HD 68695, is it a λ-Böotis or a Herbig Ae star?

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Introduction

Problem Statement

HD 68695 has characteristics of a young star with its age estimated to be about 7.3 million years (Arun et al. 2019). Murphy et al. (2020) observed strong emission in H-β, concluding that HD 68695 did not appear to be a λ-Böotis star and therefore its membership in the class was uncertain. Our observations using the SALT-HRS, in 2024, revealed emission in all Hydrogen Balmer lines, as well as in many other weaker lines.

Properties of λ-Boötis stars

Chemically peculiar, older main sequence stars with under-abundances of iron-peak elements.

- Spectral type: late B to early F-type.
- Near Solar abundances of Carbon, Nitrogen, Oxygen, & Sulphur and underabundance in iron peak elements (Cheng et al. 2019).

Herbig Ae stars

Young pre-main-sequence stars actively accreting material with emission lines and circumstellar disks. Some Herbig Ae stars have been shown to have λ Boötis abundance patterns (Murphy et al. 2020)

- Intermediate mass stars between 2 and 8 $M_{\odot}$.
- Spectral type: A to F-type.
- A notable subset of these stars have been shown to have λ-Boötis peculiarities (Folsom et al. 2012)
- Infrared excess caused by warm (T $\backsim$ 1000K) and or cold (T $\backsim$ 100K) circumstellar material.

Properties of HD 68695

Parameter	Folsom et al. (2012)	Murphy et al (2020)
$T_{eff}(K)$	9000 ± 300	8436 ± 169
log g	4.3 ± 0.3	$3.76^{+0.03}_{-0.04}$
ξ (km/s)	1.3 ± 1.1	N/A
$v \sin i$ (km/s)	51 ± 0.4	N/A
[Fe/H]	N/A	$0.16^{+0.07}_{-0.08}$
Distance	410 ± 36	344^{+106}_{-103} pc
Age (Myr)	$5.2^{+3.0}_{-1.0}$	7.3

Table 1: parameters of HD 68695 from literature

HD 68695, also shows infrared excess as seen from it's SED, furthermore:

- It has no observable magnetic fields.
- It has δ-Scuti pulsations.

Parameters derived from fitting synthetic spectra to the observed one

The best fit parameters in Table 6, were determined using FERRE (Allende Prieto & del Burgo, 2016), which is a code that fits synthetic spectrum to the observed one.

Notable spectral lines in the spectrum of HD 68695

The values in the following tables were measured using IRAF from the SALT HRS data we are presenting here:

Fe I Lines visible in the spectrum

λ (Å)	Line Center (Å)	E.W. (mÅ)
3930.30	3930.49	51.0
3997.39	3997.09	13.7
4005.25	4005.27	62.3
4045.82	4045.94	107.9
4063.60	4043.75	86.5
4071.74	4071.88	82.5
4202.03	4202.22	38.6
4235.94	4235.74	3.1
4260.48	4260.56	73.1
4282.41	4282.46	2.4
4466.55	4466.51	4.8

Table 2: Fe I lines & measured equivalent widths

Fe II lines visible in the spectrum

λ (Å)	Line Center (Å)	E. W. (mÅ)
4233.17	4233.3	108.6
4472.92	4472.97	10.1
4508.28	4508.46	59.9
4520.23	4520.29	37.0
4522.63	4522.72	70.7
4541.52	4541.66	26.7
4576.30	4576.52	26.0

Table 3: Fe II lines & measured equivalent widths

Ti II Lines visible in the spectrum

λ (Å)	Line Center (Å)	E. W. (mÅ)
4012.37	4012.39	0.32
4290.22	4290.19	37.1
4443.82	4443.92	64.6
4501.27	4501.32	16.7
4533.97	4534.08	62.3
4571.97	4571.00	0.30

Table 4: Ti II lines & measured equivalent widths

Mg II lines visible in the spectrum

λ (Å)	Line Center (Å)	E.W (mÅ)
4481.13	4481.35	250.5
4481.33	4481.36	259.3

Table 5: Mg II lines & measured equivalent widths

Fitted stellar parameters

[Fe/H]	[α/Fe]	log ξ	$T_{\rm eff}(K)$	log (g)
-1.654	0.252	0.143	10432	4.10

Table 6: Fitted Parameters

Balmer lines in the HD 68695 spectrum

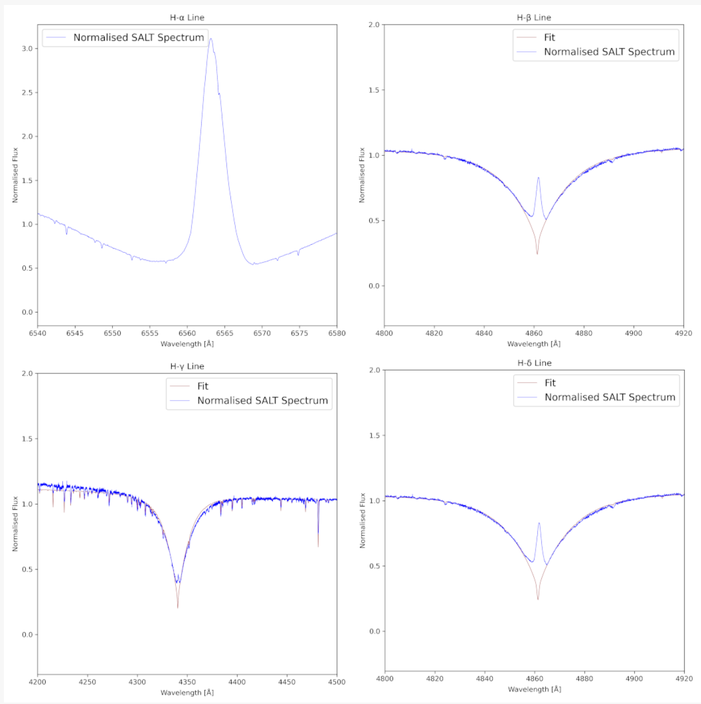

Figure 1: Balmer Lines in the HD 68695 spectrum (The red colour is the FERRE fit, blue is the SALT HRS data)

Some interesting lines in the spectrum

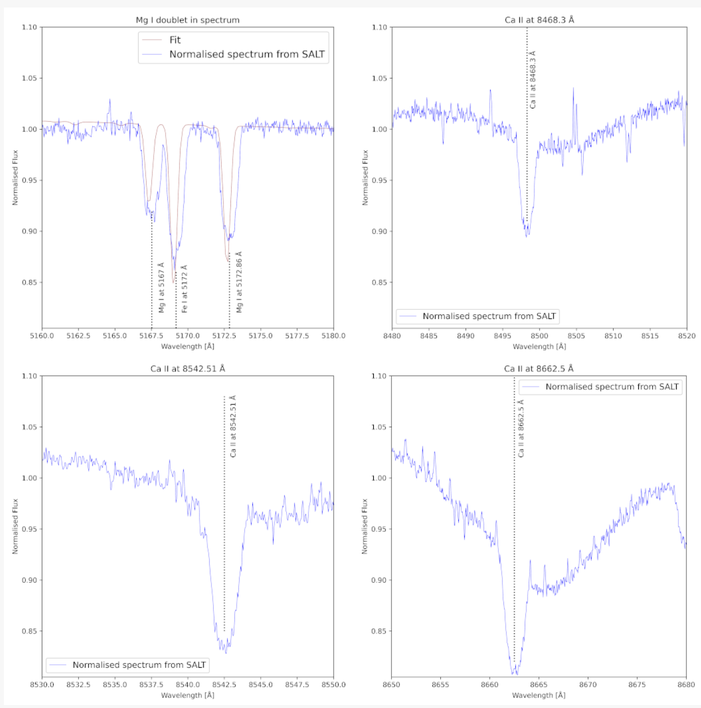

Figure 2: Lines associated with accretion in Herbig stars: Ca II triplet, and Magnesium line shown for HD 68695. Notice emissions in the centres of Mg I (5172 Å) and Ca II (8468 Å, 8662 Å) lines.

Conclusions

1. Calcium II line (8662 Å) is mostly absorption with emission at its centre (major characteristics of Herbig Ae stars). It is important to note that in Herbig stars, Ca II triplet (8498 Å, 8542 Å, and 8662 Å) are usually in emission and can be used to diagnose the temperature and density of the emitting accreted gas.
2. The presence of emission lines within all of the hydrogen lines indicate accretion of hydrogen gas on to the surface of HD 68695.
3. We have enough data to perform an abundance analysis which is the next step.

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