Stellar spectrum modelling for Gaia and beyond: A critical evaluation

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http://tinyurl.com/Gaia-SAM

http://camd08.ast.cam.ac.uk/Greatwiki/WGB4StellarAtmospheres

Summary

- Physical parameters for Gaia sources will be based on large grid of model stellar spectra assuming **1D+LTE for late-type stars**
- Gaia-SAM group explores importance of modelling assumptions for benchmark stars
  - solar type metal-poor star: Ca II 850 nm abundance in **non-LTE** is ~0.1 dex lower than in **LTE**
  - solar type metal-rich star:
    Fe abundance in **3D** is ~0.1 dex lower than in **1D**
  - subgiant: **optical** and **RVS** wavelength regions give same Fe and Ca abundances

Motivation

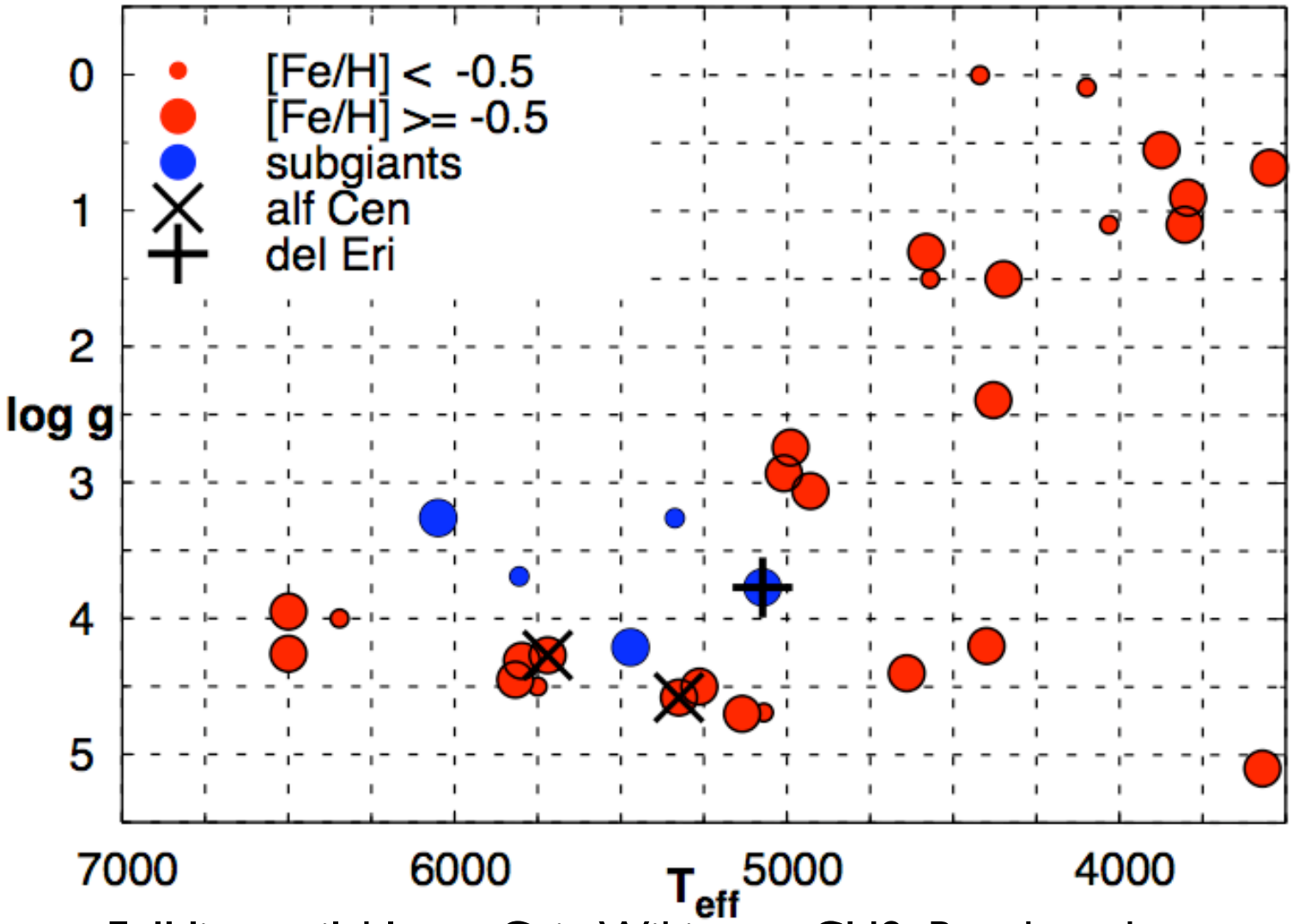
- Gaia Stellar Library is basis for parameter determination of Gaia sources (see Andreas Korn's talk)
- How realistic are these model spectra?
- Calibration for Gaia: standard stars for parameter determination – benchmark and reference stars
- The Sun is a widely used standard star for spectroscopic abundance analysis of all types of stars.

- With the Benchmark stars programme, different areas in the HR diagram each get their own standard.

Gaia-SAM group

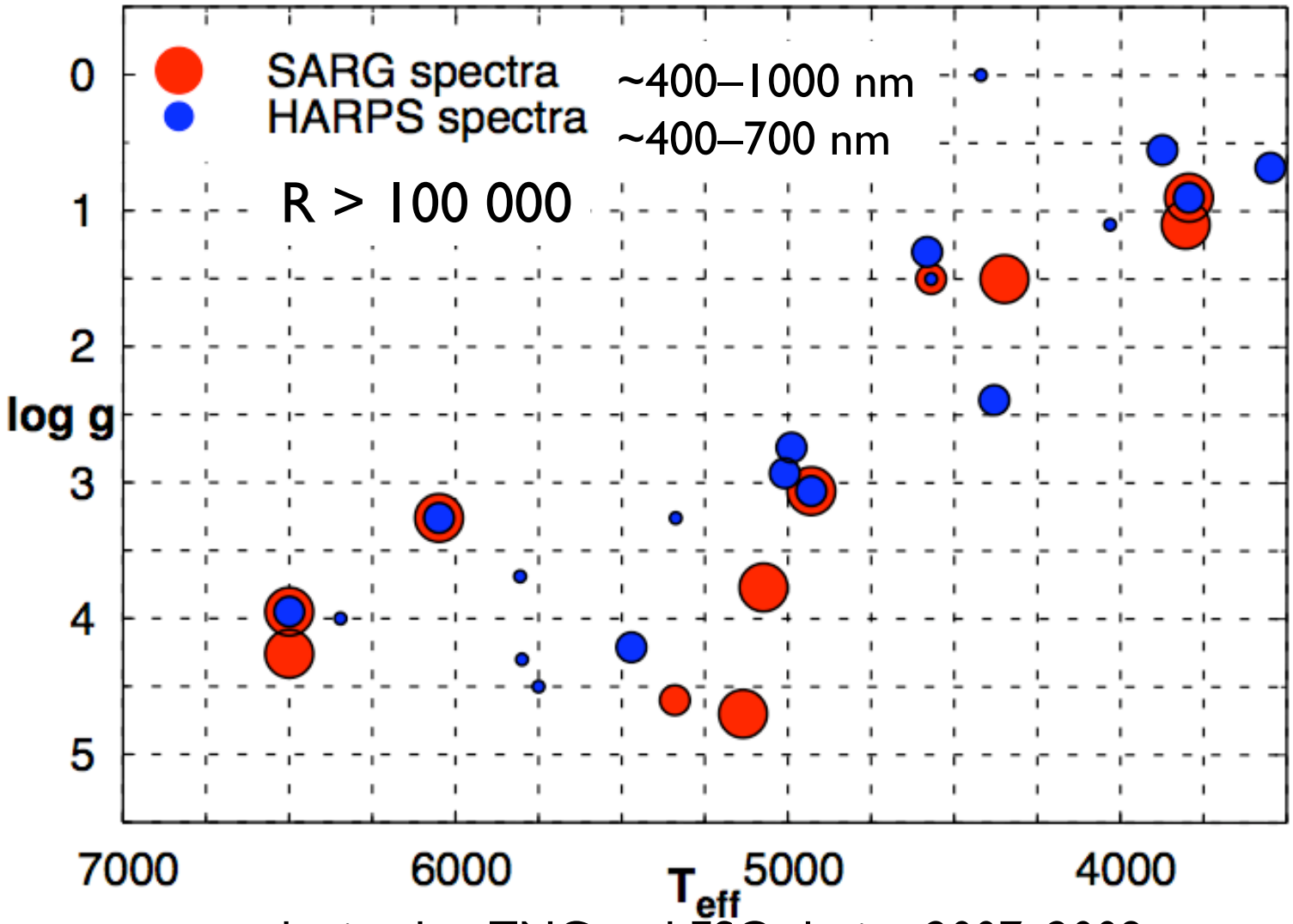
- **Selection and observations of benchmark stars** with well-known astrophysical parameters, focus on **cool stars** – $T_{eff} \leq 6500$ K
- **Evaluation of model physics** by comparing calculated and observed spectra
  - radiation-hydrodynamics in 3D for model structure
  - non-LTE for spectral line formation
  - improved spectral line data
- **Collaboration**: *Uppsala* – Heiter, Korn, Barklem, Edvardsson, Gustafsson; *Nice* – Thévénin, Bigot; *Meudon* – Feautrier et al., Kervella; *Garching* – Collet, Asplund

Benchmark star candidates



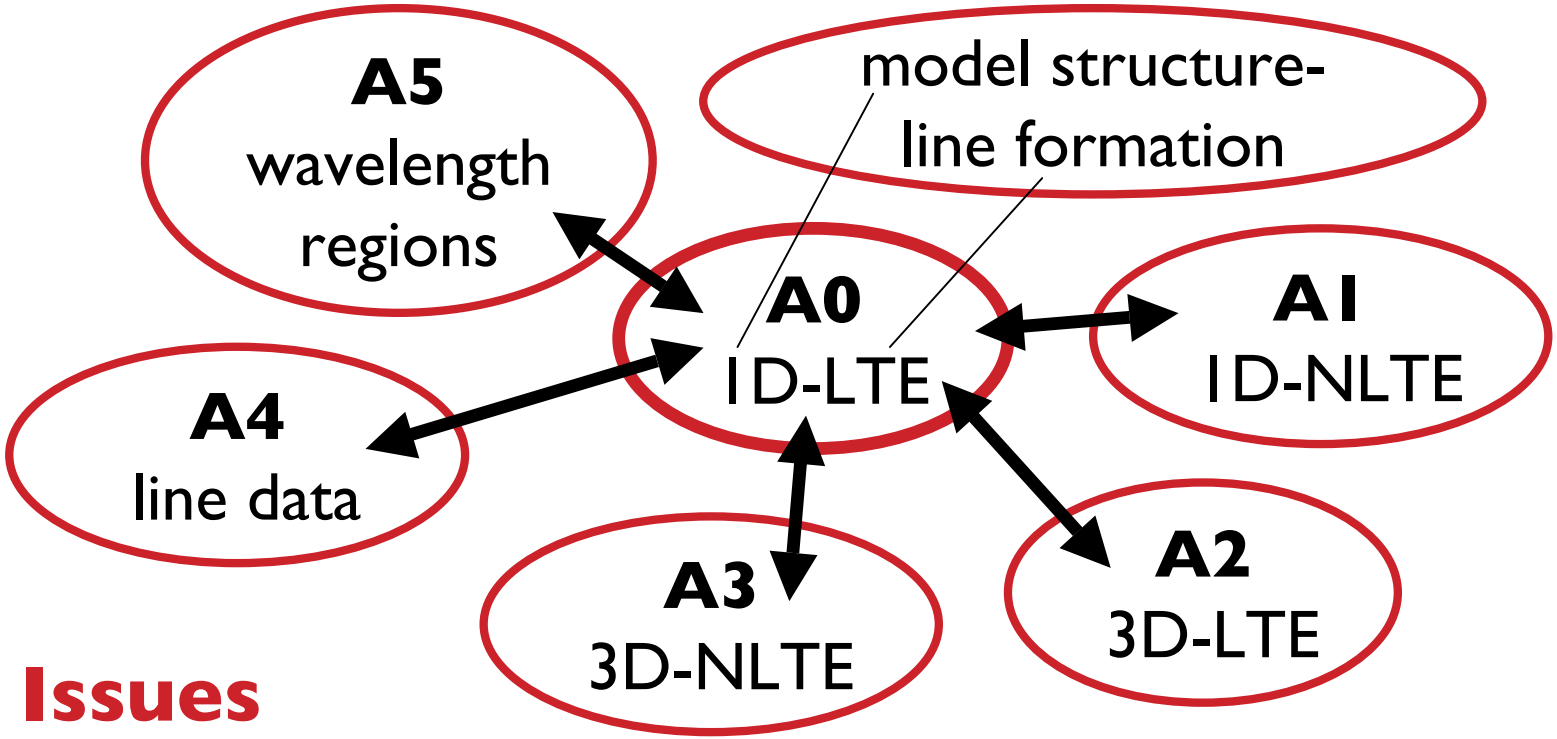
Full list available on Gaia Wiki page CU8: Benchmark stars

New observations - high-res spectra



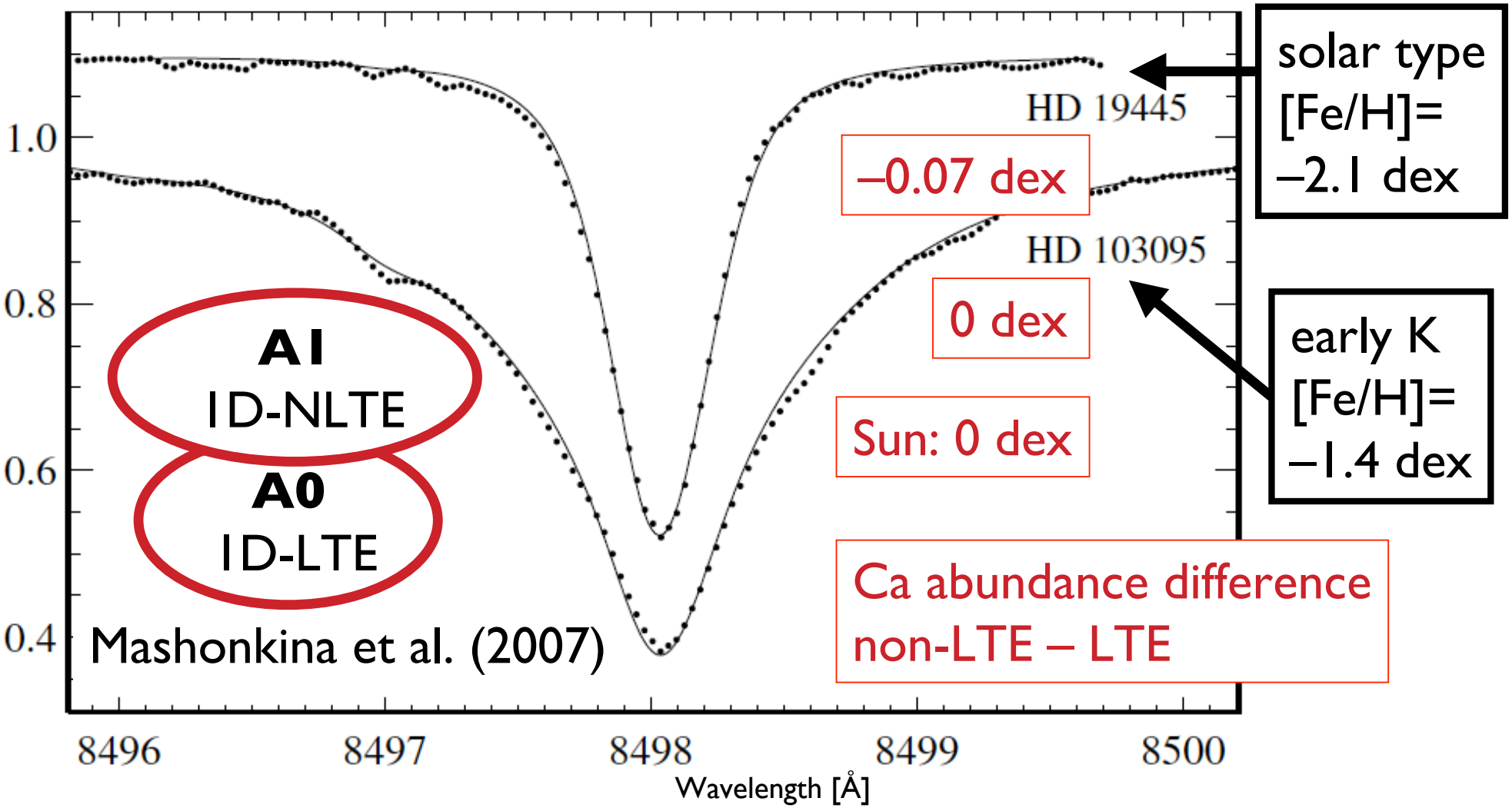
obtained at TNG and ESO during 2007–2009

Abundance tests



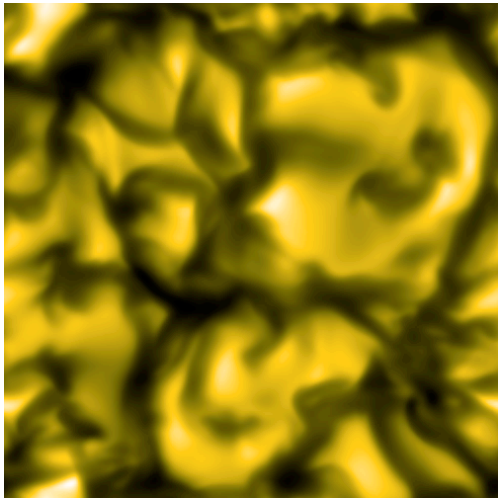
- **Issues**
  - consistency in models – must aim for real differential analysis, e.g. opacities 1D-3D
  - coupling effects (do effects add up or cancel?)

Example 1: Ca II 850 nm non-LTE



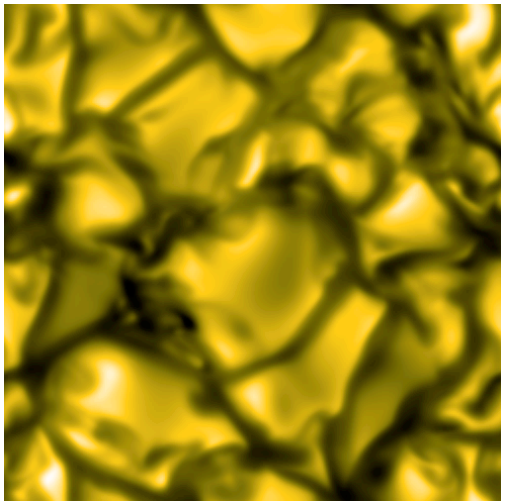
Example 2: 3D-RHD models

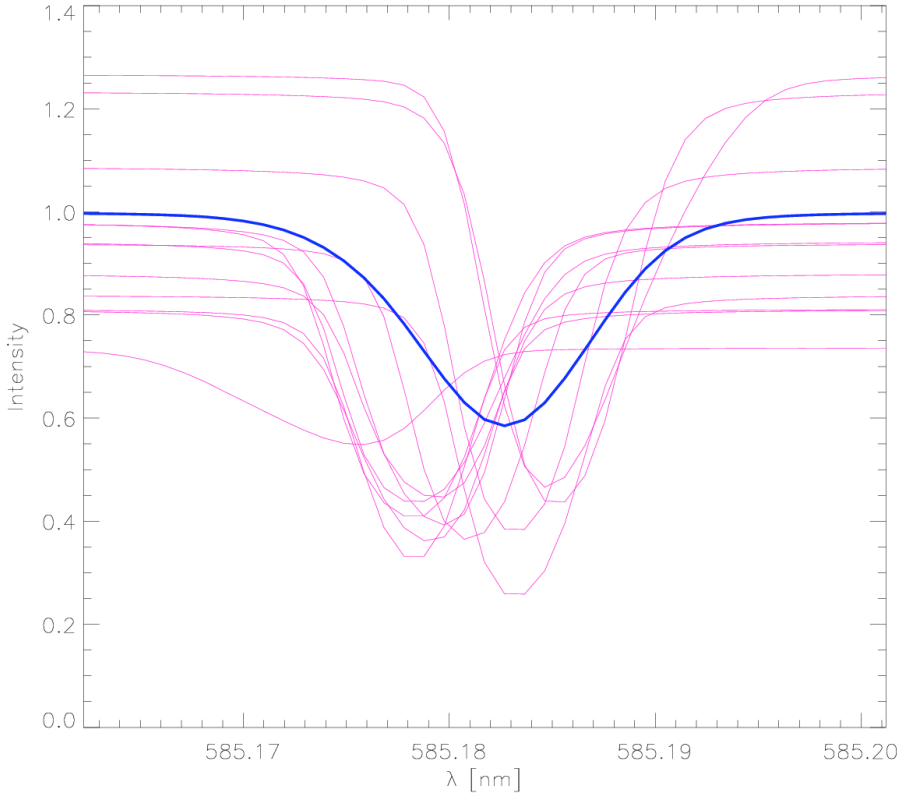
α Cen A



Sun

6000 km





Disk-center line profiles

Disk-center surface intensity

Figures: L. Bigot

Example 2: α Cen A

- **A2** 3D-LTE vs. **A0** 1D-LTE
- T_{eff}=5780 K, logg = 4.3, [Fe/H]>0
- HARPS spectrum, MARCS models, 3D models
- **Preliminary results**
  - Better fit to line profiles in 3D, without micro- or macroturbulence parameters
  - Fe abundance somewhat lower in 3D than in 1D
  - Bigot et al. (2008, Mem. S.A.It. Vol. 79, 670)

Example 3: δ Eri

- T_{eff} = 5035 K, log g = 3.8, [Fe/H] = 0
- T_{eff} from radius, log g from parallax
- **SARG spectrum**
- MARCS models, **1D-LTE analysis**
- Fit of **Fe** I, Fe II, **Ca** I lines → T_{eff} and abundances
- **optical** (555–675nm) and **RVS** wavelength regions analysed separately
- **Result:** no difference between abundances
- Makaganiuk et al. in preparation

A5 wavelength regions

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