Chemical Abundance Analysis of Late-B Type Single and Binary Stars Using Sub-meter Class Telescopes: HR 342, HR 769, HR 1284, HR 8705

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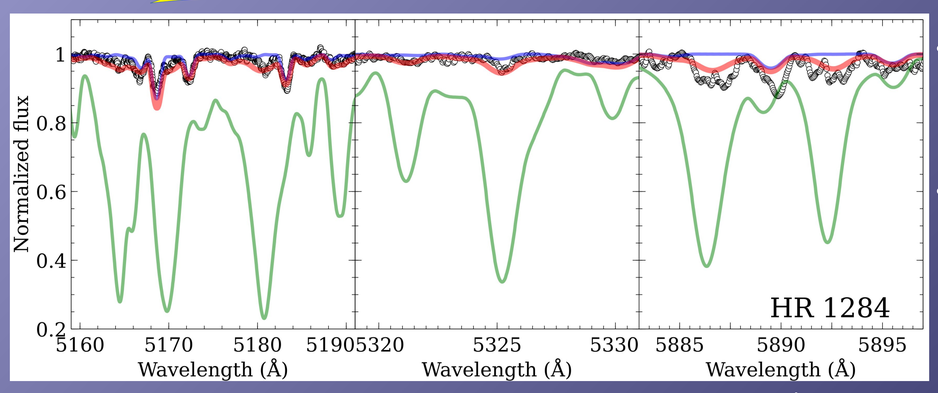
SUMMARY. We test the capabilities of 0.4 m mirror sized telescopes concerning the chemical abundance analysis of late-B type stars. We also introduce a new modification of the SYNSPEC/SYNPLOT spectrum synthesis code, which allows us to synthesize the composite spectrum of binary stars. These observations and analyses are a companion project to a high resolution survey of late-B type stars to search for new chemically peculiar candidates. We have analyzed the specta of HR 342, HR 769, HR 1284, and HR 8705 to derive their elemental abundances. We have also used theoretical diagrams (surface gravity versus effective temperature) to clarify their evolutionary status and estimate their mass and age. The medium resolution (R∼ 14 000) spectra covering the wavelength range of 4380-7350 Å of the four targets have been obtained with the Shelyak eShel Spectrograph attached to the 40 cm telescope in Ankara University Kreiken Observatory (AUKR), Turkey. The atmospheric parameters of the stars have been derived by using the photometric measurements in Johnson filters and modeling the Balmer line profiles in the spectra. The abundances of 11 elements have been derived by iteratively adjusting the parameters of synthetic spectra and modeling the selected unblended lines of the elements. We have also attempted to model the spectrum of the binary star HR 1284 to uncover the physical and chemical properties of its components. We have found that the target stars do not show remarkable departures from the solar abundances, except for HR 8705 and the primary component of HR 1284, which exhibit slight underabundances of many elements, such as O, Mg, Al, Si, and Fe. We discuss the uncertainty limits of the abundances derived using sub-meter class telescopes. We also discuss the difficulties and possible solutions to model the spectrum of binary stars (HR 1284 in our case) even when the spectral disentangling method is not suitable.

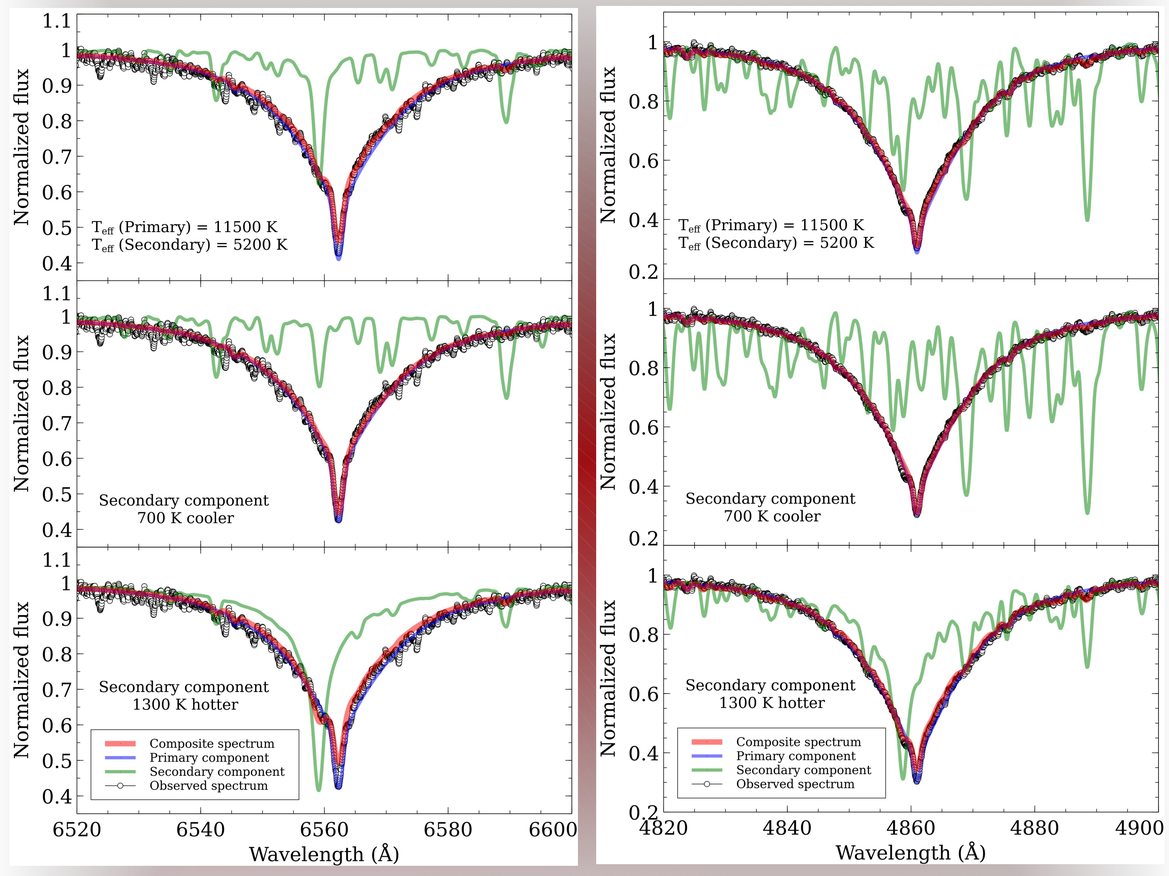
How can the barely visible secondary components of the B type stars be recognized?



- Broadening or cross-correlation functions are very useful to clarify the binarity status of the stars.
- However, there are several regions of the spectrum of B type stars where the signature of the dim secondary component is distinguishable.

- The good examples of these regions are Mg I triplets around 5175 Å, Fe I line at 5328.038 Å, and Na I doublets around 5890 Å.
- While the lines above are quite strong in late type (i.e., G type) stars, they are not or barely visible in the spectrum of B type stars. If some of those lines are detectable in the spectra of a B type star, it can be a good indicator for a secondary cooler component (even the companion star is quite dim!).

H Lines of the Binary Star HR 1284



- We attempted to synthesize the Balmer lines of the binary star HR 1284 using SYNPLOTBIN. If the cooler component is bright enough like here, a bump superposed on the H line can be seen.
- Balmer lines are useful to derive the atmospheric parameters of the components. However, only one H line may not be enough to estimate the T_{eff} of the both components. The flux contributions of the components vary from region to region due to their temperature differences.
- The atmospheric parameters derived from each Balmer line should be consistent.

- Among the large number of late-B stars observed at AUKR, we recently discovered a binary star: HR 1284. We have modified the SYNSPEC49/SYNPLOT code (Hubeny & Lanz 1992) to synthesize the spectrum of the star. ATLAS12 (Kurucz 1979) for model atmospheres. As we have only one spectrum of the star, we could not disentangle the spectra. Instead, we combine the synthetic flux spectrum of the both components using SYNPLOTBIN. We initially assumed the solar composition (Grevese & Sauval 1998). The final synthetic spectrum successfully reproduced the fluctuations caused by dim secondary component in the continuum of the observed spectrum.

Fundamental Parameters & Evolution

- Balmer line analysis did not let us to estimate the surface gravity of the HR 1284 B, as the balmer lines of these cool stars are mostly sensitive to the effective temperature. Assuming the age of A and B components are same, we estimated log *g* of the B comp. using theoretical log *g* – log T_{eff} diagram.

HR 342
- T_{eff} = 10250 ± 250 K
- Log *g* = 3.75 ± 0.05 dex
- *M* = 3.00 ± 0.10 $M_{\odot}$
- Age = 325 ± 20 Myr

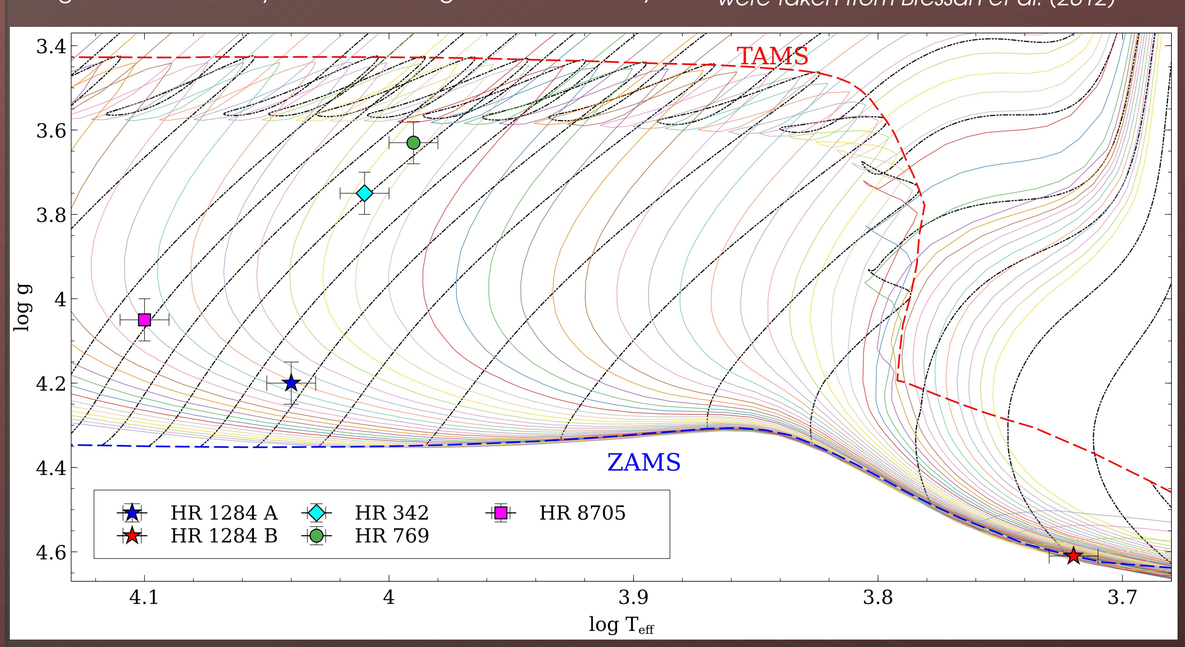
HR 769
- T_{eff} = 9800 ± 200 K
- Log *g* = 3.63 ± 0.05 dex
- *M* = 3.05 ± 0.10 $M_{\odot}$
- Age = 340 ± 20 Myr

HR 1284 A
- T_{eff} = 11000 ± 300 K
- Log *g* = 4.20 ± 0.05 dex
- *M* = 2.67 ± 0.10 $M_{\odot}$
- Age = 200 ± 20 Myr

HR 1284 B
- T_{eff} = 5200 ± 300 K
- Log *g* = 4.61 dex
- *M* = 0.90 ± 0.02 $M_{\odot}$
- Age = 200 ± 20 Myr

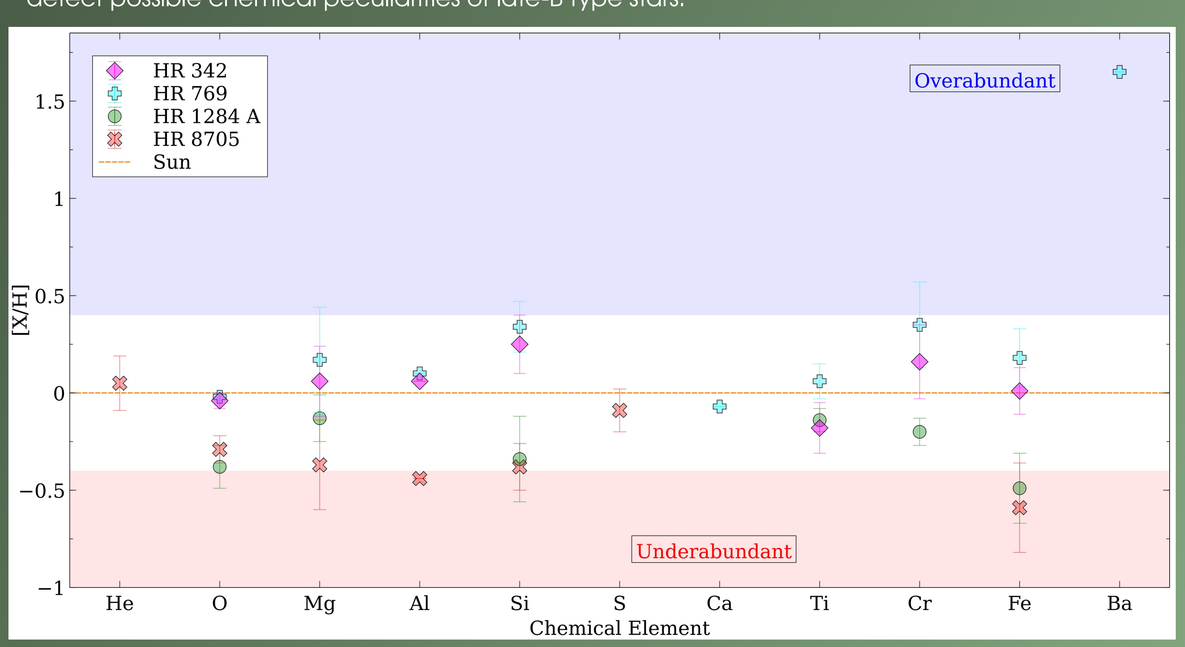
HR 8705
- T_{eff} = 12500 ± 500 K
- Log *g* = 4.05 ± 0.05 dex
- *M* = 3.40 ± 0.10 $M_{\odot}$
- Age = 158 ± 20 Myr

- *The atmospheric parameters of the stars were first estimated by Johnson BV magnitudes and the calibrations of Flower (1996).*
- *Theoretical evolution tracks and iocrones were taken from Bressan et al. (2012)*



Results and Discussion

- This study is a part of a survey including large number of chemically peculiar/normal late-B and A stars.
- We derived the chemical abundance of 11 elements for the target stars.
- The chemical pattern of the stars does not show a remarkable peculiarity respect to the Sun or chemically normal A stars, with two exceptions:
  - Many elements such as O, Mg, Al, Si, and Fe are slightly underabundant for HR 8705. This star might be a chemically peculiar star. However, its higher resolution spectrum is needed to clarify its nature. As a second scenario, a cooler component may also lead to an erroneous atmospheric parameter derivation for the star.
  - The synthetic modeling of the spectrum of HR 1284 showed that many metal lines in its observed spectra were shallower than the synthesized ones for the primary component, which suggests that the star can be slightly underabundant for several elements, as in HR 8705.
- Using a 0.4-mirror-sized-small telescope and a medium resolution spectrograph, we obtained the abundances with a precision between ±0.10 and ±0.25 for various elements for the target late-B stars. Even though these error limits are not quite precise, we conclude that they are enough to detect possible chemical peculiarities of late-B type stars.



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