Mapping Accretion In Intermediate Mass Stars

University of Dundee

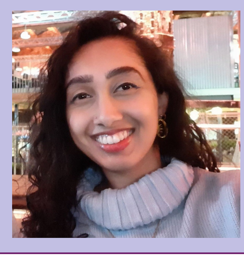
SUPA

Ruhee Kahar, Aurora Sicilia-Aguilar, Justyn Campbell-White

2475089@dundee.ac.uk

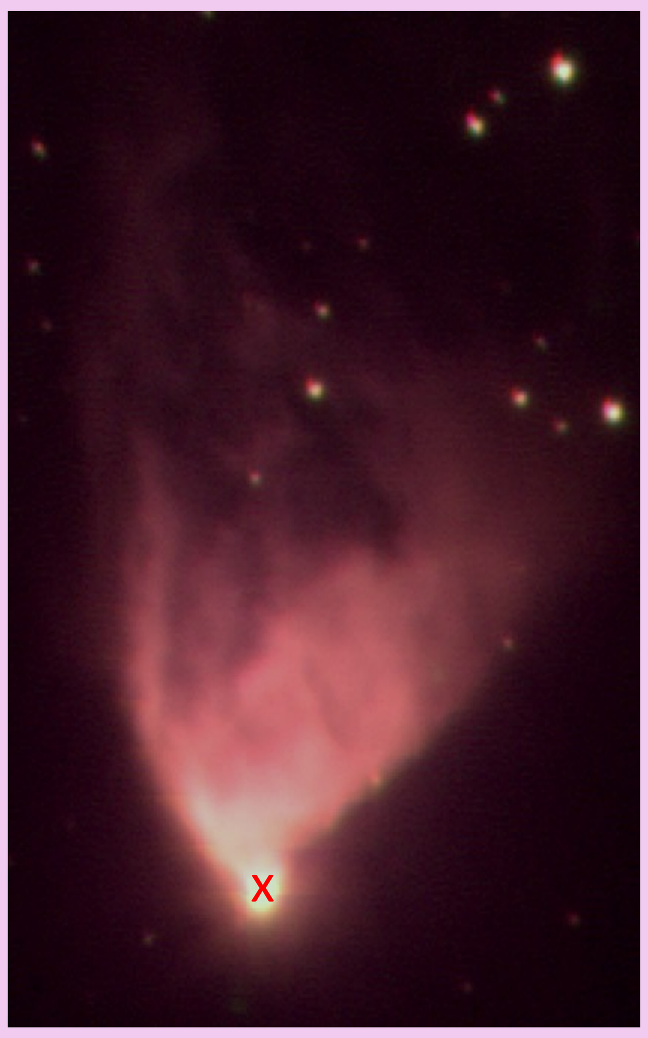
Science and Technology Facilities Council

STAR MELT

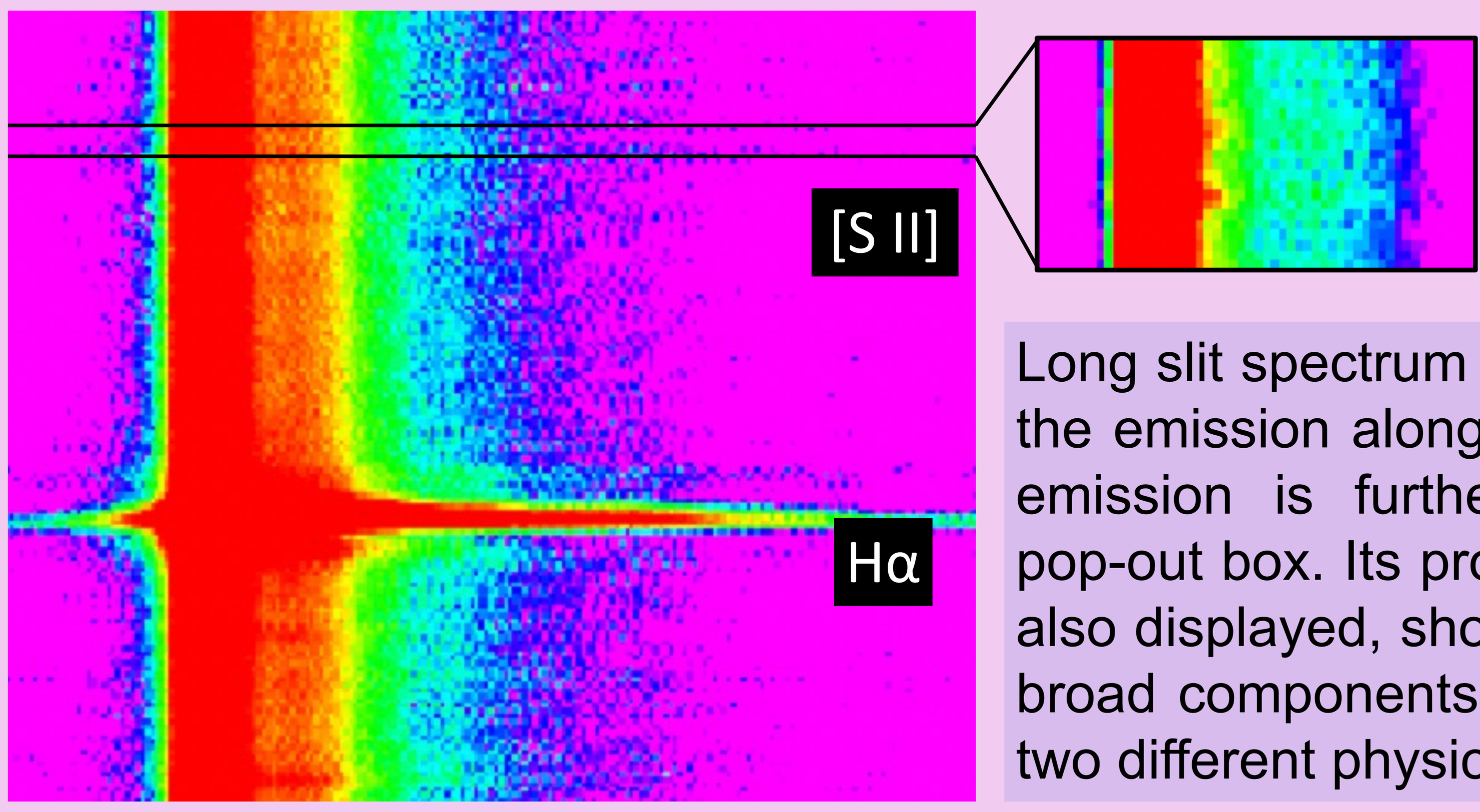


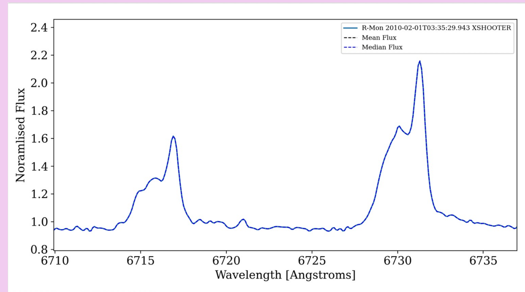
ABSTRACT

In earlier type Herbig Ae/Be stars the accretion mechanisms are not yet well understood because their magnetic fields are too weak to sustain magnetospheric accretion. These are the first steps in my study of time variability of accretion-related lines in young intermediate-mass stars, using the STAR-MELT code, combined with long- and short-cadence spectroscopic data. The targets chosen for study are promising sources as they have well-known protoplanetary discs, and evidence of extinction by circumstellar material. Emission and absorption lines with broad and narrow components, including metallic ones, are detected in these stars in a similar way to what is found in their lower-mass counterparts, and the STAR-MELT Python code assists in quantifying any variability found. By measuring the variability in velocity and relative intensity for different lines we aim to trace the structure of accretion columns and distinguish between different accretion mechanisms as they evolve over time.



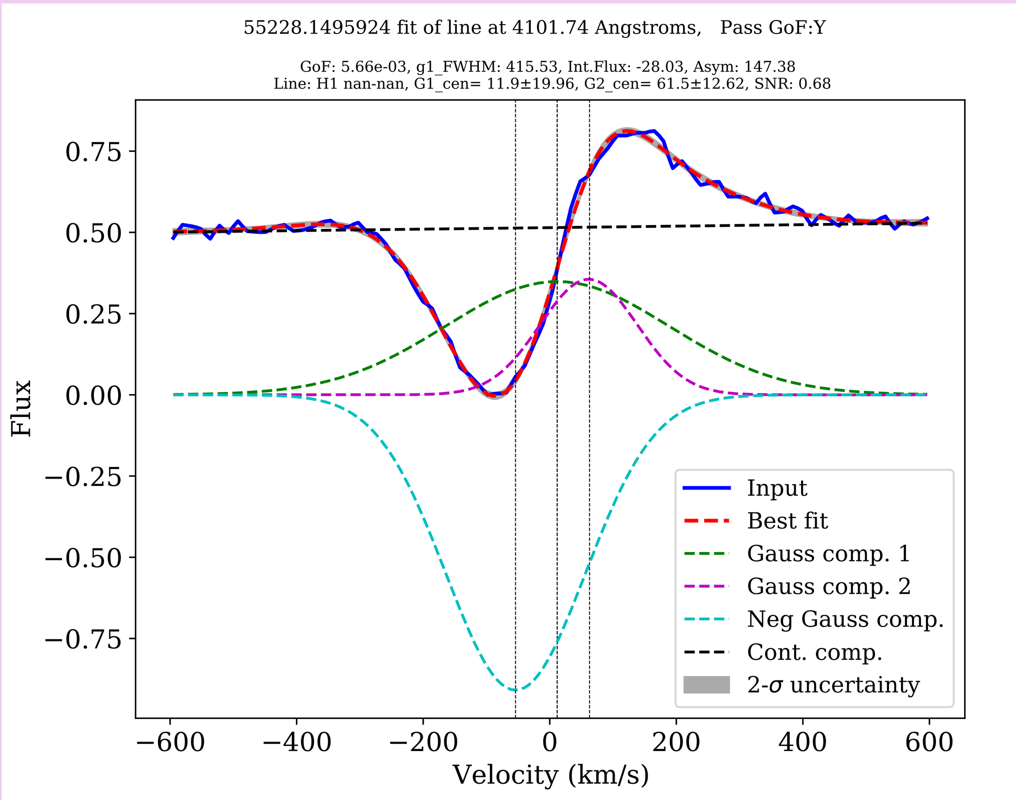
R MON: A young intermediate mass Herbig Ae/Be star, illuminating the reflection nebula NGC2261, Hubble's variable nebula; as seen here with CAFOS filters [S II], red and visible (where north is up). The nebula acts as a giant screen allowing us to see other angles towards the star. The variability is due to the shadows cast over the nebula by circumstellar material (Lightfoot, 1989). R Mon has a systemic velocity of 1.3 km/s (Sandell+, 2020) and is located at ~800 pc (Jiménez-Donaire+, 2017) (the red x marks its location).



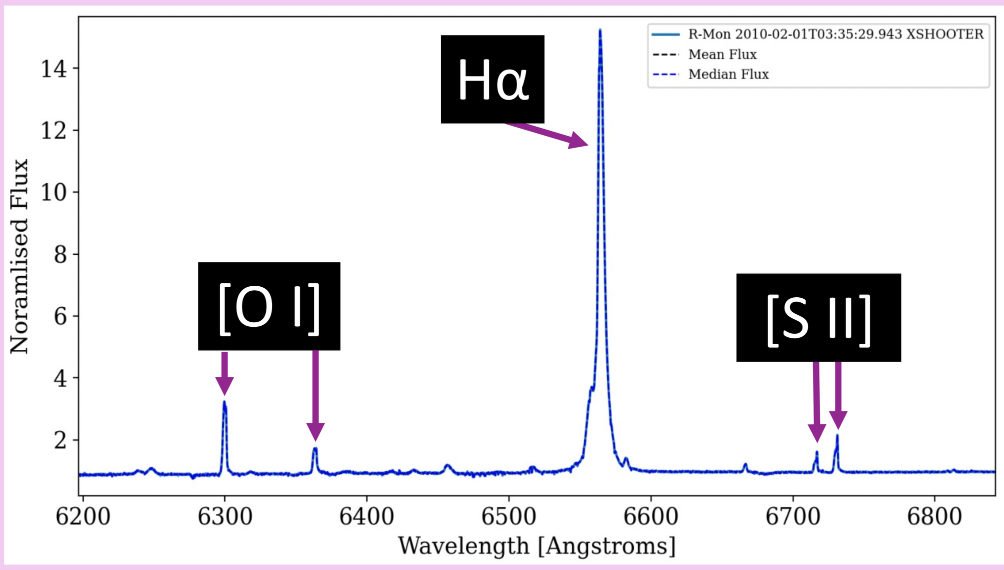


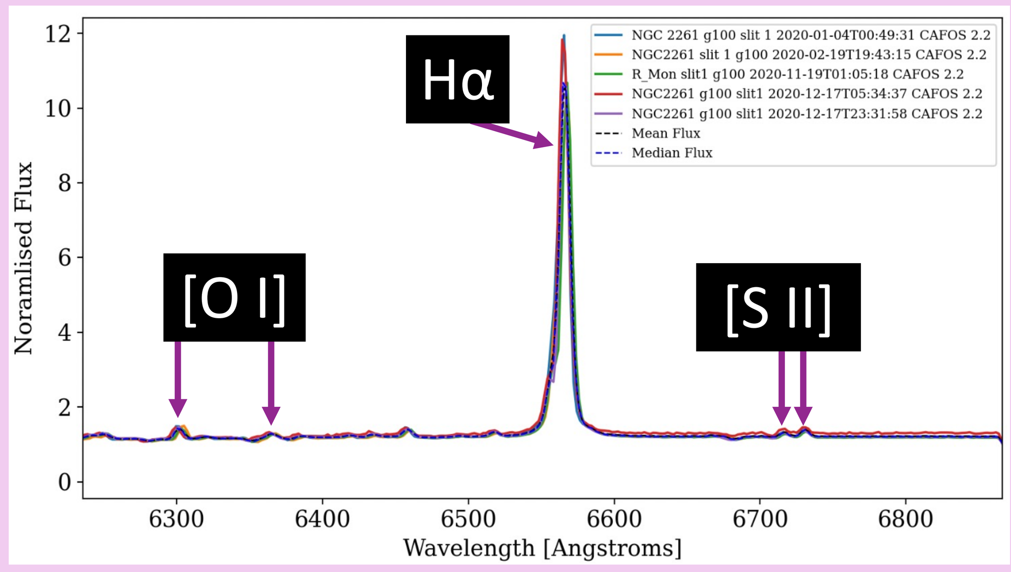
Long slit spectrum from CAFOS showing the emission along the nebula, the [S II] emission is further highlighted in the pop-out box. Its profile from X-Shooter is also displayed, showing both narrow and broad components that are coming from two different physical locations.

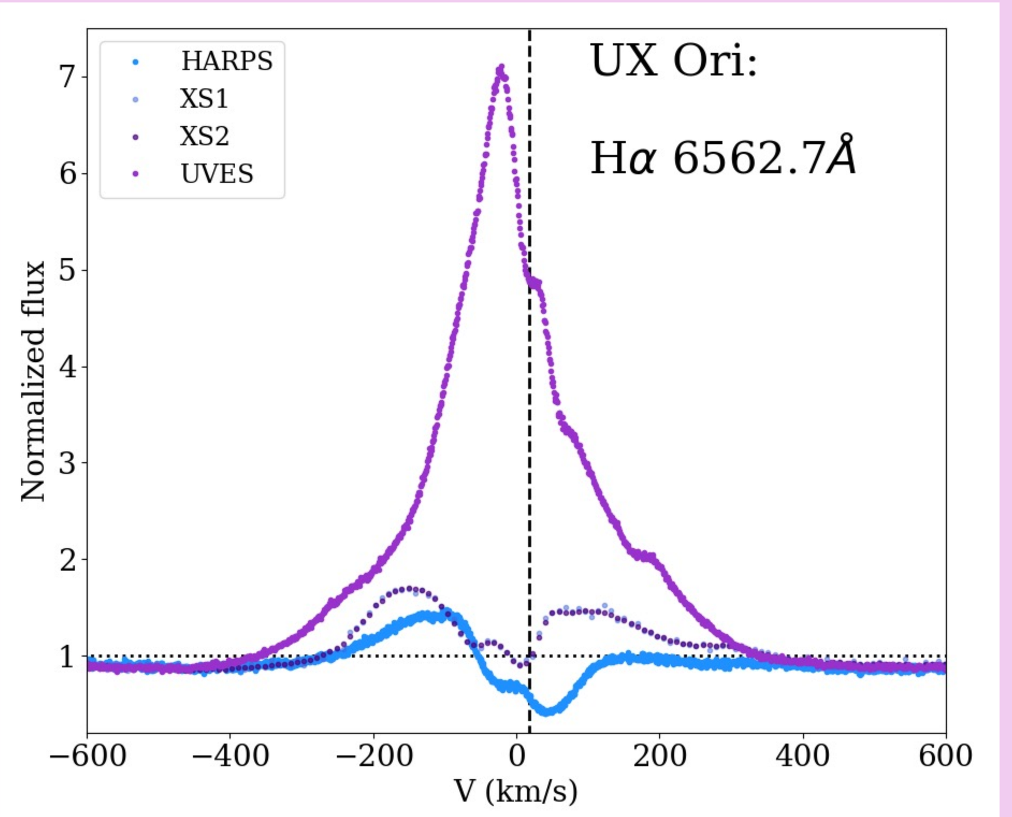
A Balmer Hydrogen emission line found with X-Shooter and displayed using the STAR-MELT code. Fit with two gaussians and a negative gaussian. The absorption seen in the line is likely due to wind absorption.



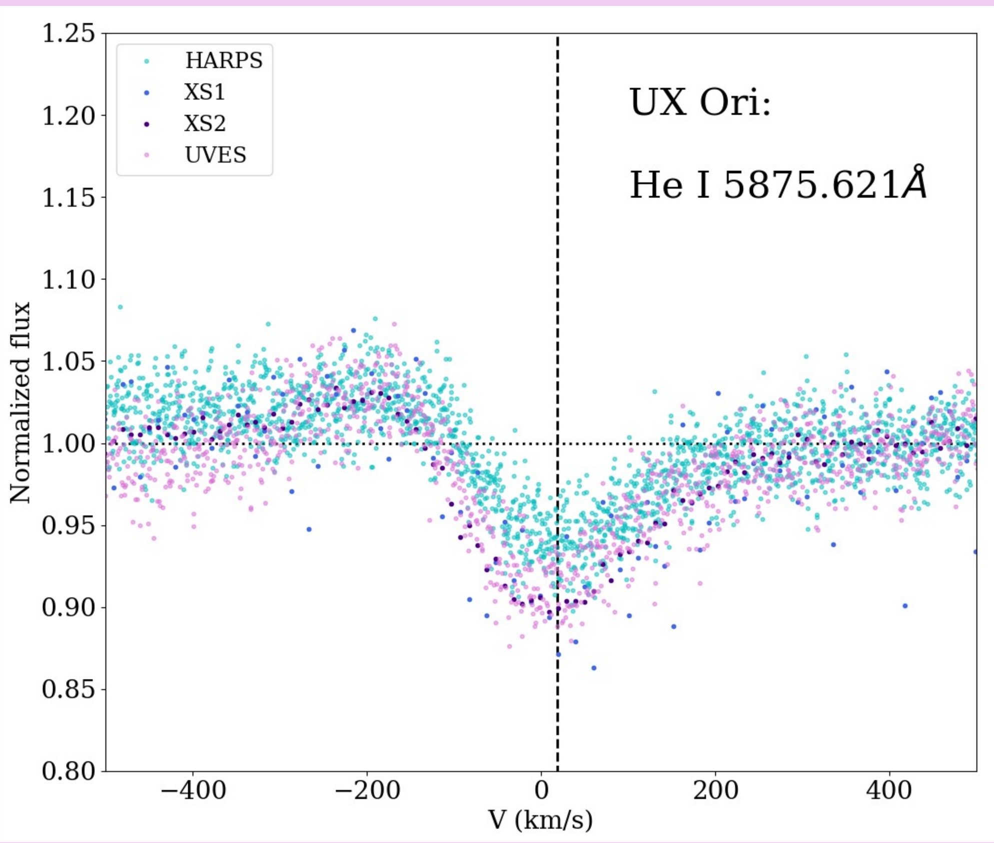
Below is a section of the X-Shooter spectra (left) and CAFOS spectra (right). The X-Shooter slit extracted data on the star, whereas the CAFOS data is taken with a long slit and was extracted along the nebula through R Mon. Therefore more nebula emission is seen with CAFOS and we can study the properties of this extended emission with spectroastrometry. The nebula reflects what happens in the star which helps to get details of features that would otherwise be invisible.



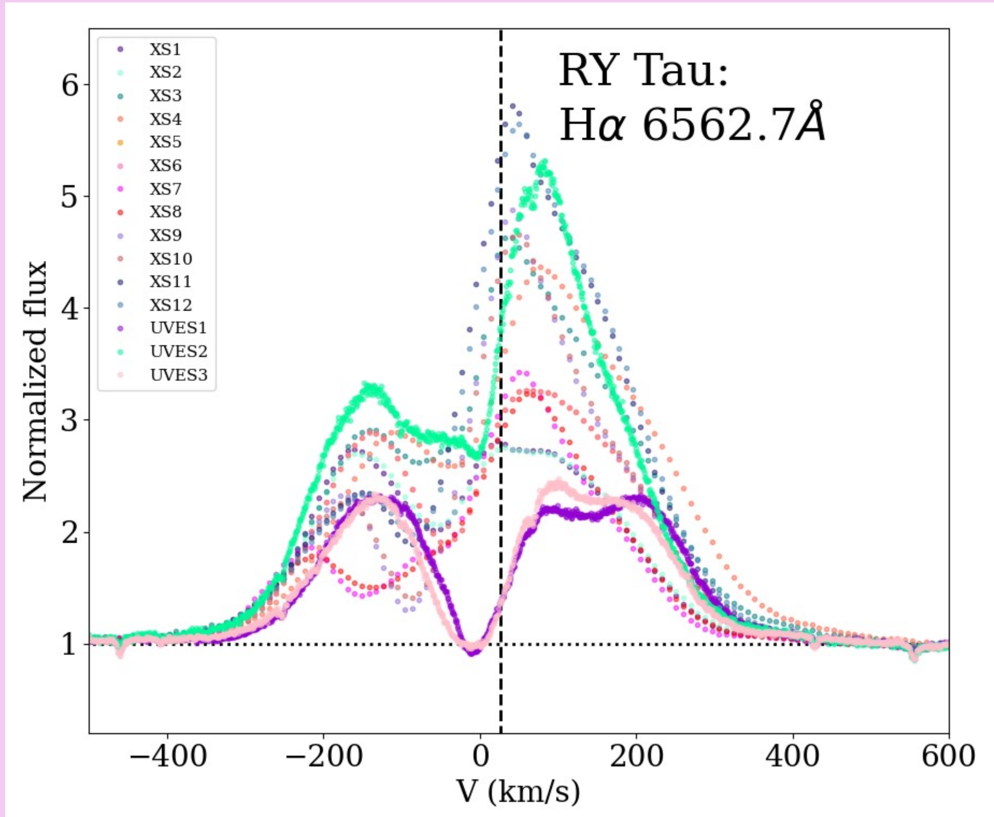




UX ORI: A Herbig Ae/Be star, spectral type A3, located at ~430 pc (Natta+, 1999) It has complex spectrometric and photometric variability that has been interpreted as coming from a circumstellar disc (Grinin+, 1991).

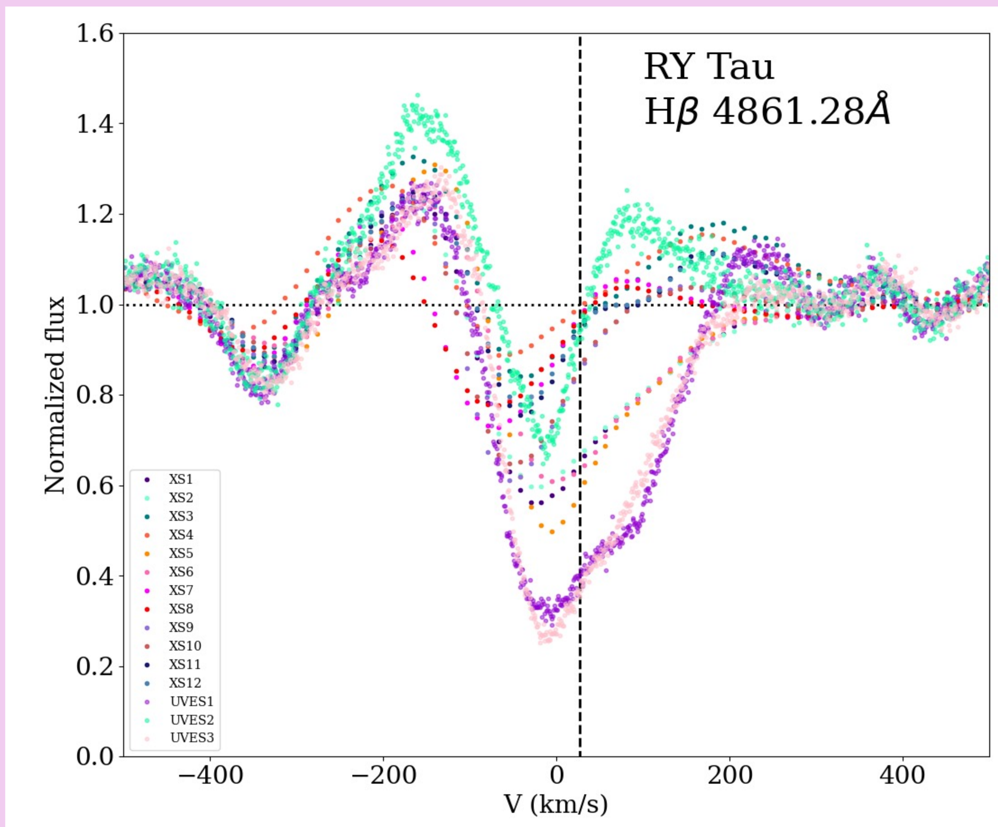


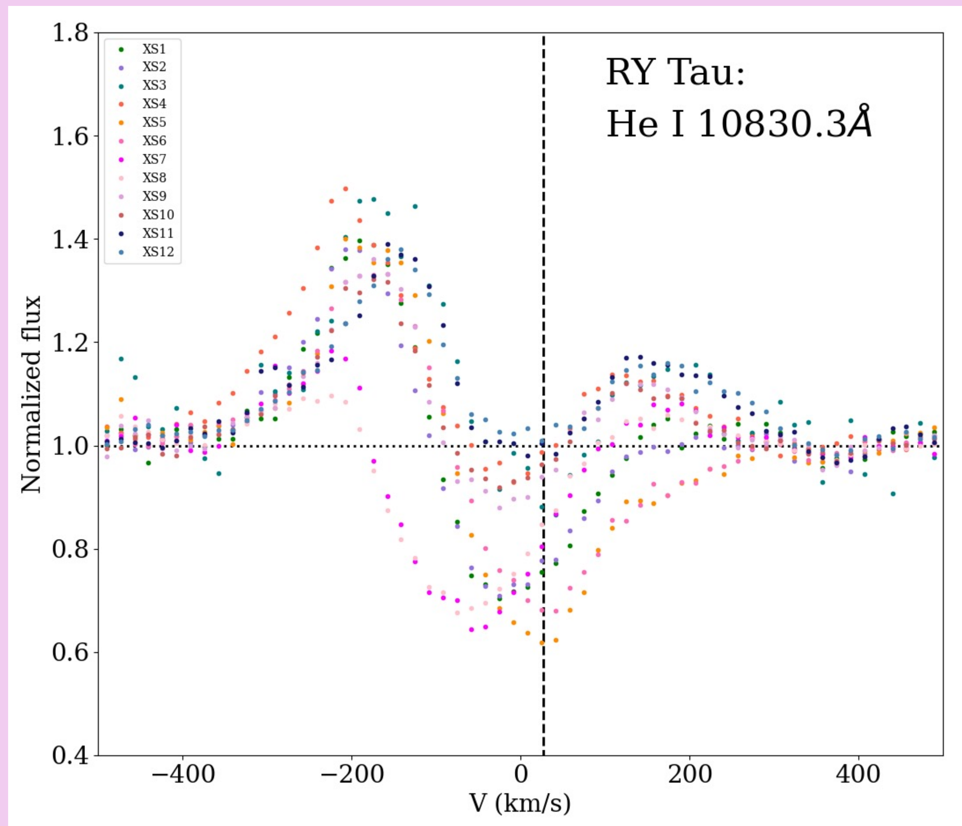
The line profiles of both the Hα and the He I 5875Å show red shifted absorption components which is a sign of infalling material along the line-of-sight.



RY TAU: A bright massive T-Tauri star, with an uncertain spectral type between G and K, located at 140 pc, and has irregular variability (Brooks et al. 2001).

The line profiles show highly variable blue and red-shifted components (see figures) related to variable accretion and winds.





FUTURE WORK

Our plan is to continue to analyse time-resolved spectroscopy (both our own and archived) from different high-resolution optical spectroscopes (X-Shooter, UVES, HARPS, and HIRES) of several stars, including HAeBe and massive T Tauri stars, that will evolve into A and B stars. Next semester we are expecting new CARMENES high resolution data. The time-resolved spectra will allow us to transform velocity variability into spatial scales, and using the STAR-MELT Python package will allow us to efficiently and accurately extract a large number of emission lines over the variety of targets in the observations. This data can then be used to explore the 3-D structure of accretion columns and is also a promising way to unveil the planet-disc connection and the inner structure of protoplanetary discs. We will compare our findings to lower-mass stars.

References: Sandell et al. (2020) ApJ, 889:2 pp. 9 --- Jiménez-Donaire et al. (2017) A&A, 605. pp.12 --- Lightfoot (1989) MNRAS, 239, pp. 665-675 --- Natta et al. (1999) A&A, 350 pp. 541-552 --- Grinin et al. (1991) Ap&SS, 186:2 pp. 283-298 --- Brooks et al. (2001) MNRAS, 327:1 pp. 177-190