ExoplaNeT accRetion mOnitoring sPectroscopic surveY (ENTROPY)
Time series of Balmer line profiles of Planetary Mass Objects

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and

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Abstract

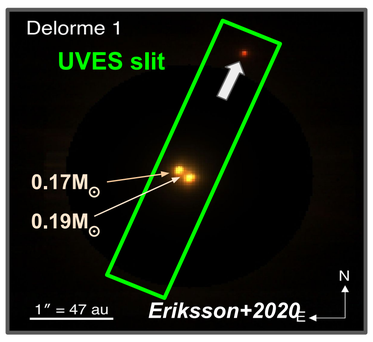
Giant planets forming in protoplanetary disks have their evolutionary pathways determined by their accretion phase. Yet, their study remains limited by the current sample of embedded accreting planets: PDS 70 b and c, and the new challenger WISPIT 2b. However, **wide-orbit planets** may serve as **proxies for embedded ones**: although slightly more massive, they are **not limited to the use of AO instruments**, which often comes at the cost of spectral resolution.

Accretion mechanisms are studied through emission lines (Halpha, Paschen Beta, ...) forming at or near the accretion shock. They have been discovered on a couple dozen wide-orbit Planetary-Mass Companions (PMCs). However, studies often use **medium-resolution spectrographs** (e.g., MUSE R~3000), **insufficient to resolve the line profiles** and probe the gas dynamics. Recent studies have shown that echelle spectrographs (R ~ 50 000) may in fact be used to study bright optical lines, offering a unique opportunity to constrain accretion models and accretion dynamics.

We present the results of a monitoring campaign of the **Balmer emission lines** (**Halpha**, **Hbeta**, ...) of **Delorme 1 (AB)b**, at **R~50,000** with VLT/UVES. The lines are clearly resolved with variable line profiles and fluxes, on days to year timescales. We detect a **UV excess**, direct tracer of the accretion shock. We find that its **Balmer lines are the combination of two components**, only one of which is correlated with the UV excess. We discuss implications in the context of magnetospheric accretion and shock-induced emission. Finally, we present the early results of the **ENTROPY** program (ExoplaNeT accRetion mOnitoring sPectroscopic surveY), consisting of a systematic variability study of Balmer emission lines on 8 PMCs with **VLT/UVES**. We find different line behaviors depending on the target, where line **profile variability observed at timescales of 20 minutes up to a year**.

1. ENTROPY program

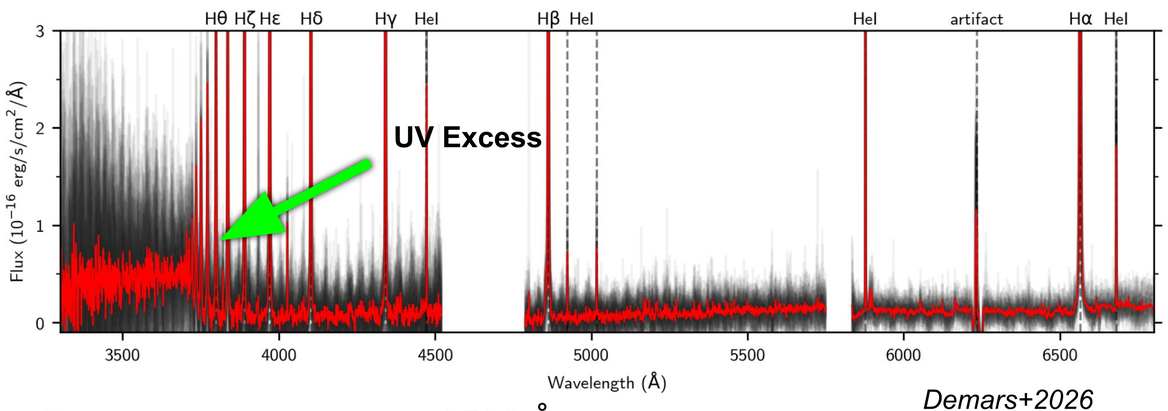
Object	Type[c]	d (pc)	Mass (M_{Jup})	Age (Myr)	Sep. (au, ["])
Delorme 1 ABb	Comp	47	14	45	80 [1.8]
SR 12C	Comp	112	13	2	1083 [8.7]
DH Tau b	Comp	133	10	1	307 [2.3]
FU Tau b	Comp	126	19	1	719 [5.7]
2M0226	Isol.	46	14	45	...
OTS44	Isol.	162	12	2	...
2M1115	Isol.	45	7-21	5-45	...
VISTA1611	Isol.	125	5	11	...



- **Large program with VLT/UVES, 65h, PI: Bonnefoy**
  - seeing-limited echelle spectrograph
  - 3300 – 7000 Å @ R~50,000
- **4 runs** of **7 half-nights**
  - Balmer series (Hα, …)
  - Helium and metal lines (and UV excess!)
  - Line profile variability over consecutive hours and nights
  - Variability at the rotational period timescale

ENTROPY I *ENTROPY II*

2. Delorme 1 (AB) b – Line variability



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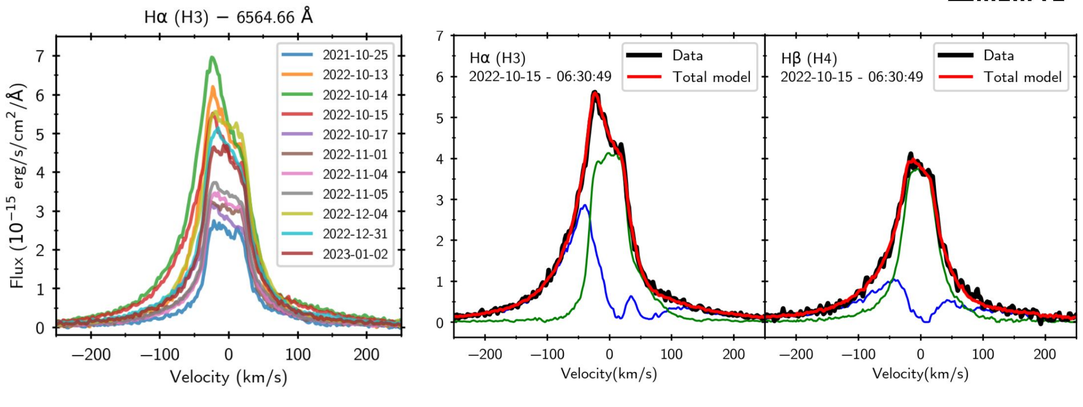
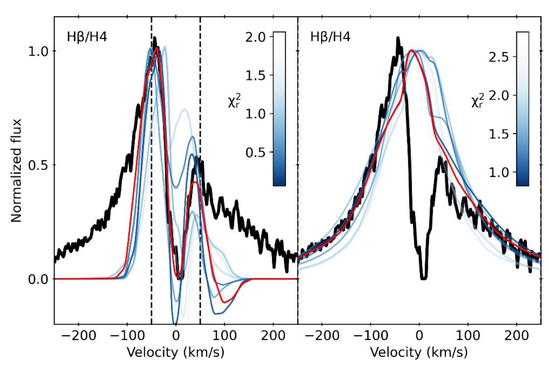
- **Observed UV excess (< 3500 Å)**
  - Tracer of the accretion shock
  - Excess variability observed between epochs



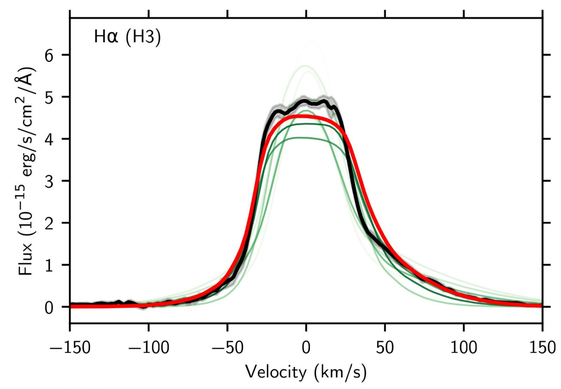
- **Strong line and profile variability**
  - Asymmetric profile in bright epochs
  - Variability explained by two components: **wings** and **core**
  - Components only vary in flux (same profile for all observations)

3. Delorme 1 (AB) b – Lines origin

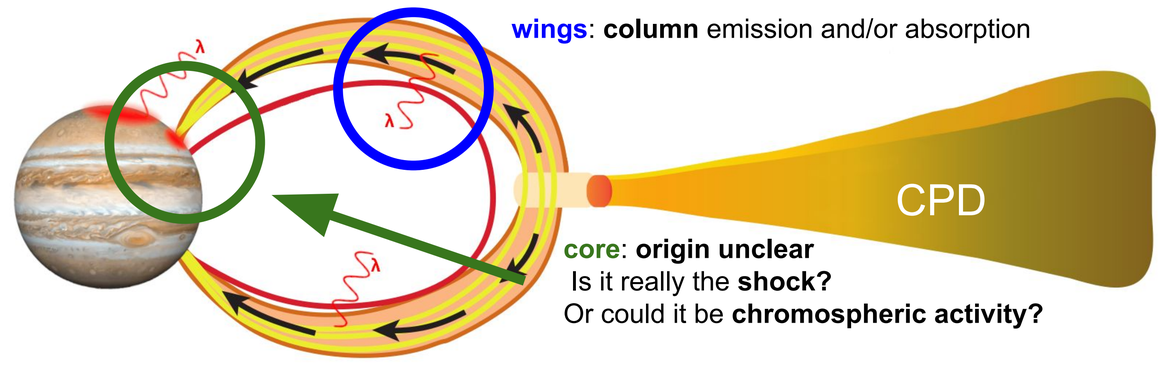
Magnetospheric accretion modeling



Shock modeling



- **wings:** magnetospheric accretion modeling
  - Reproduces **absorption features**
  - Extended wings and core absorption not reproduced simultaneously
  - Strong correlation with UV excess
- **core:** shock modeling
  - Reproduces the components at first order
  - Low correlation with UV excess, raising doubts on the shock origin



4. ENTROPY – Other targets

- **Different behavior** between targets: **plateau like** profile (2M0226, 2M1115), **bursts** (2M0226) or **highly asymmetric** (e.g., FU Tau b)
- Quiescence plateau may be the **baseline chromospheric level**, modulated by absorption from the infalling material
- HeI lines dominated by accretion, with contribution from chromospheric activity (Viswanath et al. submitted)