Taking MARCS to the next level
Ca IR triplet lines in NLTE

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Context

- **Using the MARCS code (Gustafsson *et al.* 2008), Uppsala is producing model atmospheres for F, G and K stars (4000 K ≤ T_{eff} ≤ 8000 K) spanning five orders of magnitude in metallicity and surface gravity.**

- **These model atmospheres are used to produce synthetic observables for the stellar classification to be performed in the framework of the ESA Gaia space mission:**
  1. fluxes for optical spectro-photometry (so-called BP/RP spectra)
  2. spectra for near-IR spectroscopy around the Ca IR triplet lines at R = 11500 (so-called RVS spectra)

- **While the basic assumptions of, e.g., mixing-length convection and LTE cannot be relaxed globally on the timescale of the Gaia mission, we are making an effort to remove some of the most obvious biases to sharpen Gaia's view of the stellar content of the Galaxy.**

- **Here, we report on work in progress to relax the assumption of LTE in the formation of the Ca IR triplet lines (see Fig. 1) for the whole grid of MARCS spectra.**

NLTE calculations

- **The NLTE calculations are performed using an ALI version of DETAIL tailored for cool stars (Gehren, priv. comm.). The Ca I/II model atom is the one recently presented by Mashonkina, Korn & Przybilla (2007). It was carefully calibrated on stars with well-known stellar parameters and removes systematic differences between weak and strong lines of Ca I and II.**

An example:

The metal-poor turnoff star **HD 84937** (T_{eff} = 6350 K, log g = 4.0, [Fe/H] = –2.2) has $[\mathrm{Ca/Fe}]_{\mathrm{LTE}} \approx 0.3$ as measured from optical Ca I lines. However, Ca II 8498 indicates $[\mathrm{Ca/Fe}]_{\mathrm{LTE}} \approx 0.65$ (see Fig. 2). **Using our NLTE approach, a single [Ca/Fe] of 0.40 ± 0.05 is derived**, a typical value for [α/Fe] in halo stars.

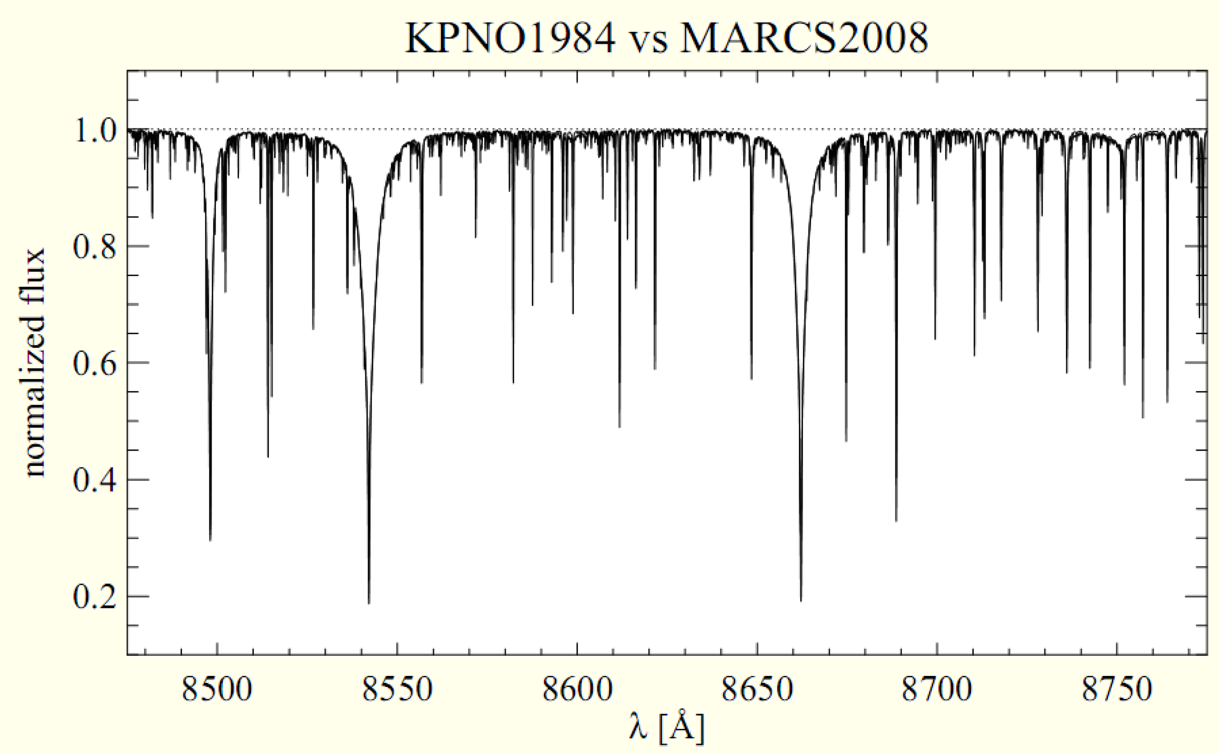

Figure 1: Spectral range covered by Gaia's RVS spectrograph: Sun observed with an FTS spectrograph (Kitt Peak atlas, Kurucz *et al.* 1984) and compared to the latest model spectrum produced with MARCS and BSYN.

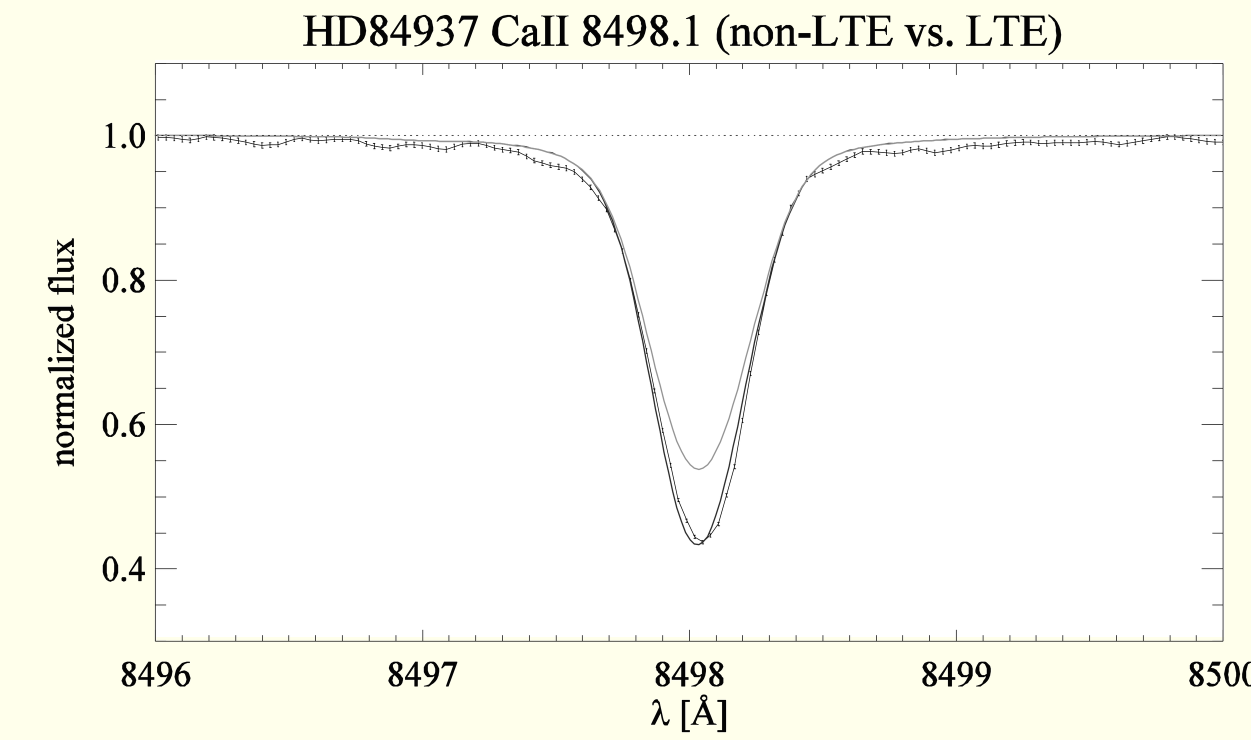

Figure 2: Ca II 8498.1 in HD 84937. A good fit is obtained at the calcium abundance derived from weaker optical lines of Ca I while the LTE profile (grey) is clearly too weak. The non-LTE effect is –0.26 dex in log (abundance).

Spin-Offs

- The photospheric NLTE line strengths of the Ca IR triplet lines will serve as a point of reference in Gaia's classification of (chromospherically) active stars (in collaboration with A. Lanzafame *et al.*, Catania, Italy)

- Optical Ca I NLTE corrections can be computed with little overhead. We plan to make these available with a web interface.

- The near-IR model spectra (R = 200 000) produced in this way may prove useful in modelling the integrated IR light of old stellar populations (e.g dSphs).