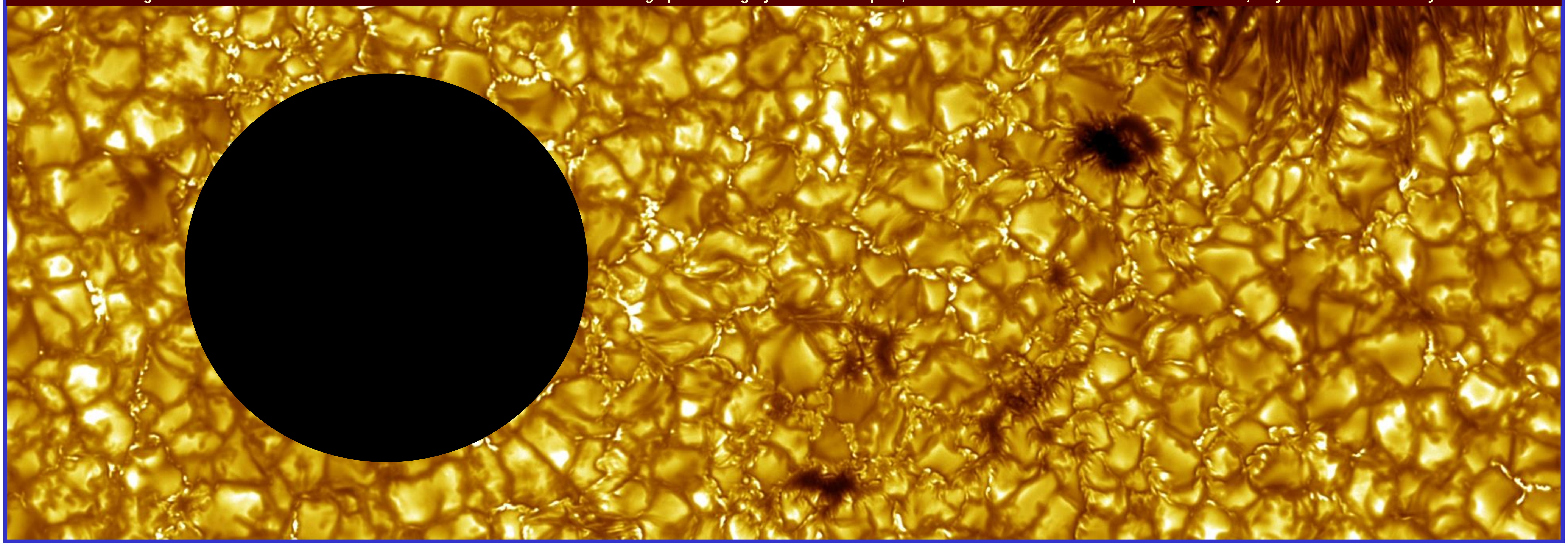
Solar surface granulation in Ca II H λ 396.37 nm wideband. Observations and image processing by Vasco Henriques; Swedish 1-meter solar telescope on La Palma; Royal Swedish Academy of Sciences



SPATIALLY RESOLVED SPECTROSCOPY ACROSS HD 189733 (K1 V) USING EXOPLANET TRANSITS

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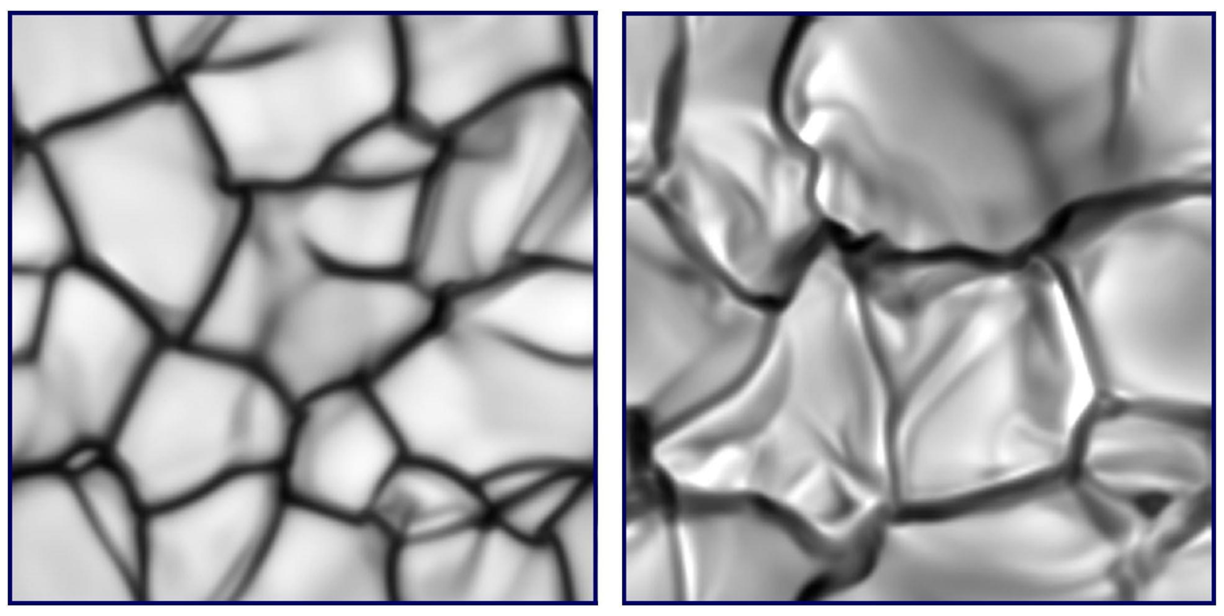
Transiting exoplanets successively hide small segments of the stellar disk.

Differential spectroscopy between various transit phases provides spectra of those surface segments that were hidden behind the planet.

3-dimensional hydrodynamics can be studied in center-to-limb variations of line shapes, asymmetries and wavelength shifts.

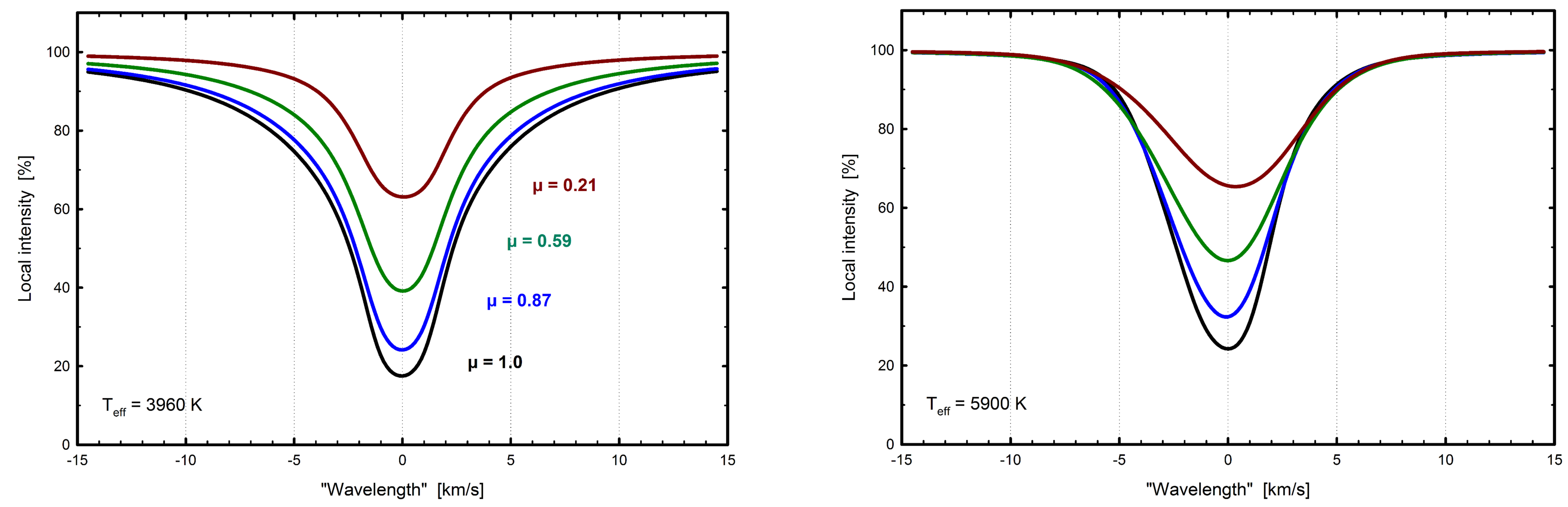
Ongoing studies of the star HD189733 ('Alopex') aim at observing the center-to-limb variation of its photospheric line profiles.

How to verify 3-D model atmospheres?



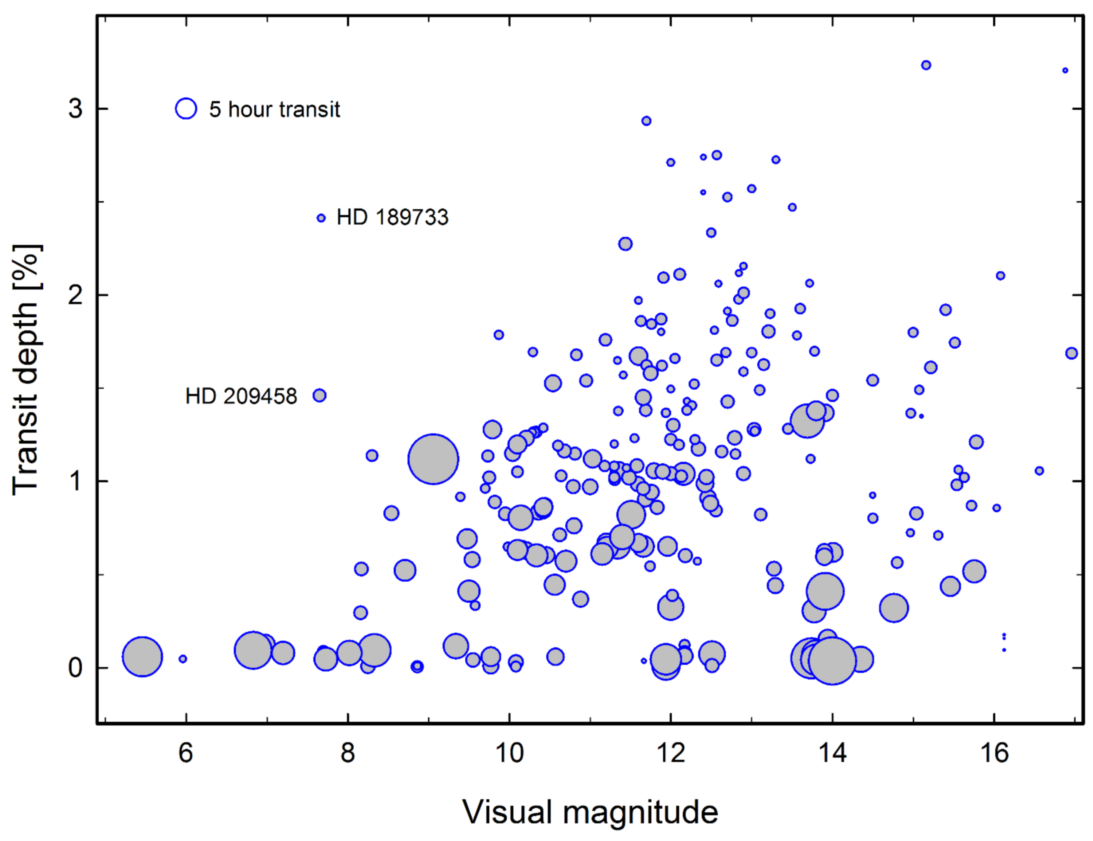
Simulations of 3-dimensional hydrodynamics: Granular structure on a 12,000 K white dwarf (left) and a 3,800 K red giant, computed with CO⁵BOLD. The areas differ greatly: 7×7 km^2 vs. 23×23 $R_\odot^2$. It has become possible to model widely different stars, but the observational means for verifying such simulations remain limited, except for the Sun.

3-D simulations predict line profiles across stellar disks



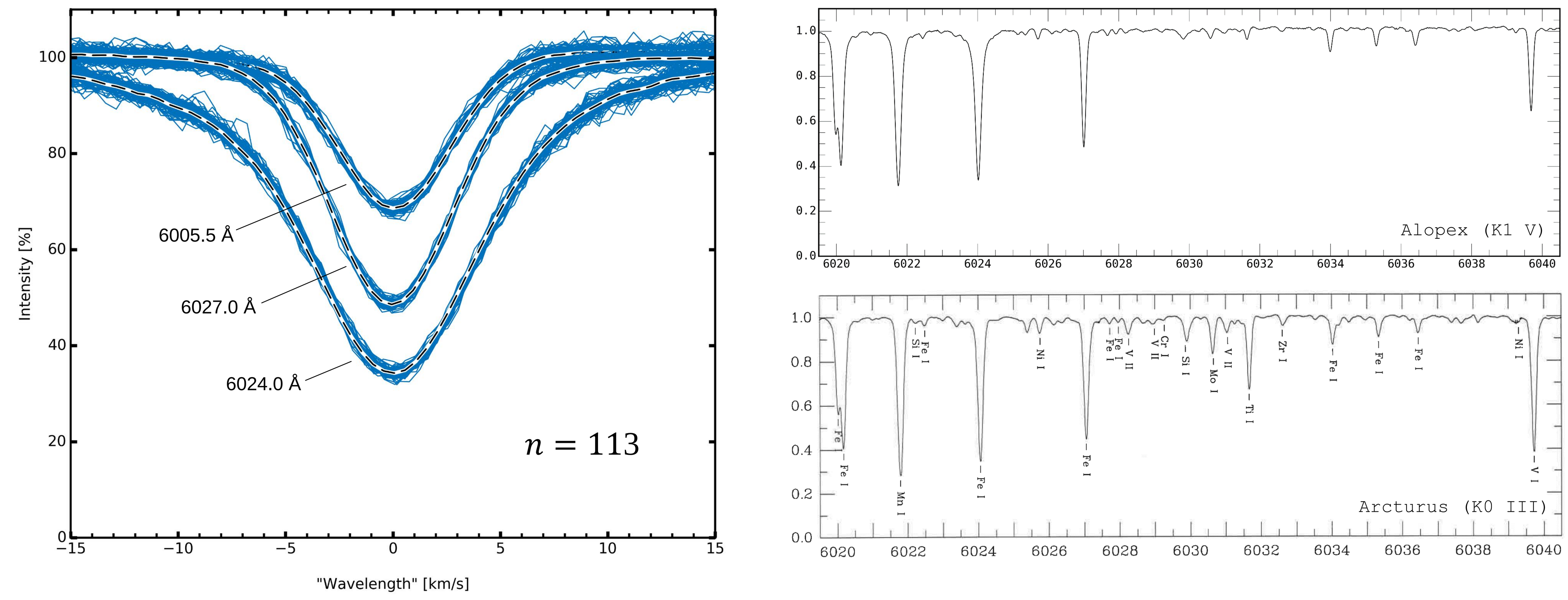
Synthetic line profiles are computed as spatial and temporal averages over the 3-D simulation. The changing line strengths, widths, asymmetries and convective wavelength shifts across the stellar disk reflect details of the atmospheric structure. These profiles from CO⁵BOLD models of main-sequence stars exemplify center-to-limb differences in line asymmetries. Synthetic profiles for one Fe I line at λ= 620 nm, χ = 3 eV, at the successive center-to-limb positions $\mu = \cos\theta$ = 1.0, 0.87, 0.59 and 0.21 were normalized to the local limb darkening. The star HD 189733 ('*Alopex*'*) currently under study has a temperature in between these models, $T_{eff} \sim 4900$ K.

Spatially resolved spectroscopy?



Spatially resolved stellar spectroscopy from exoplanet transits is observationally challenging since planets cover only ~ 1% of its host star. Thus, to achieve a signal-to-noise ratio of e.g. ~ 100 requires an original signal-to-noise of ~ 10,000. HD 189733b is selected since it exhibits the deepest transit among the brighter systems.

Example of observed Fe I line profiles in HD 189733 (Alopex, K1 V)*



The signal-to-noise is increased by averaging many exposures of many similar line profiles. The left panel shows 113 exposures and their averages of three different Fe I lines in HD 189733 ('*Alopex*'*) formed using archive data from the ESO HARPS spectrometer. At upper right is an averaged spectrum of *Alopex* (K1 V, $T_{eff} \sim 4900$ K); lower right a reference spectrum of Arcturus (K0 III, $T_{eff} \sim 4300$ K; Hinkle et al., 2000). The similarity in spectral type of these two stars enables straightforward line identifications.

* *We refer to HD 189733 as 'Alopex' (from the Greek 'αλεπού'), denoting a fox related to the one that gave name to its constellation of Vulpecula.*