X-Shooter monitoring of the accretion rate in Herbig Ae/Be stars

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OVERVIEW

AIMS : To understand whether the accretion paradigm accepted for classical T Tauri (TT) stars can be extended to their massive counterparts, the Herbig Ae/Be (HAeBe) stars. To analyse if the spectroscopic accretion tracers commonly used for TT stars are also reliable to estimate accretion rates in HAeBe stars. Understanding these topics is crucial for future demographic surveys aiming to study the role of planet formation in dissipating disks around *all* types of pre-main sequence stars that are capable to form planets. See [1] and references therein for a more detailed theoretical background.

SAMPLE AND OBSERVATIONS (see panel 1): We are analysing X-Shooter/VLT spectra of 14 prototypical, isolated HAeBe and intermediate-mass TT stars monitored during five epochs separated by timescales ranging from days to months.

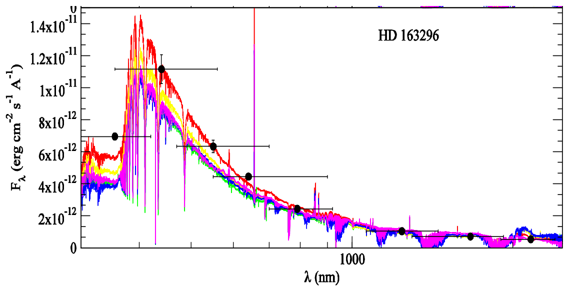
METHODOLOGY (see panel 2): We are deriving accretion rates from the excess in the Balmer region of the spectrum, using magnetospheric accretion and boundary layer models. These direct estimates of accretion are being compared to secondary ones, obtained from the luminosity of several emission lines that span from the UV to the near-IR, and are commonly used as accretion tracers in TT stars.

PRELIMINARY RESULTS (see panel 3): All 70 X-Shooter spectra of the 14 stars in the sample have been reduced. Two prototypical HAe stars, HD 31648 and HD 163296, have been analysed in detail (paper submitted to ApJ), providing further evidence that magnetospheric accretion can be succesfully applied to these stars. The accretion rates derived are the typical for the HAes (~ 10^{-7} $M_{\odot}$/yr). Moreover, all UV-optical-near infrared spectroscopic lines valid for TTs provide accretion rates for the HAe stars with similar accuracy. The HBe objects in the sample are being analysed. Their variability seems to be comparatively lower and the one with the earliest spectral type, HD 85567, presents such a strong Balmer excess that cannot be reproduced from magnetospheric accretion.

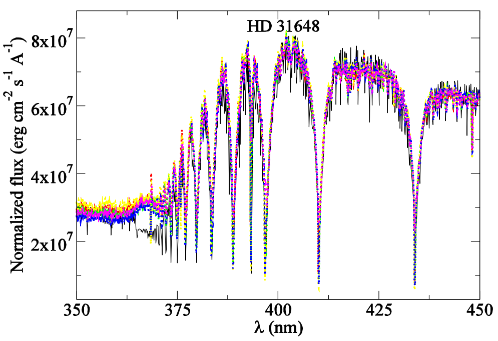
1. SAMPLE & OBSERVATIONS

Star	Spt	Star	Spt	Star	Spt
HD 85567	B2	HD 97048	A0	CQ Tau	F5
HD 114981	B5	HD 163296	A1	RY Ori	F6
LkHa 220	B8	BF Ori	A2	NV Ori	F6
HD 38120	B9	HD 34282	A3	RY Tau	F8
HD 101412	B9	HD 31648	A5	...	...

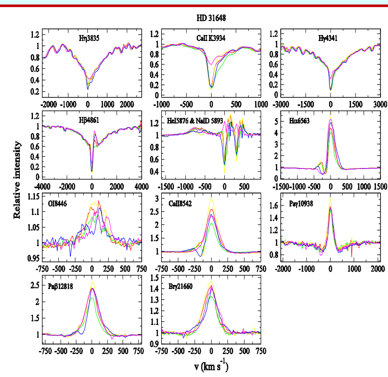
The sampe is constituted by a representative selection of five HBe, five HAe and four intermediate-mass TT stars (see table). Each object has been observed five times, on a timescale covering from days to months, with the X-Shooter spectrograph mounted on the VLT ([2]). This instrument allows simultaneous coverage from the UV to the near- IR (311-2475 nm) at mid-resolution (R ~ 5000). This simultaneity is crucial when dealing with variable stars. The figure on the right shows five flux-calibrated X-Shooter spectra of HD 163296. Broadband photometric data extracted from the literature are overplotted for comparison with solid circles, the horizontal bars indicating the passbands of the photometric filters.



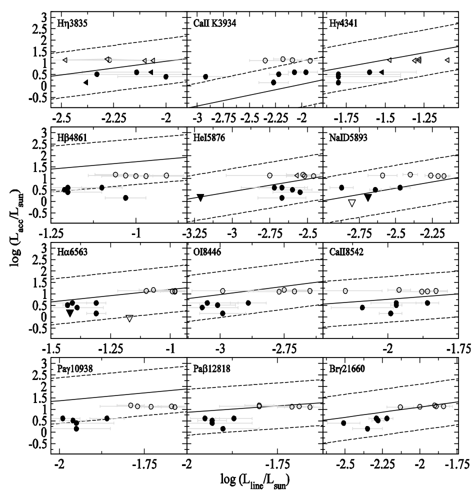
2. METHODOLOGY



The figure on the left shows five UV X-Shooter spectra of HD 31648, normalized to the corresponding Kurucz photospheric template (black solid line). A flux excess is apparent at the Balmer region (350—370 nm). The Balmer excess and its variations can be modelled, providing a direct estimate of accretion and its variability - the mean mass accretion rate for HD 31648 is 1.11 x 10^{-7} $M_{\odot}$/yr, showing variations between 5.24 x 10^{-8} $M_{\odot}$/yr and 1.46 x 10^{-7} $M_{\odot}$/yr on timescales of a few days. This type of accretion estimates are being compared with secondary ones that can be inferred by using empirical calibrations between several line luminosities (see figure on the right, and e.g. [3]) and accretion.

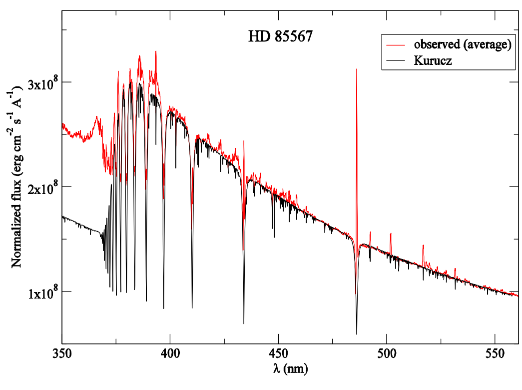


3. PRELIMINARY RESULTS



The figure on the left shows the accretion luminosities from the Balmer excess versus emission line luminosities for HD 31648 (filled symbols) and HD 163296 (open symbols). Left triangles represent upper limits for the line luminosities. Upper limits for the accretion luminosity obtained ~ 15 years ago are plotted with big triangles (filled and open for HD 31648 and HD 163296, respectively), with respect contemporaneous HeI5876, NaID and Hα luminosities. Empirical calibrations from previous works ([4], [5], [6], [7], [8], [9]) and typical 1 dex upper limit uncertainties are indicated with solid and dashed lines, respectively. Our results provide evidence that 1) magnetospheric accretion is also able to reproduce the Balmer excess of HAe stars, 2) the empirical relations with all emission lines used for TT stars are also valid to estimate accretion rates for HAe stars, with a similar 0.5--1 dex accuracy, but 3) these line luminosities do not generally provide accurate estimates of the accretion variability, which is typically lower than 0.5 dex.

We are currently analysing the HBe stars in the sample, finding that the variability of some of them tend to be comparatively lower. HD 85567 is the star with the earliest spectral type in the sample, and shows the strongest Balmer excess (figure on the right), which cannot be reproduced from magnetospheric accretion. Alternative boundary layer models are being applied.



References:

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