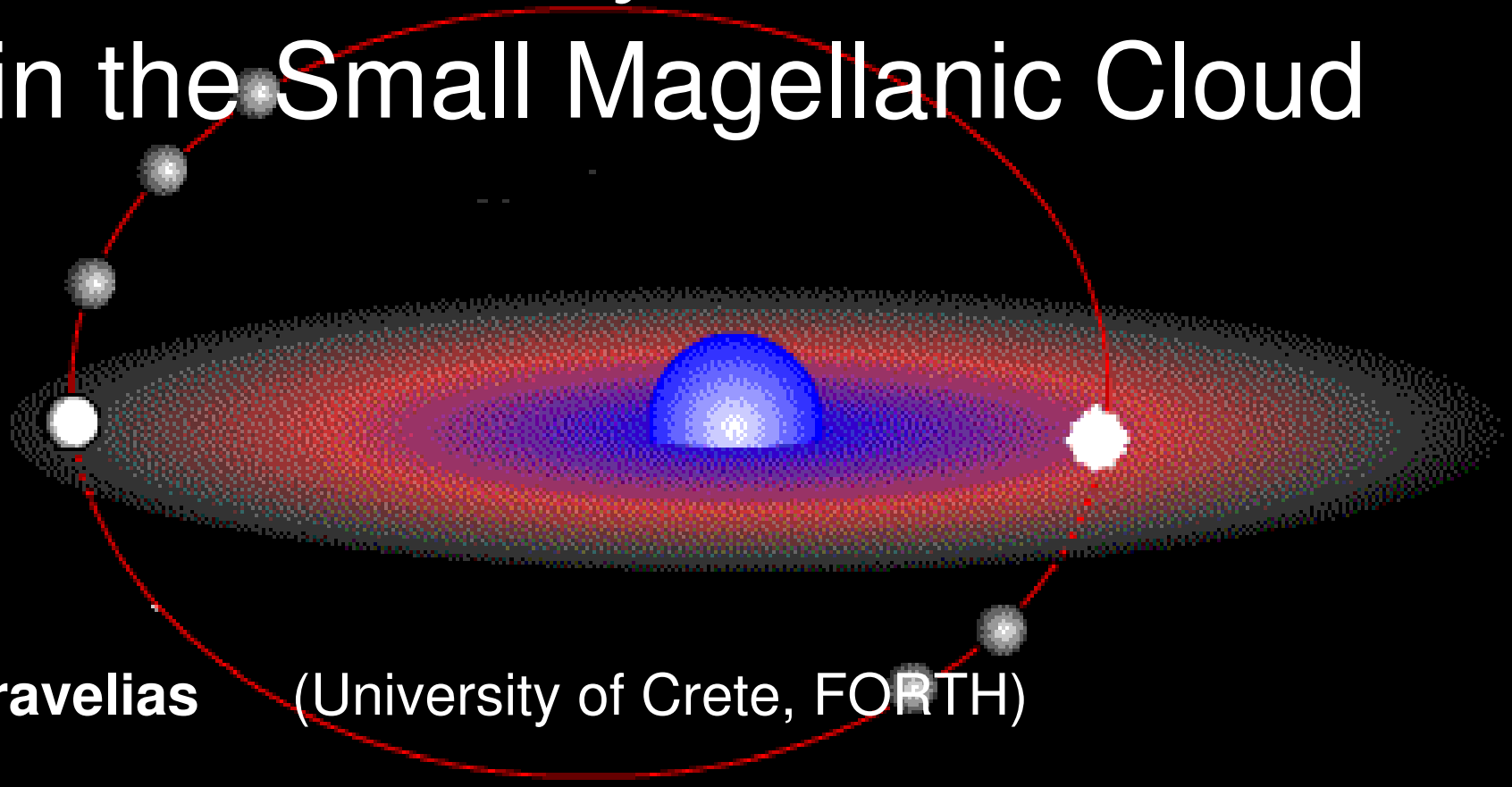
Optical spectroscopy of Be X-ray Binaries in the Small Magellanic Cloud



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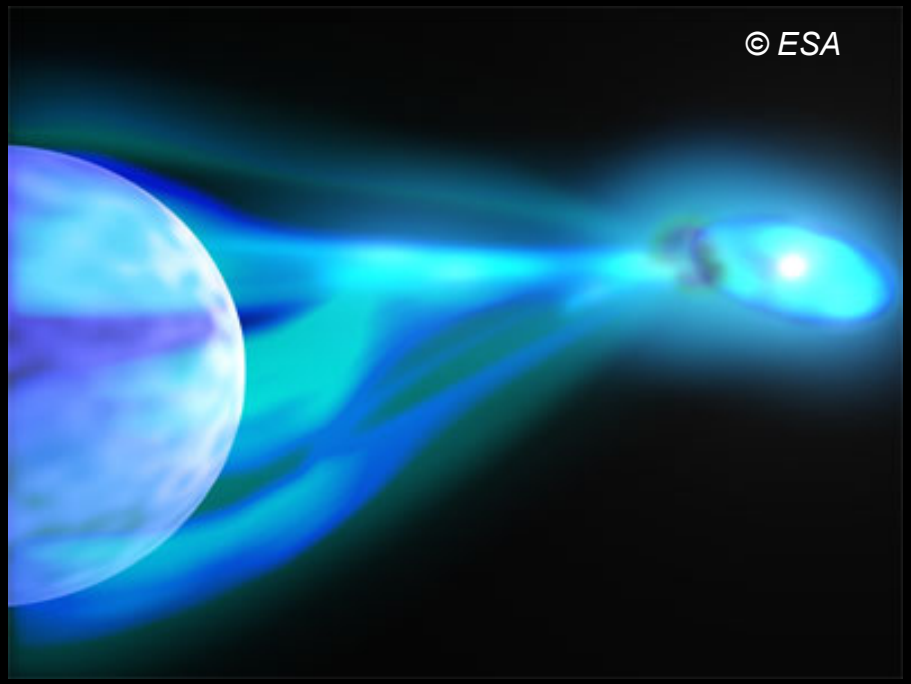
X-ray binaries



Compact Object
+
Stellar Companion

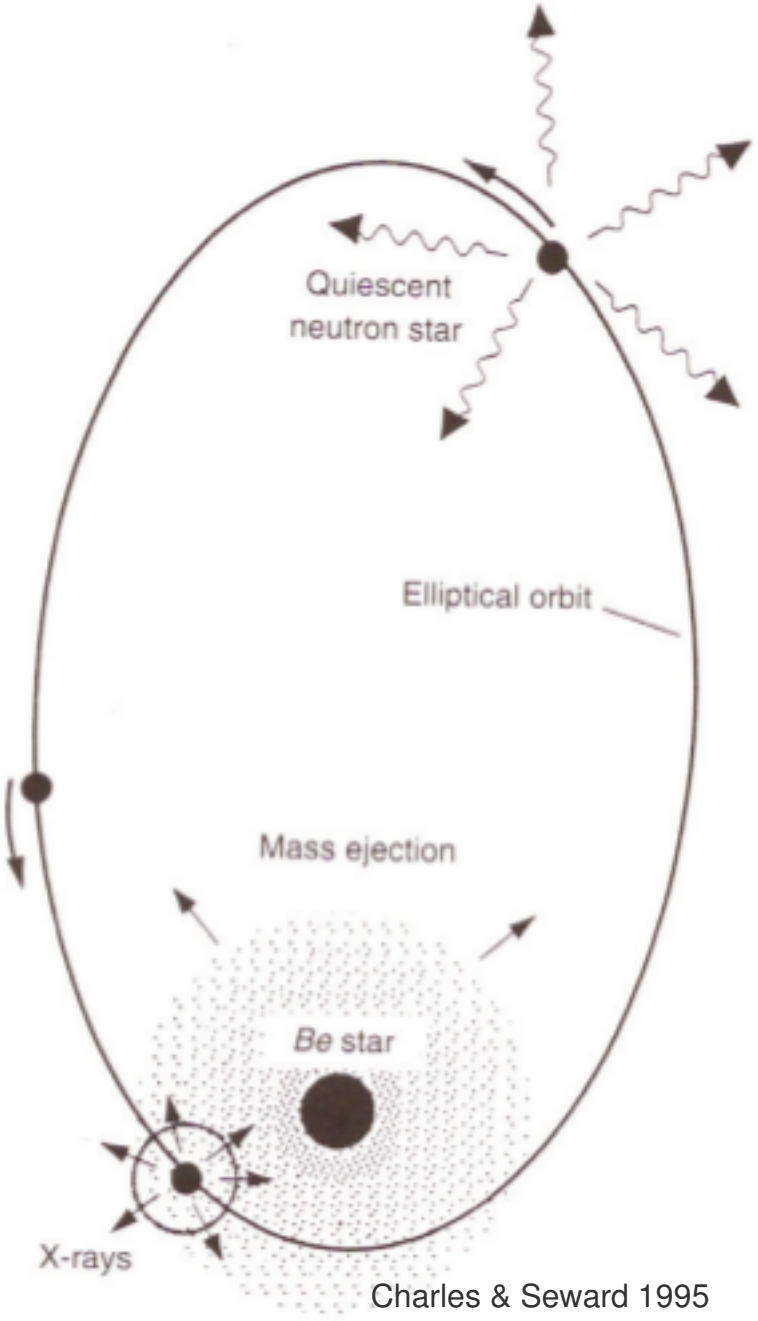
Low Mass X-ray Binaries
late type
M < 2 Mo

High Mass X-ray Binaries
early type OB
M > 8 Mo

Supergiant X-ray Binaries
Supergiant (I-II)

Be X-ray Binaries
Be star (V-III)

Be X-ray binaries - BeXRBs



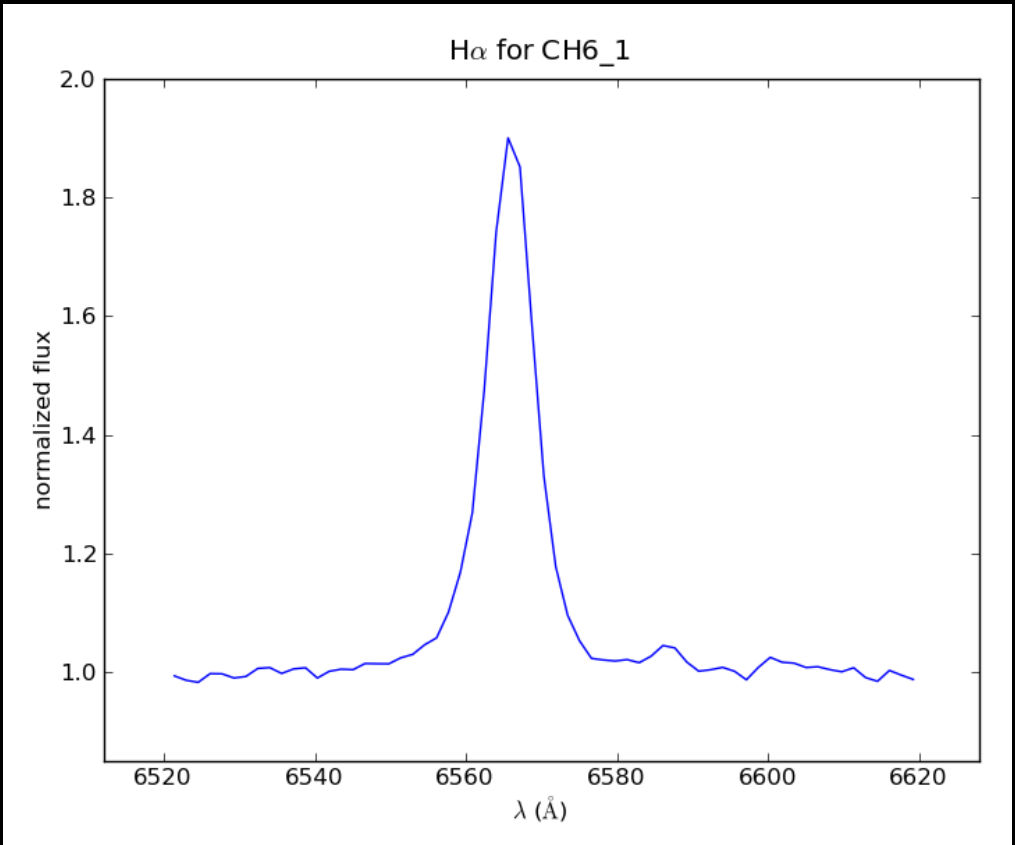
Charles & Seward 1995

- Neutron stars and matter under extreme conditions
- Be phenomenon and disk interaction with neutron star
- Binary & Stellar evolution
- Population links to star-formation history

The Small Magellanic Cloud laboratory

- Large number of BeXRBs (~80)
- Can detect sources down to Lx ~10^{33} erg s^{-1} (non outbursting)
- Well determined & uniform distance
- Relatively low intergalactic extinction
- Low line-of-sight depth of young, central stellar populations
- Relatively uniform metallicity
- Well-determined star formation history

Need for optical spectroscopy



SMC case *:

> Suspected and confirmed BeXRBs ~ 80

> Spectroscopically confirmed and classified ~ 50
(for Lx > 10^{34} erg s^{-1})

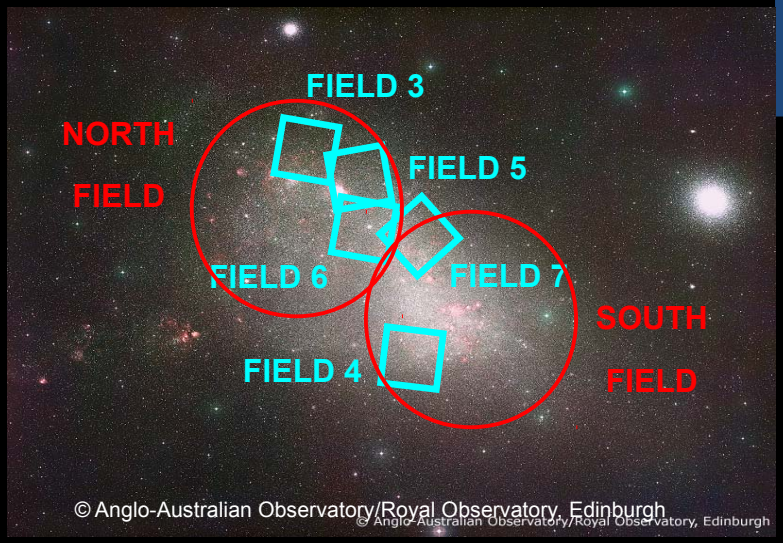
Optical spectroscopy provides:

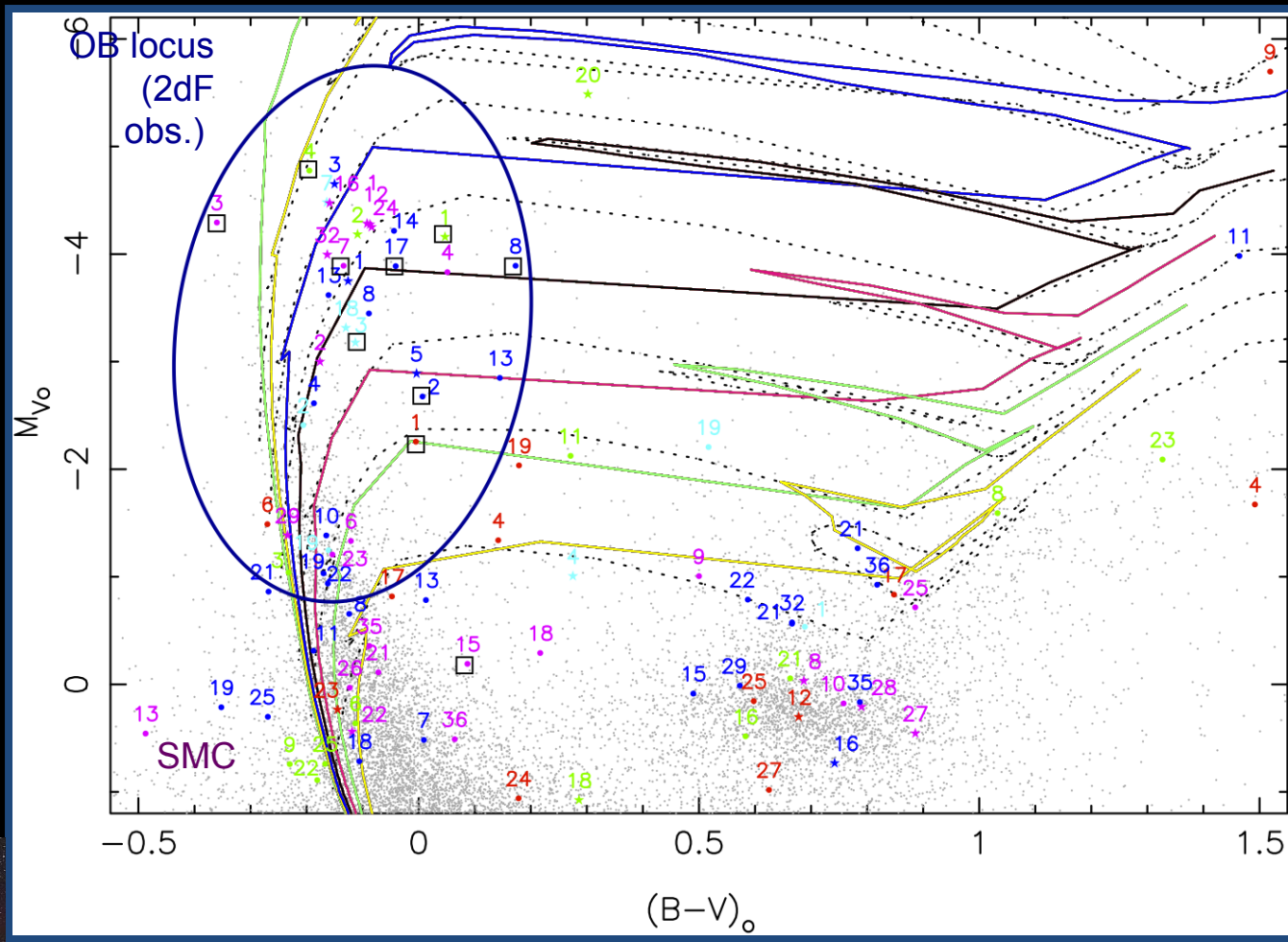
- ✔ Proof of the real optical counterpart
- ✔ Provide information on the properties of the system

*http://xray.sai.msu.ru/~raguzova/BeXcat/

Approaching method & Sample

- Chandra X-ray sources ($L_X \sim 4 \times 10^{33}$ erg s^{-1}) with suggested optical counterparts (Antoniou et al. 2009)
- XMM-Newton sources detected but without optical counterparts/classification (Haberl & Pietsch 2004)



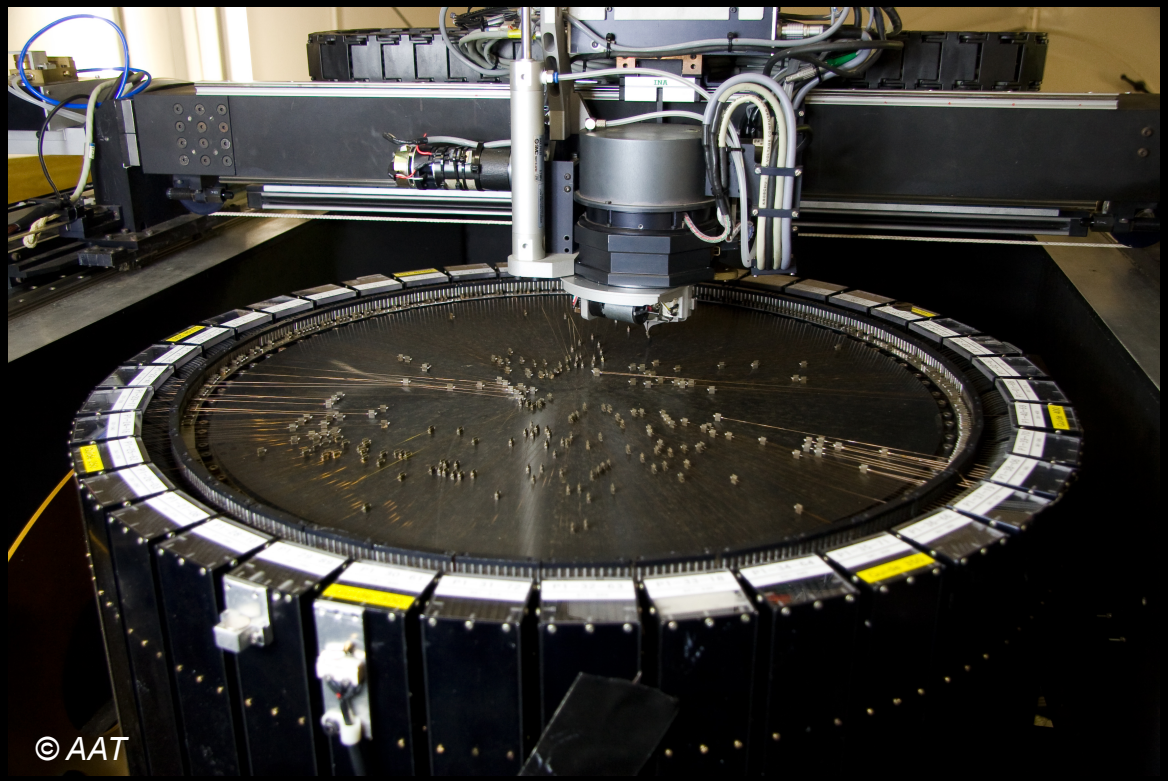


Selection of most probable OB optical counterparts

Observed sources:

133 Chandra & 145 XMM-Newton

Observations & data reduction



Optical spectroscopy using AAOmega multi-object (400 fibers), double-arm spectrograph at 3.9m Anglo-Australian Telescope

During service time (2008):
2 nights, 6.4h total exposure time,
resolution ~3.8 Å @ blue
~1.9 Å @ red

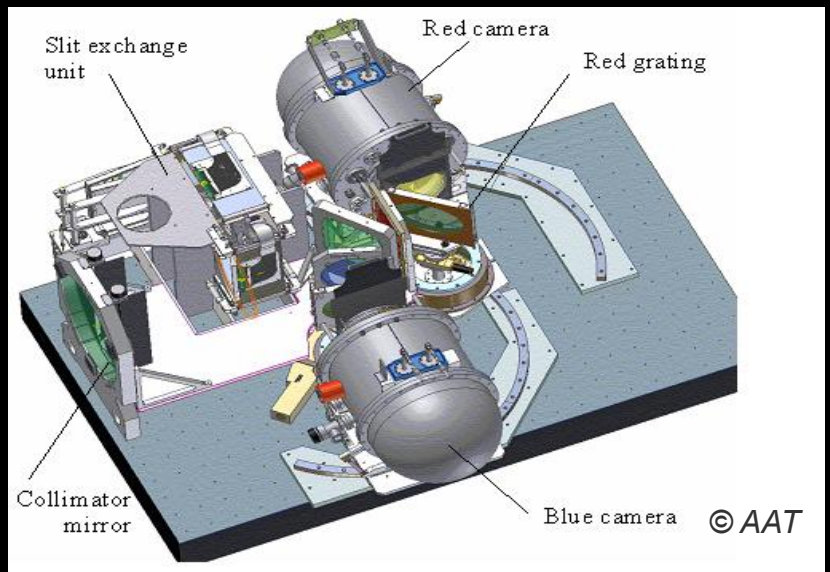


Figure 1. Physical layout of AAOmega, layout, showing the red camera in high dispersion mode, and blue camera in low dispersion mode.

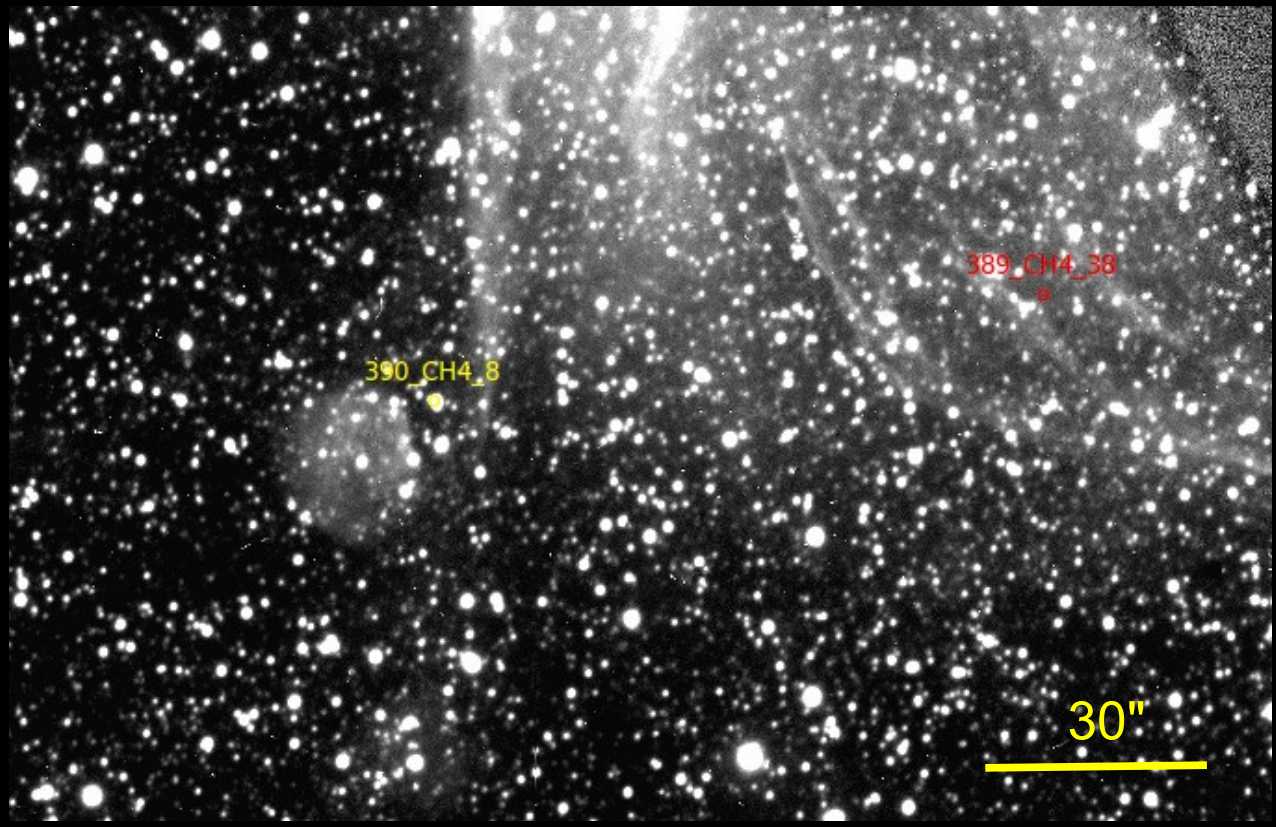
Data Reduction:

> 2dfdr v4 tool
> Starlink's Figaro & Dipso

Selection criteria for BeXRBs

$SNR_{objects} > 20$, $SNR_{sky} > 15$

Not trivial sky subtraction
- > dedicated sky fibers (away from target sources)
- > presence of SN remnants
  - optical examination (free from sources)
  - FWHM(Hα)= 2.01±0.08 Å
  - [SII]/Hα <0.4 (SN remnants case)

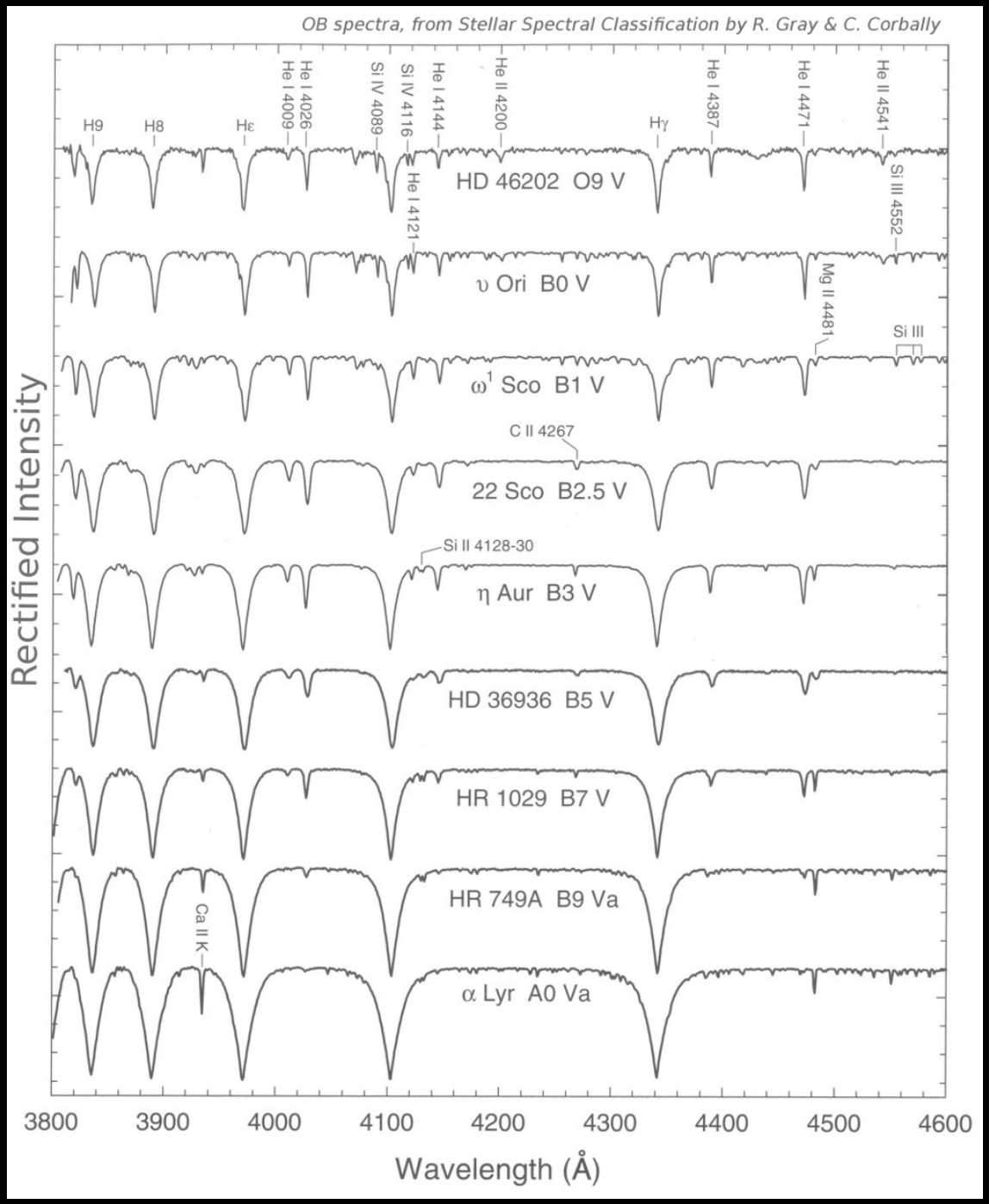


Criteria for BeXRBs candidates

- broad Hα emission determined as: $FWHM(H\alpha_{object}) > FWHM(H\alpha_{sky})+3\sigma$
- [SII]/Hα(object) < [SII]/Hα(sky)
- correct counterpart within fiber (from OCLEII + MAGELLAN data)

Results: 20 spectra from 18 different sources

Classification criteria



SMC: low metallicity
Using mainly

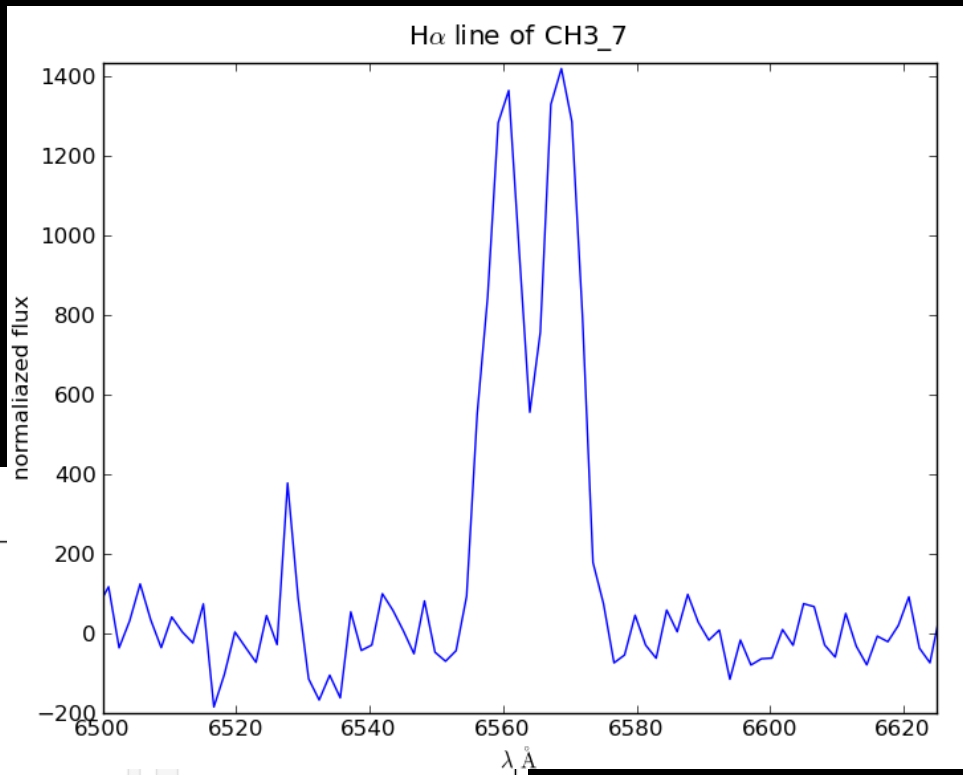
- He II λλ4200, 4541, 4686
- He I λ4471
- Mg II λ4481
- Si III λ4553

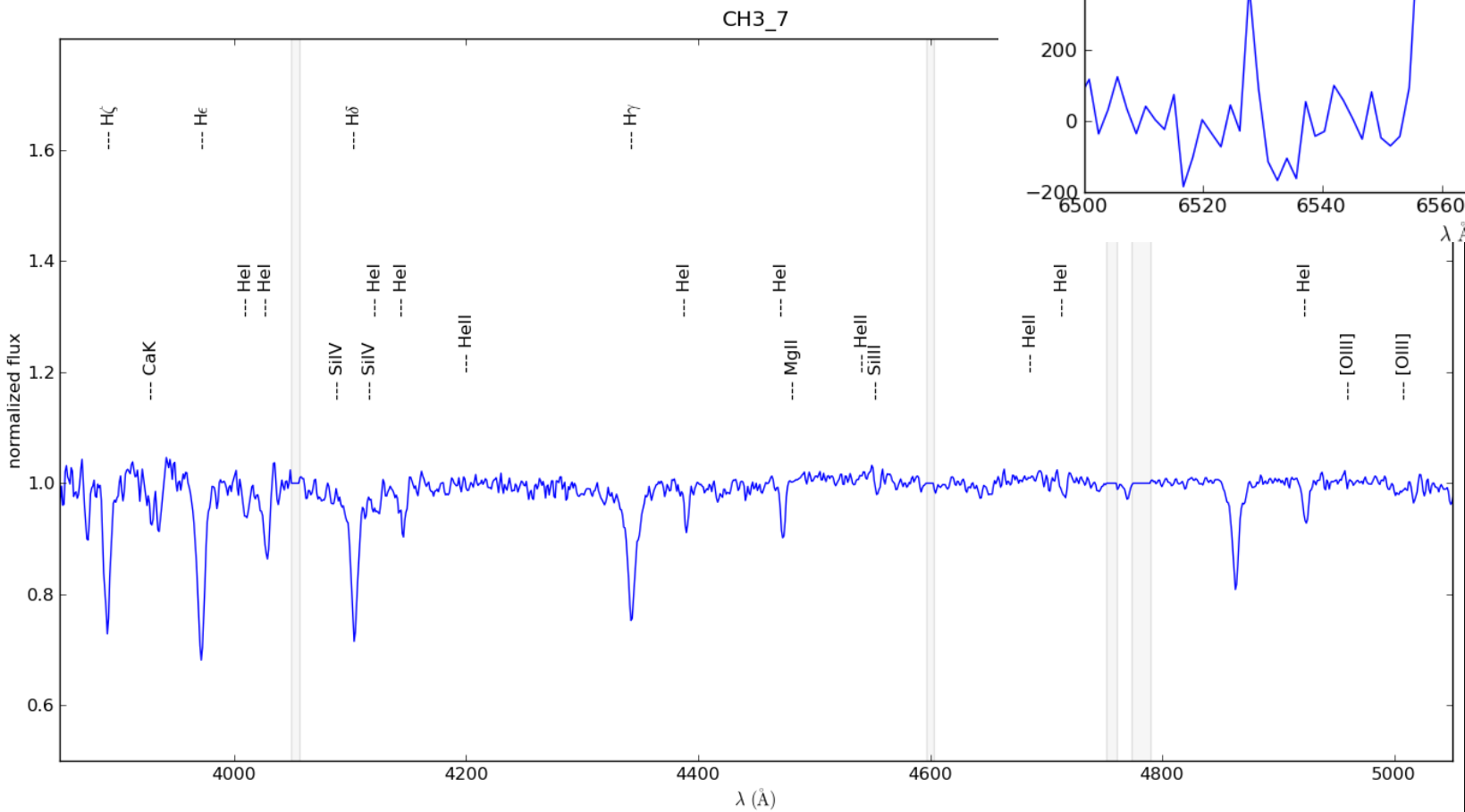
(Antoniou et al. 2009,
Evans et al. 2004)

Results: a new B2e XRB

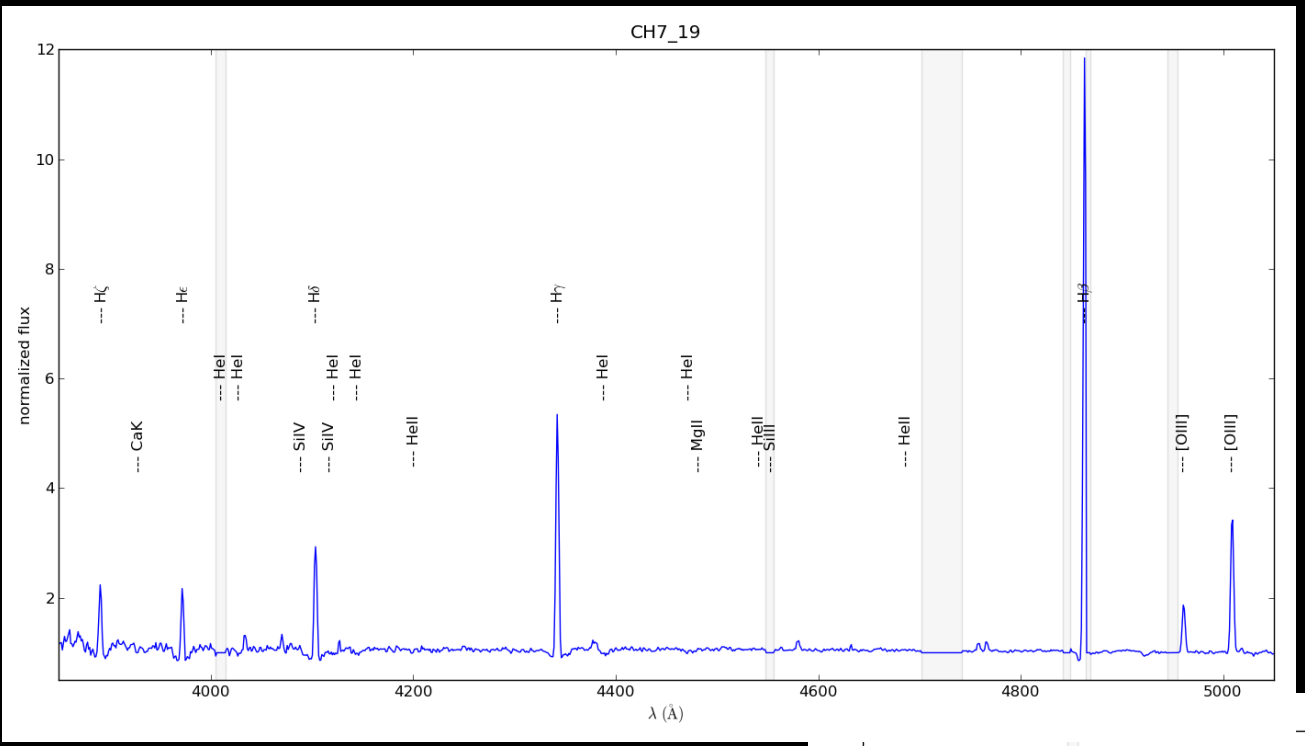
CH3_7:

Classified as B2e

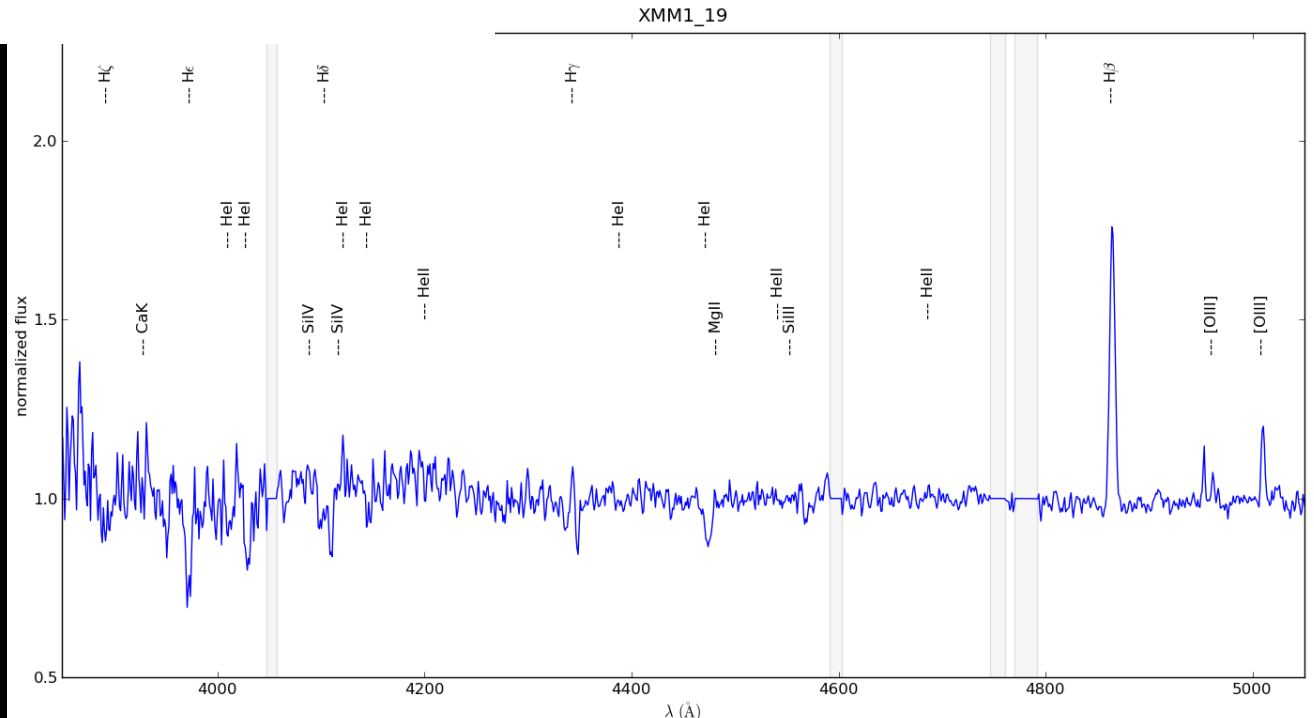




Results: 2 new confirmed BeXRBs



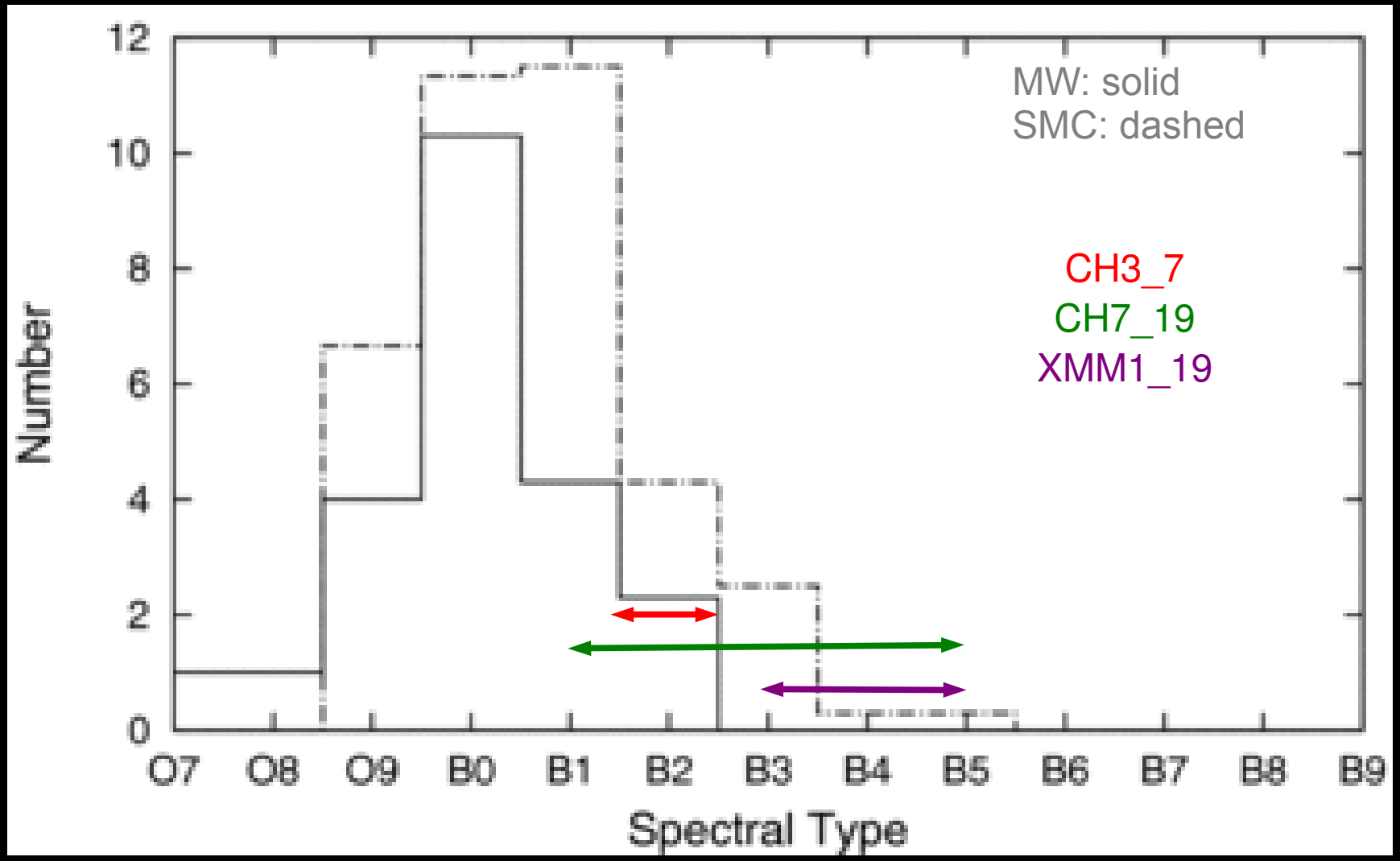
<< ***CH7_19: Classified as B1-B5 e***



>> ***XMM1_19: Classified as B3-B5 e***

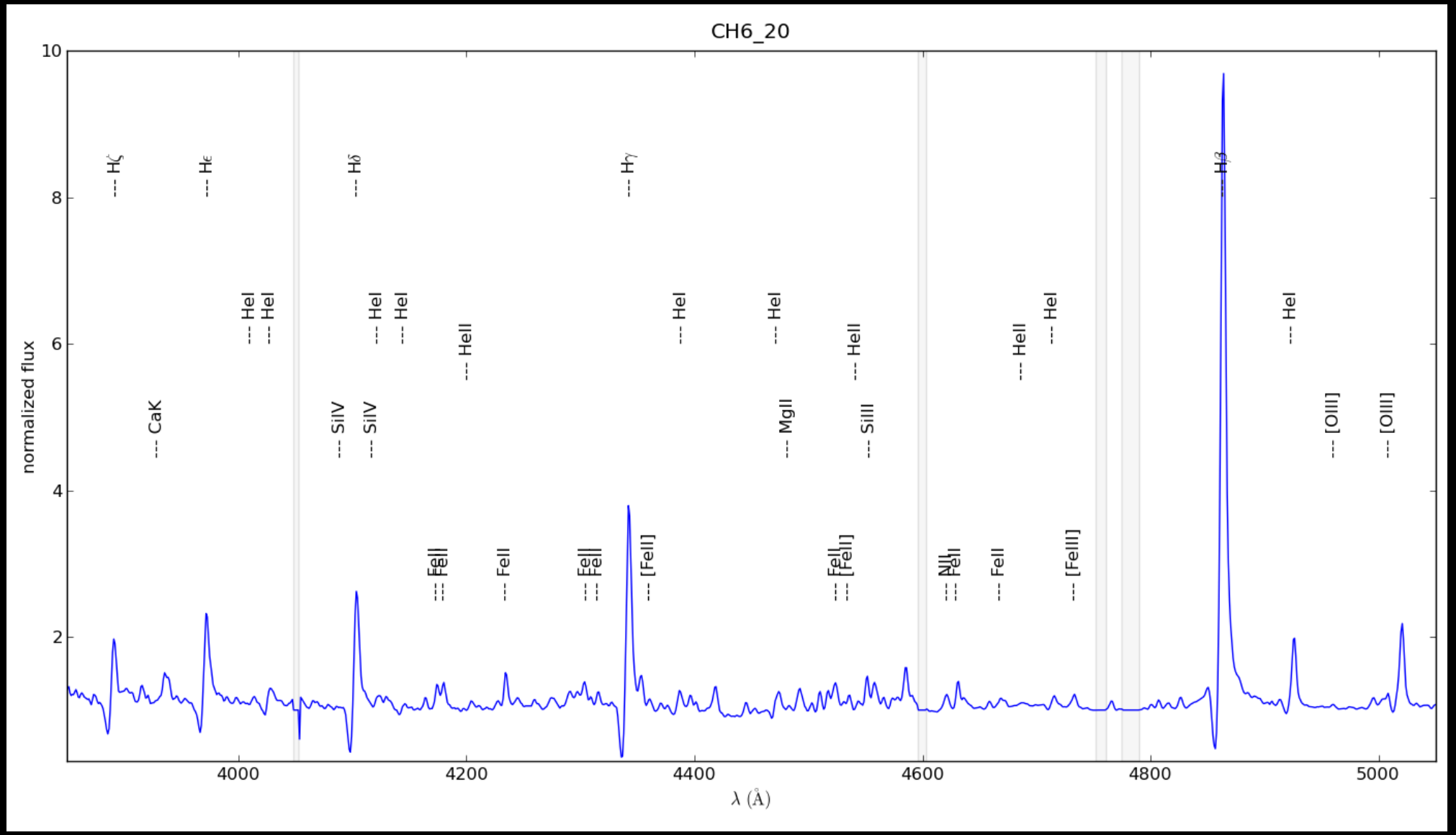
Results: spectral distribution

McBride et al. 2008



Spectra ranges consistent with distribution of BeXRBs

Results: the SG XRB



CH6_20: classified as sgB[e]

Well known star (Antoniou et al. 2009, Massey & Duffy 2001) but not as an X-ray source

2nd SG XRB in SMC !!!
wind-fed system

Summary

Results

- ✔ Identification method is working !
- ✔ 18 sources identified
- ✔ 4 new confirmed BeXRBs ($L_X \leq 10^{34}$ erg s^{-1})
- ✔ 1 new SGXRB in SMC / first wind-fed system identified
- ✔ Spectra ranges consistent with distribution of BeXRBs

Future work

- Complete classification of SMC sources
- Extend to LMC
- Measure periods and orbital parameters
- Complete characterization of systems

References

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Charles & Seward 1995, Exploring the X-Ray Universe, Cambridge University Press, c1995, ISBN 0521261821

Evans et al. 2004, MNRAS, 353, 601

Haberl & Pietsch 2004, A&A, 414, 667

Massey & Duffy 2001, ApJ, 550, 713

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