λ Boo stars as tracers of planet formation

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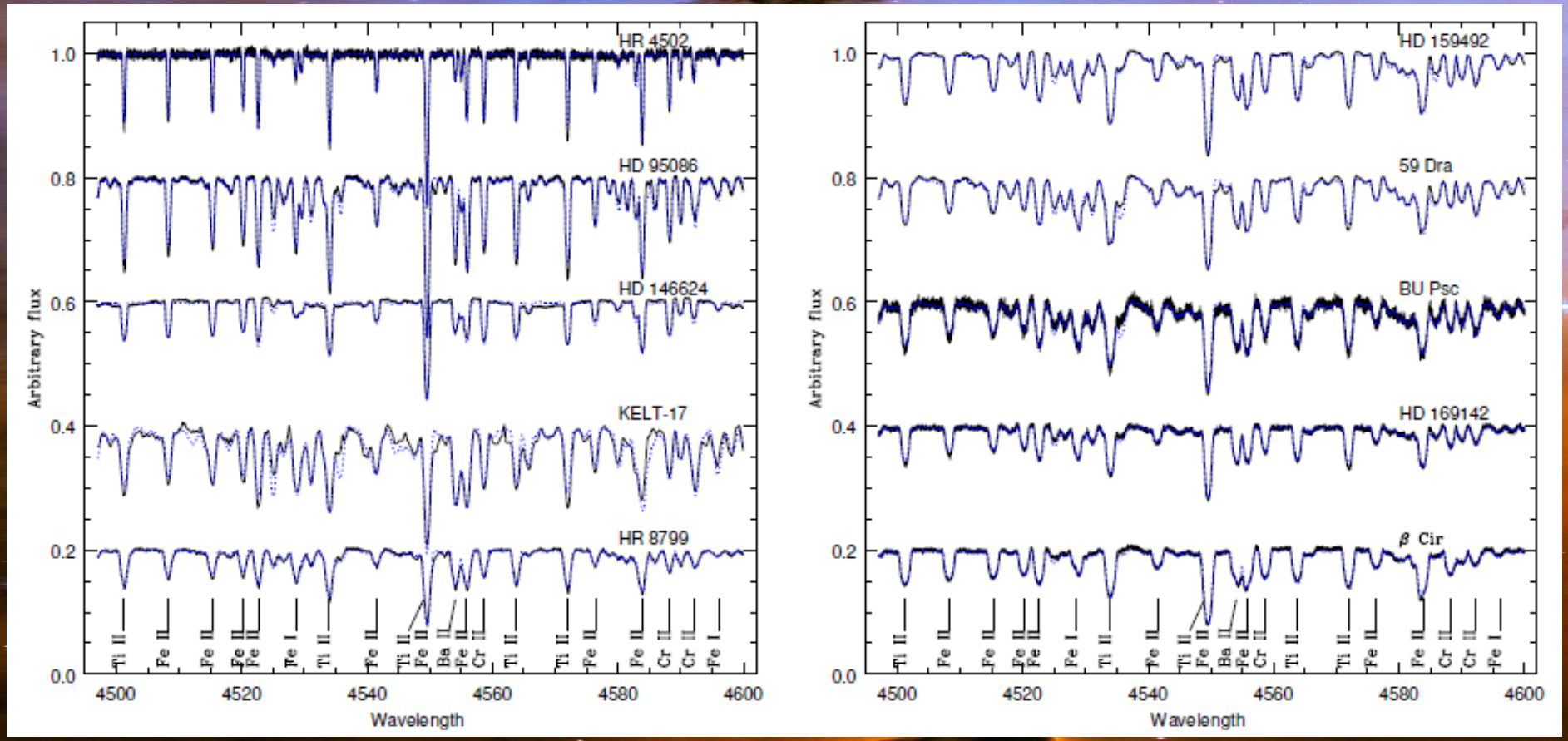
We study the possible chemical signature of planet formation in early-type stars with planets. In particular, we analyze a likely relation between the λ Boo chemical pattern and the presence of giant planets by using spectral synthesis. Our first sample includes 13 stars with planets and 24 stars without detected planets. We have detected four λ Boo stars in our sample, two of which present planets and circumstellar disks (HR 8799 and HD 169142) and one without detected planets (HD 110058). We also identified the first λ Boo star which is orbited by a brown dwarf (ζ Del). Our results support a scenario in which giant planets orbiting pre-main-sequence stars block the dust of the disk and result in a λ Boo pattern. On the other hand, we do not support a proposed scenario in which the winds form hot-Jupiter planets could produce a λ Boo pattern on early-type stars.

Description of the work. We studied a sample of ~40 early-type stars with and without planets, using high-resolution spectra taken from different sources (HARPS, HIRES, ELODIE, REOSC, etc.).

Determination of fundamental parameters and abundances:

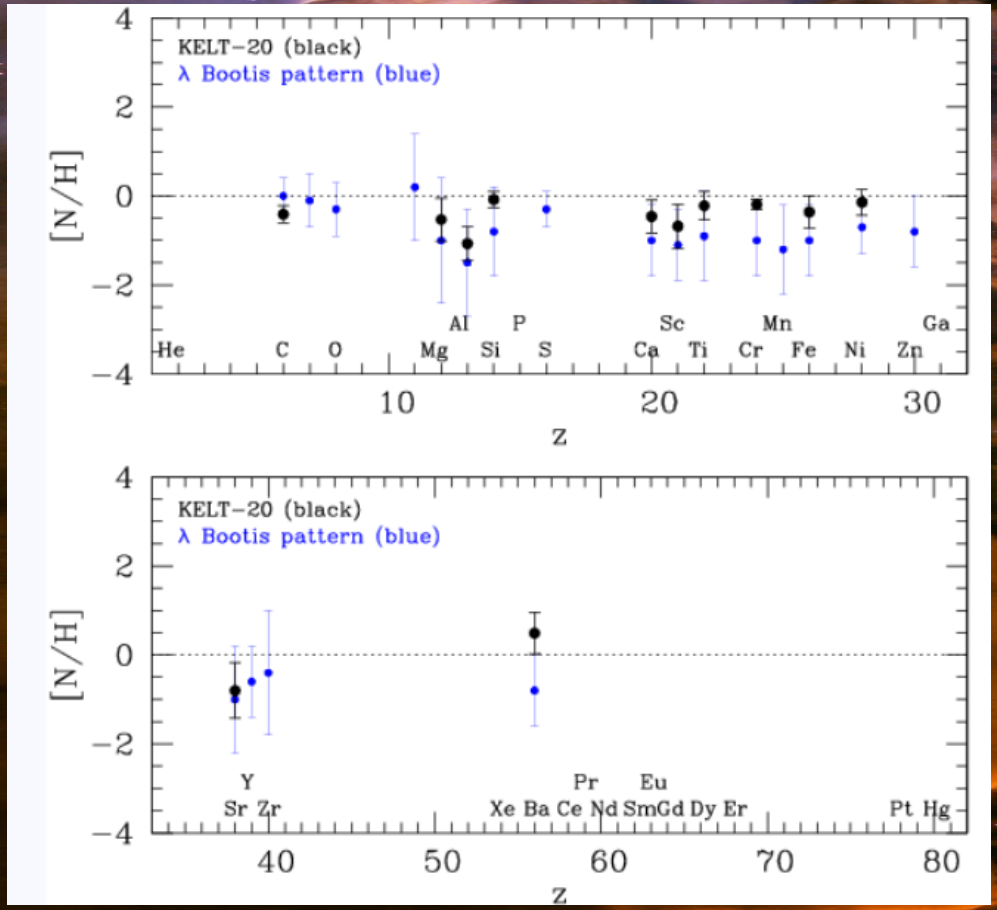
- Initial estimation of parameters using Strömgren photometry and/or literature values
- When possible and/or necessary, we refined starting parameters by imposing excitation and ionization balances of iron lines.
- Determination of specific opacities (and not solar-scaled values) was calculated iteratively by using ATLAS12 model atmospheres together with the code SYNTHE (Kurucz 1993). Individual abundances were varied in steps of 0.01 dex and chequed by eye on a line-by-line basis.
- Rotational velocites were estimated initially by fitting the line Mg II 4481 and then were refined by fitting most iron lines in the spectra.
- Synthetic spectra produced by SYNTHE, were convolved with an instrumental profile (using the Kurucz's command broaden, corresponding to the resolving power of each instrument) and with a rotational profile (using the command rotate).



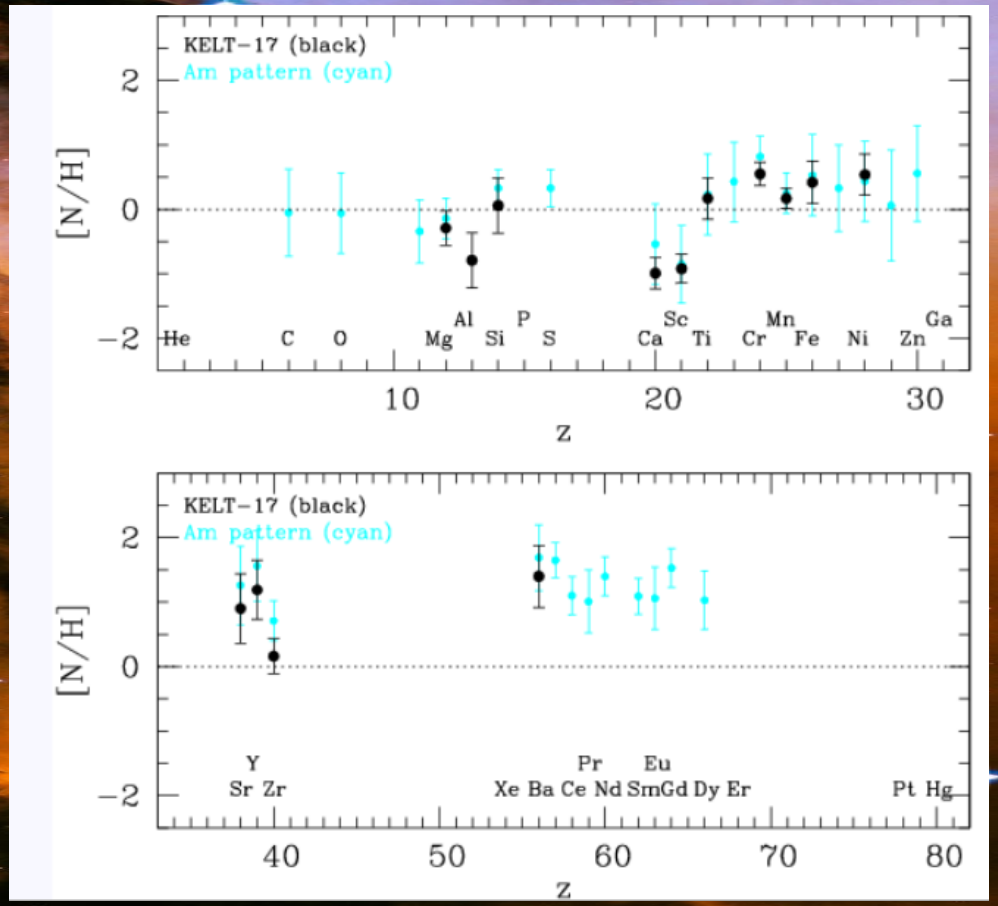
Observed and synthetic spectra (black and blue), for some stars in our sample.

Example of chemical patterns derived

KELT-20: mild- λ Boötis

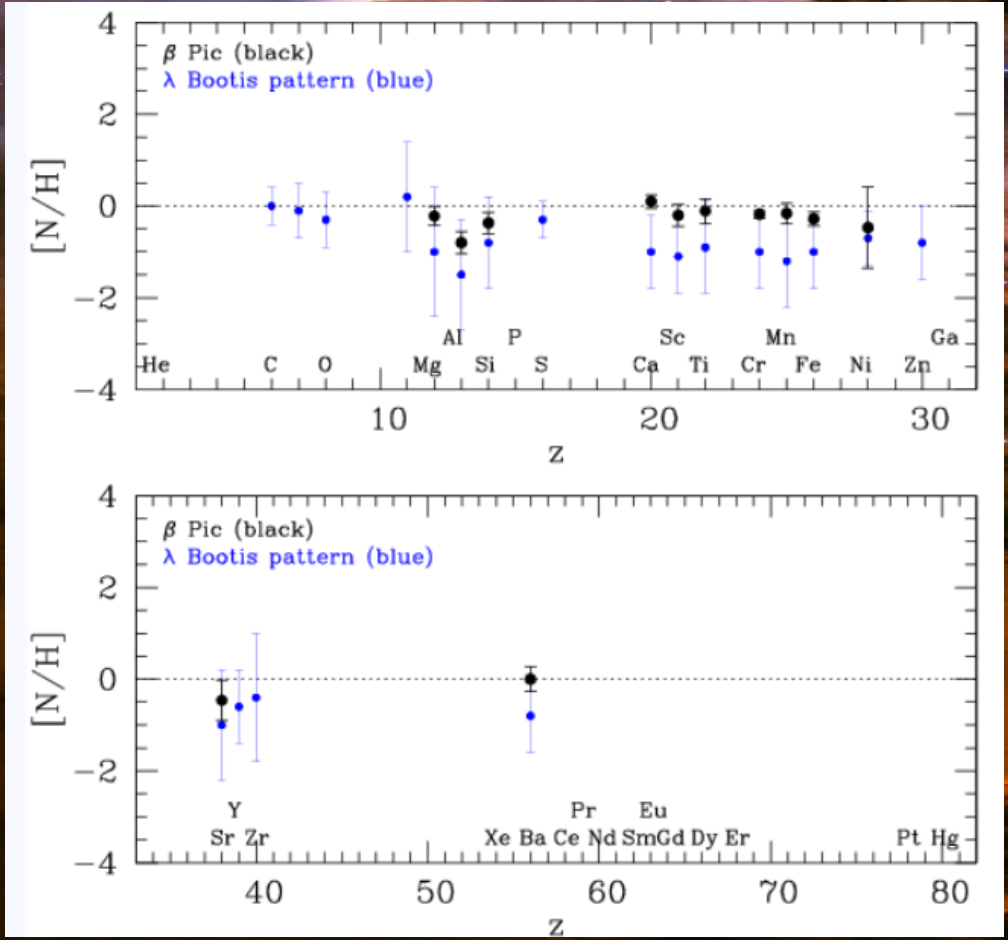


KELT-17: Am pattern

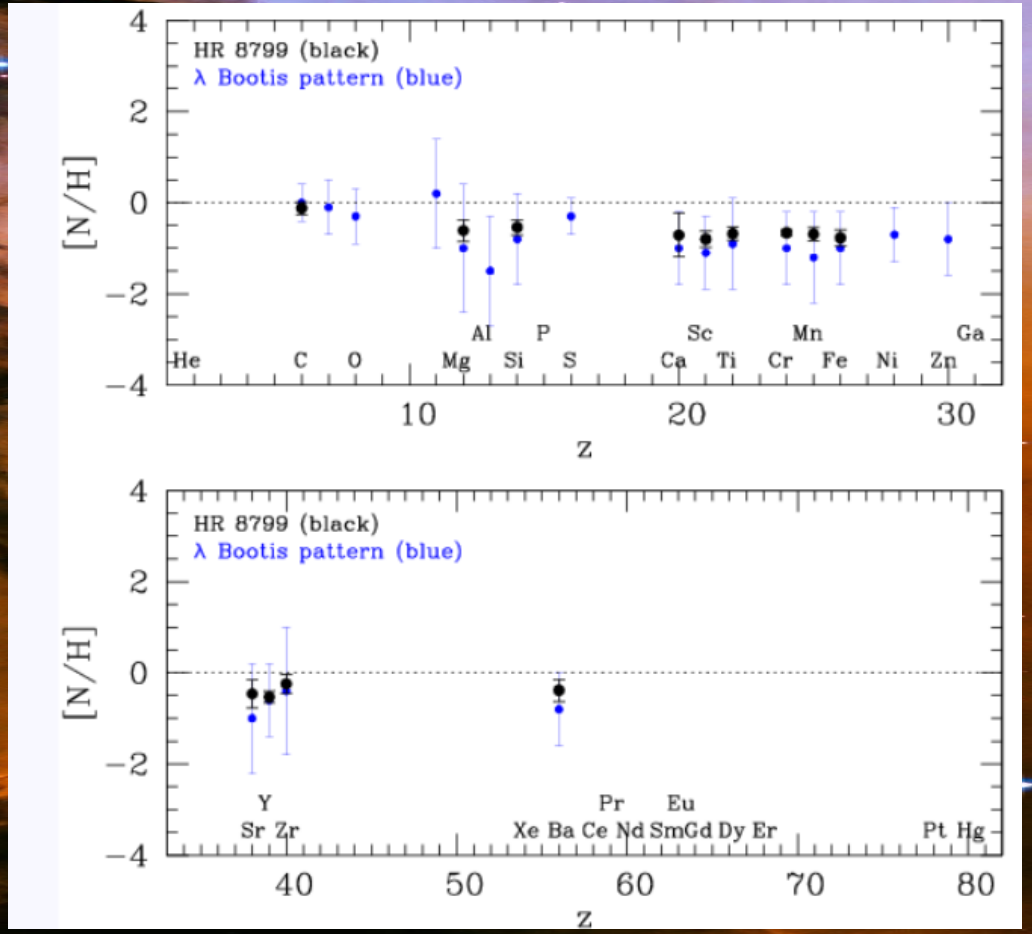


Example of chemical patterns derived

Beta-Pictoris: mild- λ Boötis



HR 8799: λ Boötis



The main results of this study are as follows:

- We have found four λ Boo stars in our sample, two of which present planets (HR 8799 and HD 169142), one without planets (HD 110058), and the first λ Boo star orbited by a brown dwarf (ζ Del). This last interesting pair composed by a λ Boo star + brown dwarf, could help to test stellar formation scenarios.

- We find no unique chemical pattern for (early-type) planet bearing stars. Within this group, we found λ Boo stars (HD 8799 and HD 169142), a chemically peculiar Am star (KELT-17), a number of stars showing mostly solar abundances, and one metal-rich object (WASP-167).

- The λ Boo signature that we observe in the Herbig AeBe star HD 169142 and in the young star HR 8799, support in principle the scenario proposed by Kama et al. (2015). They suggest that the presence of giant planets in very young stars possibly block the dust from protostellar disks and allow the accretion of volatile-rich gas, resulting in a λ Boo pattern.

- The abundances derived in this work for different hot-Jupiter exoplanet host stars do not support, in principle, the accretion from hot-Jupiters winds proposed to explain the origin of λ Boo stars. We suggest that other mechanisms should account for the presence of main-sequence λ Boo stars.