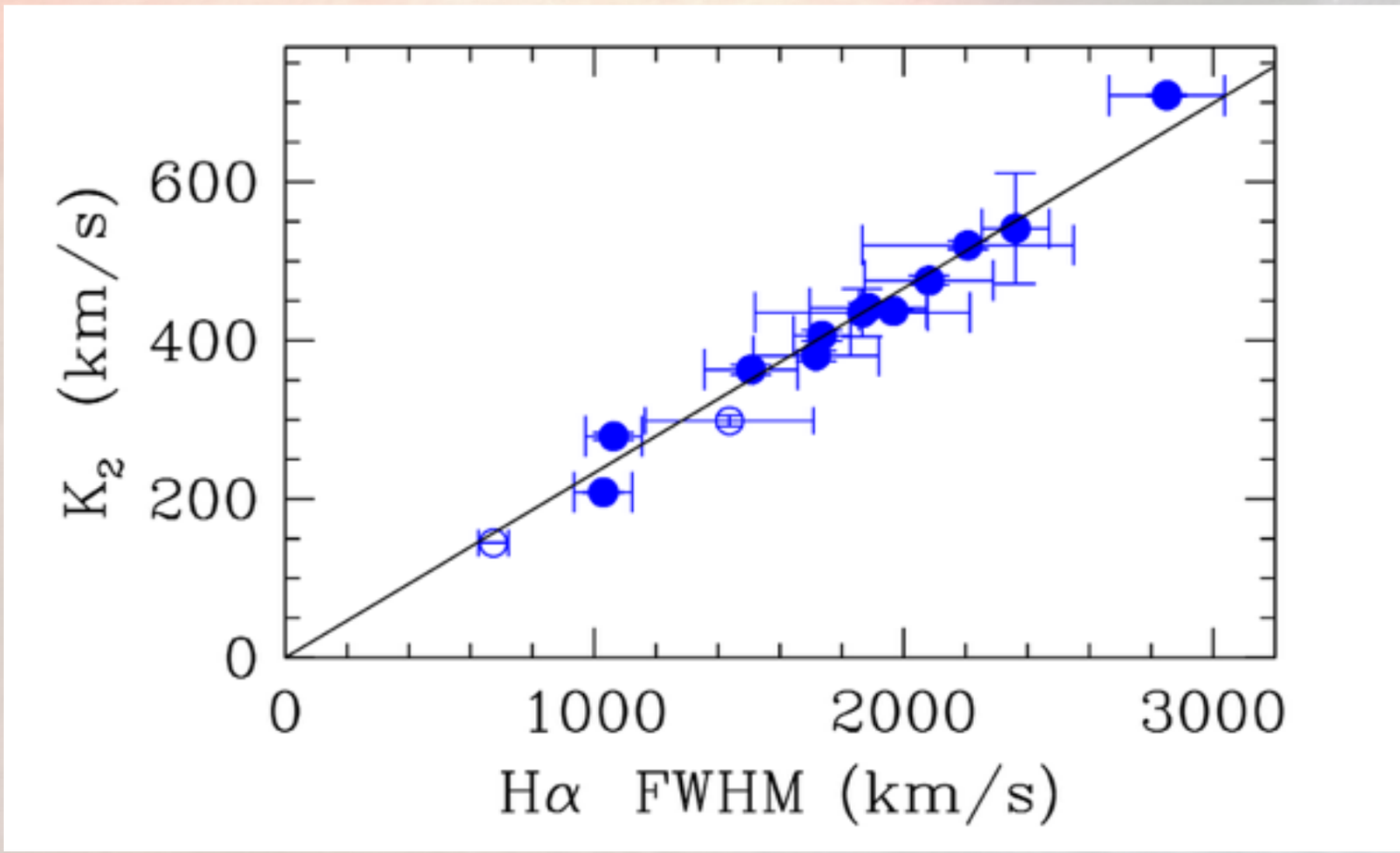
The loud quiescence of Swift J1357



Mata Sánchez, D. et al. (2015b)

The loud quiescence of Swift J1357

K2 - FWHM (Hα) correlation

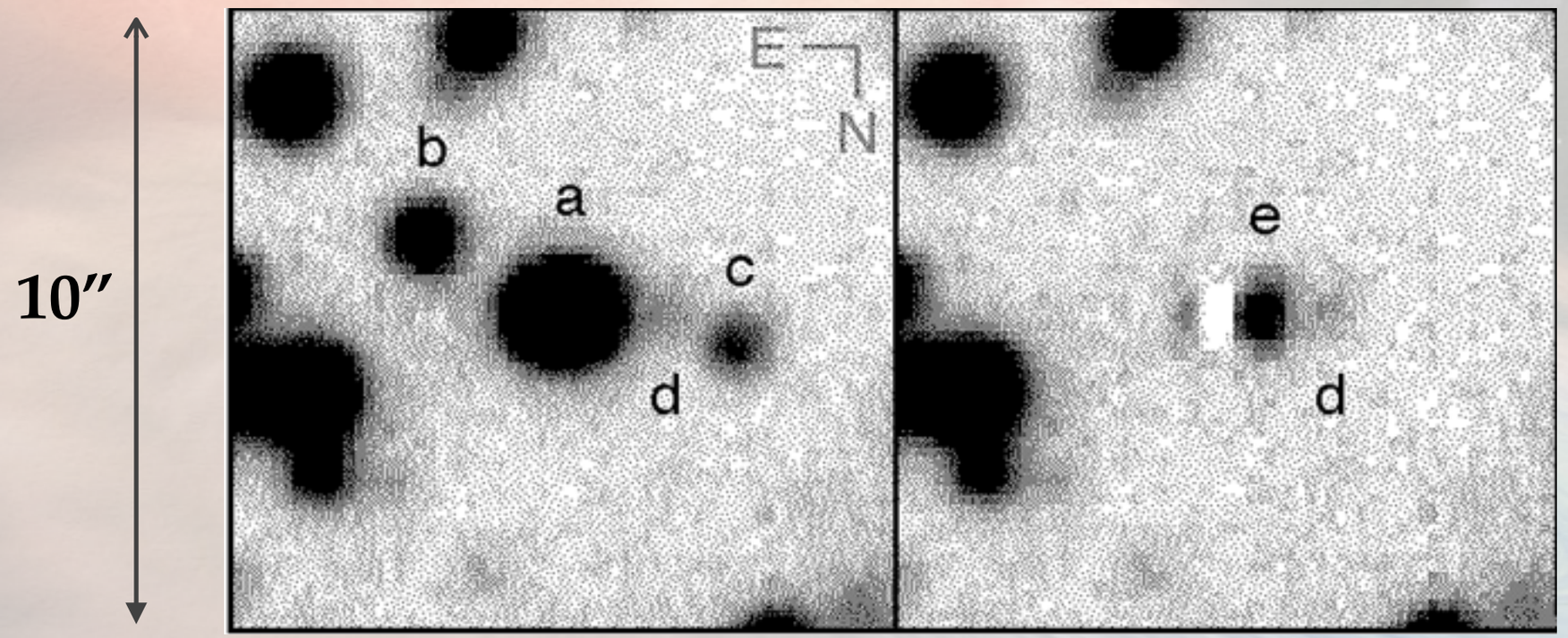


Casares, J. (2015)

Reveals a massive BH: $M_{BH} > 9.3\ M_{\odot}$ (Mata Sánchez et al. 2017a)

The crowded field of Aql X-1

Aquila X-1 finding chart field



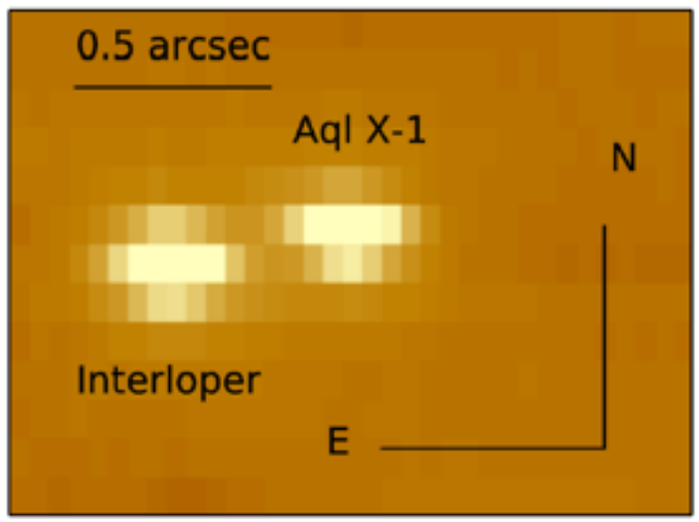
I-band

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

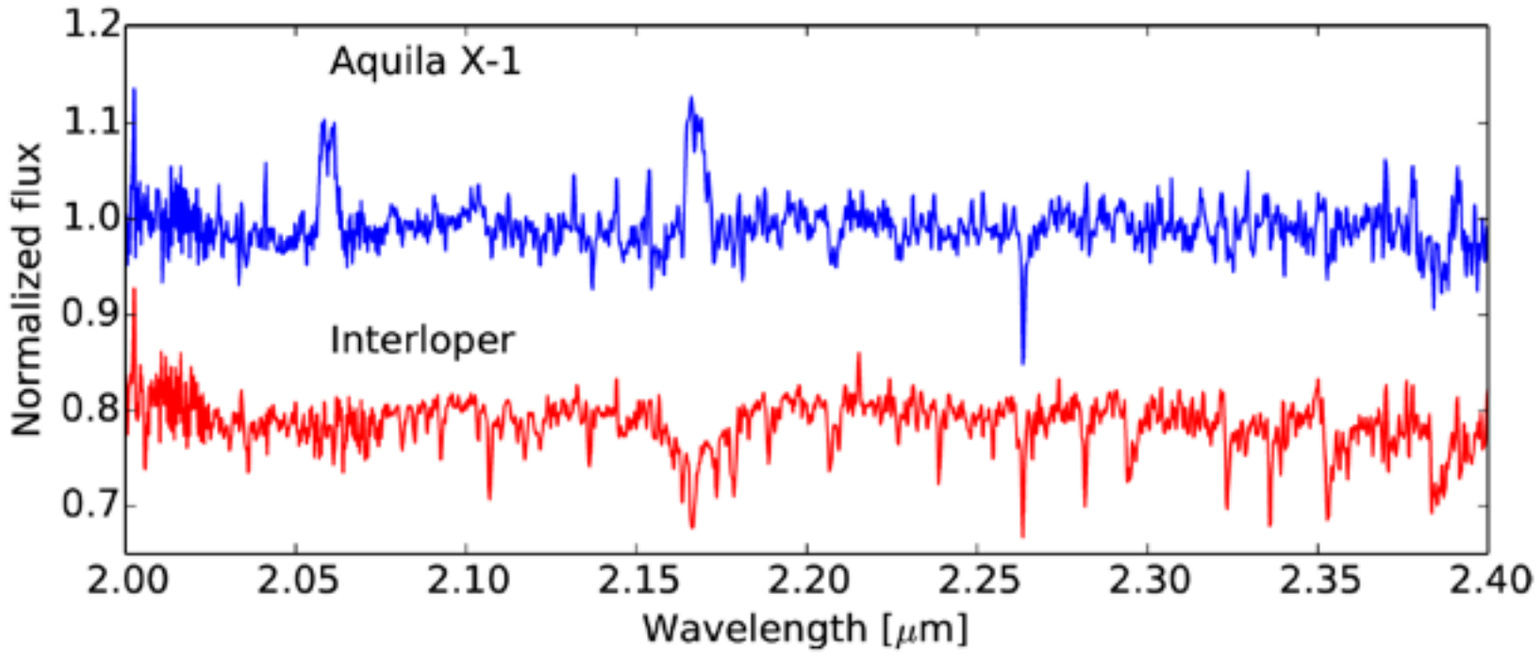
Chevalier et al. (1999)

The crowded field of Aql X-1

SINFONI (VLT) + Adaptive optics module



K-band

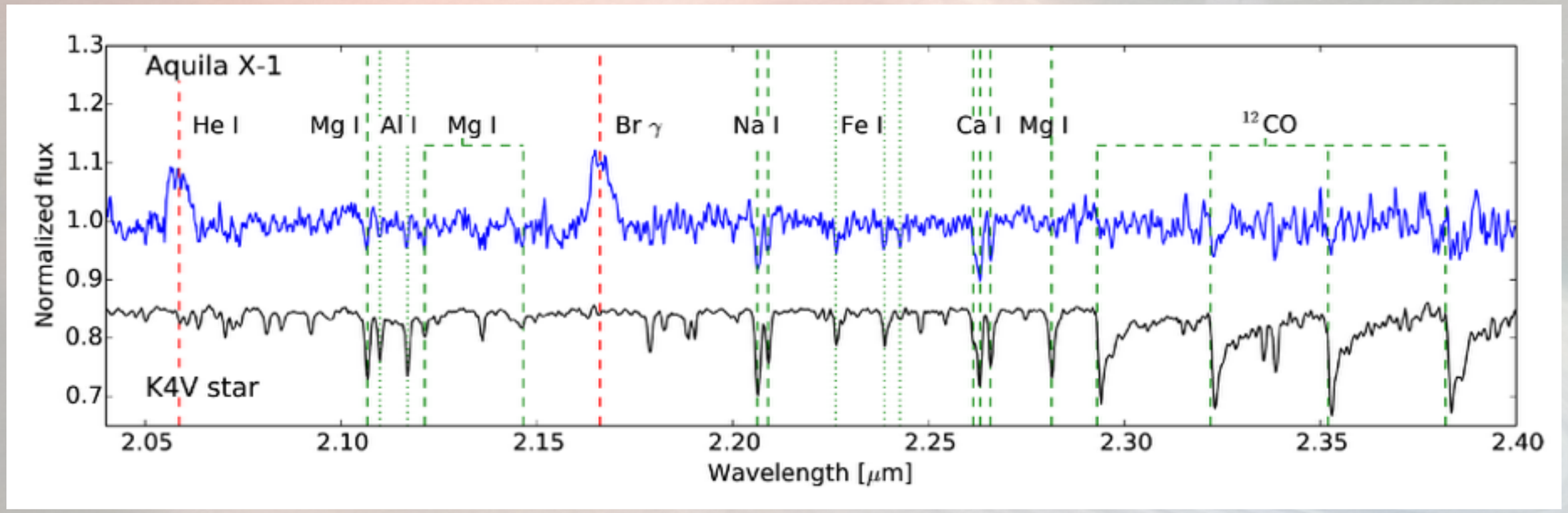


NIR spectroscopy on Aql X-1 for the first time

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

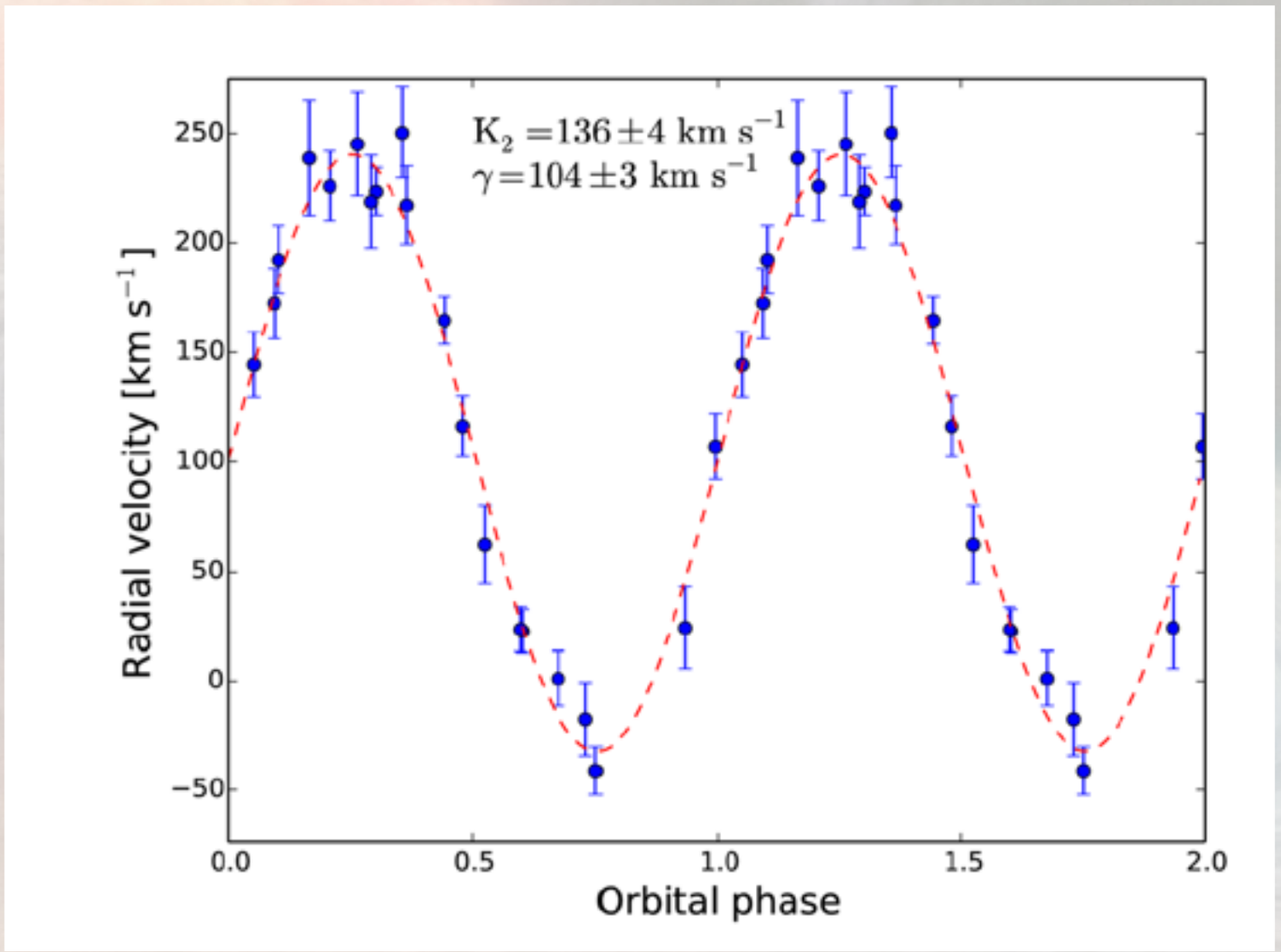
Fundamental parameters:

$f(M_1) = 0.21 \pm 0.02\ M_{sun}$

$K_2 = 136 \pm 4$ km/s

$36^o < i < 47^o$

$d = 6 \pm 2$ 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

PNS 2017 - St. Petersburg, Russia