Strong Hα emission and signs of accretion in a circumbinary planetary mass companion from MUSE

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With the recent addition of the Narrow Field Mode (NFM), the Multi Unit Spectroscopic Explorer (MUSE) integral-field spectrograph on VLT UT4 now offers an AO-corrected field of view of 7.5'' x 7.5'' with a mean resolution of 3000 at 480-930 nm. Using MUSE in NFM we have observed 2MASS J01033563-5515561 (AB) b (Delorme 1 (AB) b), a 47 pc distant 12-14 M_{Jup} object orbiting a pair of young M5 stars at 84 AU [1]. Observations covered 2.5 hours and obtained a near-visual spectrum (4750-9350 Å) of this hot, young planet/brown dwarf, in addition to resolving both components of the 0.25'' binary (Fig. 1).

Here we present some highlights from our analysis of Delorme 1 (AB) b in Eriksson et al. (2020, *A&A 638, L6*). The most interesting one being very strong Hα emission, 17 times the local continuum with a mean equivalent width of -138±13 Å, accompanied by Hβ and weaker He I lines. Together, these lines provide a strong indication that Delorme 1 (AB) b could be actively accreting, possibly putting it at tension with its estimated age of 30-45 Myr, or hinting at the presence of an unusually old disk.

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Background and overview

- Hα emission is a strong indicator of accretion and chromospheric activity, and has been detected in a number of young brown dwarfs and planetary-mass companions [2,3,4].
- Additional accretion indicators include emission in e.g. Hβ, He I (6678, 7065, 7281 Å) from the accretion shock caused by infalling matter [2], and Ca II (8542, 8662 Å) [3].
- Tracing accretion in these young objects improves our understanding of their formation and subsequent evolution.

The near-visual spectrum of Delorme 1 (AB) b

Classification
The spectrum of Delorme 1 (AB) b (Fig.2) indicates a spectral type of L0±1, with detected Li I absorption, weak alkali lines and very strong VO bands - signs of youth and low gravity [5].

Accretion
Accretion rates can be estimated from e.g. the flux of the Hα line or its 10% width [2,4]. For Delorme 1 (AB) b, the line width is uncertain due to the resolution of MUSE, but combined flux and width estimates yield accretion rates of $0.8 - 3.0 \times 10^{-8}$ M_{Jup} per year.

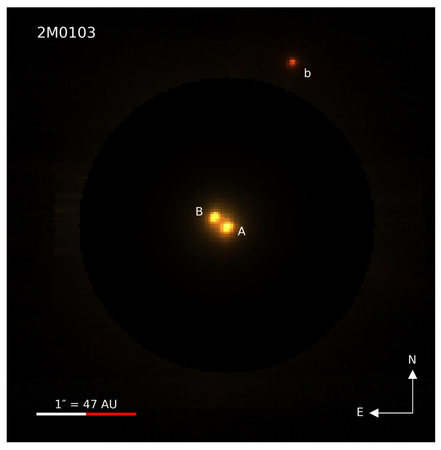

Fig.1 RGB image showing the three resolved components. The central parts of the image is scaled down in flux by a factor of ~200.

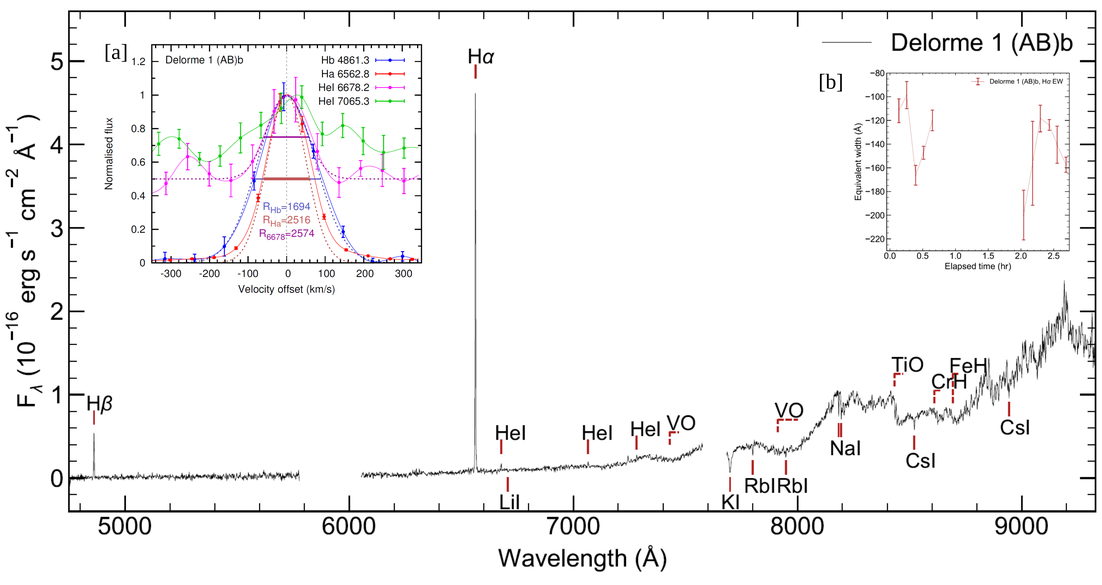

Fig.2 MUSE near-visual spectrum of Delorme 1 (AB) b with spectral features highlighted, created from the mean of 11 data cubes. Inset **[a]** shows how well, or poorly, some lines are resolved by MUSE, and **[b]** the time-evolution of the Hα equivalent width (EW) with, error bars.

Disentangling the system

System background
Delorme 1 is a highly probable candidate for Tucanae-Horologium membership [6], an association with an estimated age of 30-45 Myr.
The MUSE spectrum of A and B (Fig.1) shows high Hα activity at the time the system was observed. (Fig.3)

A & B are overluminous
Both central components have been found to be overluminous, laying above the β Pictoris isochrone [7]. This could indicate either a younger age or further multiplicity in both components. However, we do *not* detect any Doppler shifts in either A or B that would indicate that AB is a quadruple system.

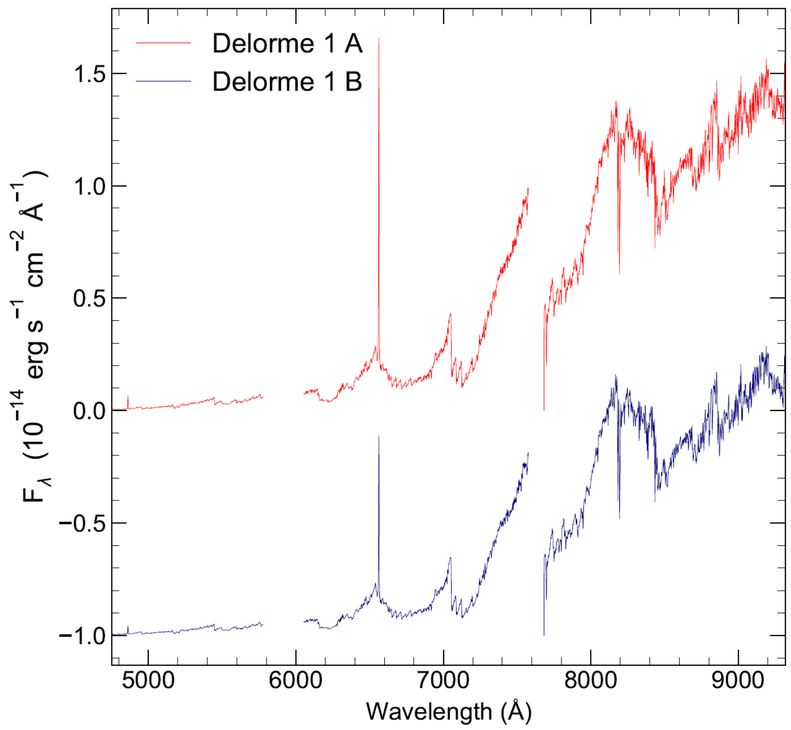

Fig.3 Spectra of the two near equal-mass (A/B:0.19/0.17 M_{Sun}) ~M5 components of Delorme 1 AB, with B shifted in flux by 1. A is actively flaring during the observation, while B shows high quiescent activity.

Conclusions

- Very strong Hα and Hβ emission indicative of accretion at $\sim 10^{-8}$ M_{Jup} per year.
- 10% Hα width likely above 200 km/s, commonly found in brown dwarfs with accretion disks.
- Integrated Hα line flux (adjusted for distance) is similar to the flux of PDS 70 c [8].
- An intriguing possibility of active accretion in such an 'old' system is that Delorme 1 could be an example of a 'Peter-Pan disc' system [9]. These make up a group of old (~30 - 50 Myr), very low-mass systems with confirmed discs and on-going accretion.
- MUSE is excellently suited for detecting young, accreting substellar objects. **However**, care must be taken during line width analysis, due to the lines usually being marginally resolved, or entirely unresolved.

References

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