What influences the results?

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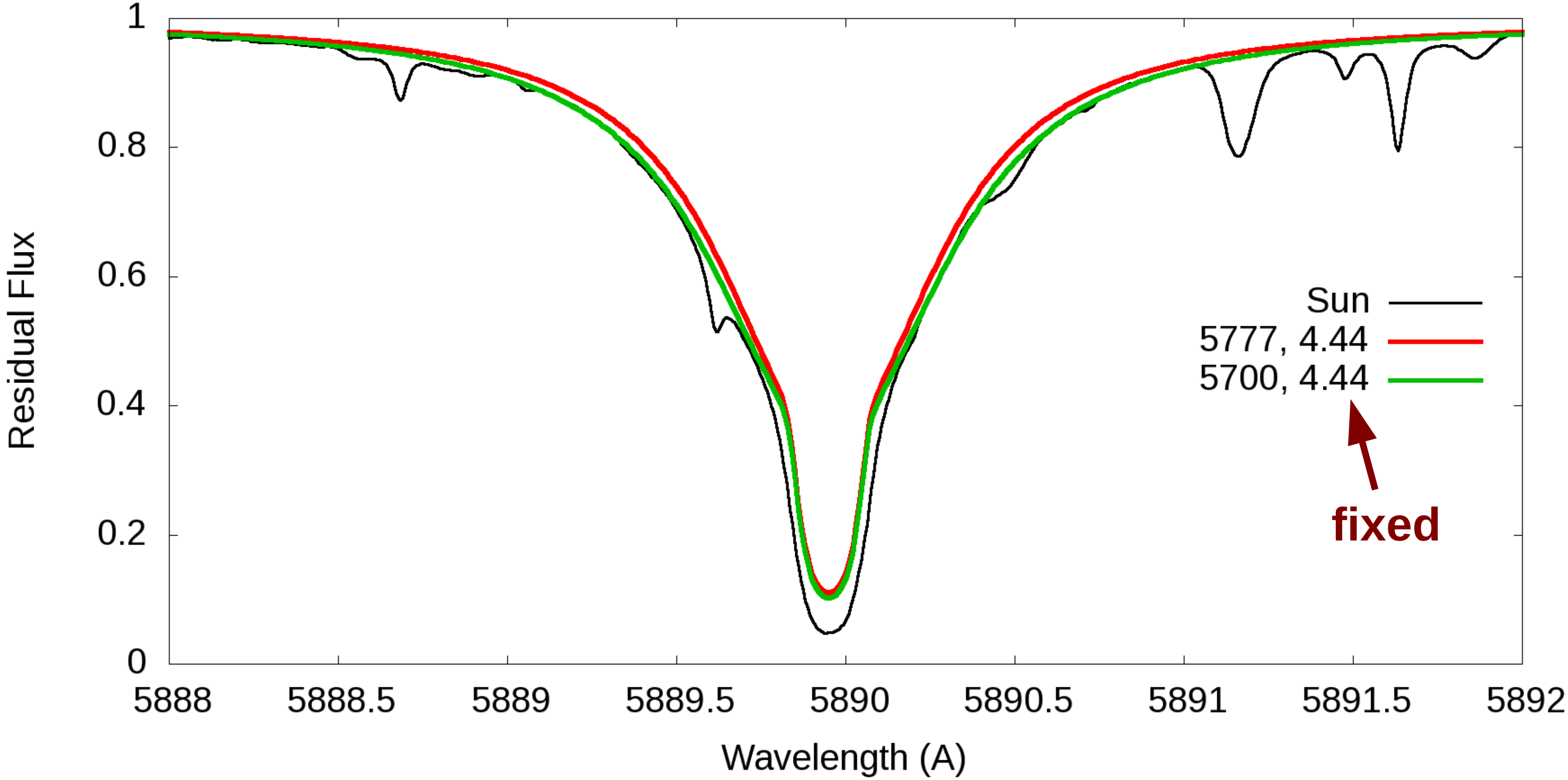
Incomplete list of influences

- Atomic data
  - Log gf, damping constants, missing/bad lines, hyperfine structure, isotopes
- Model Atmosphere Physics
  - NLTE, convection, turbulence, spots, abundance clouds
- Code internals
  - Partition functions, continuous opacities, numerical precision
- Analysis Method
  - Equivalent widths, profile fitting, choice of lines and wavelength regions
- Data Quality
  - S/N, scattered light, continuum normalisation, telluric/interstellar lines
- Stellar properties
  - Binarity, variability

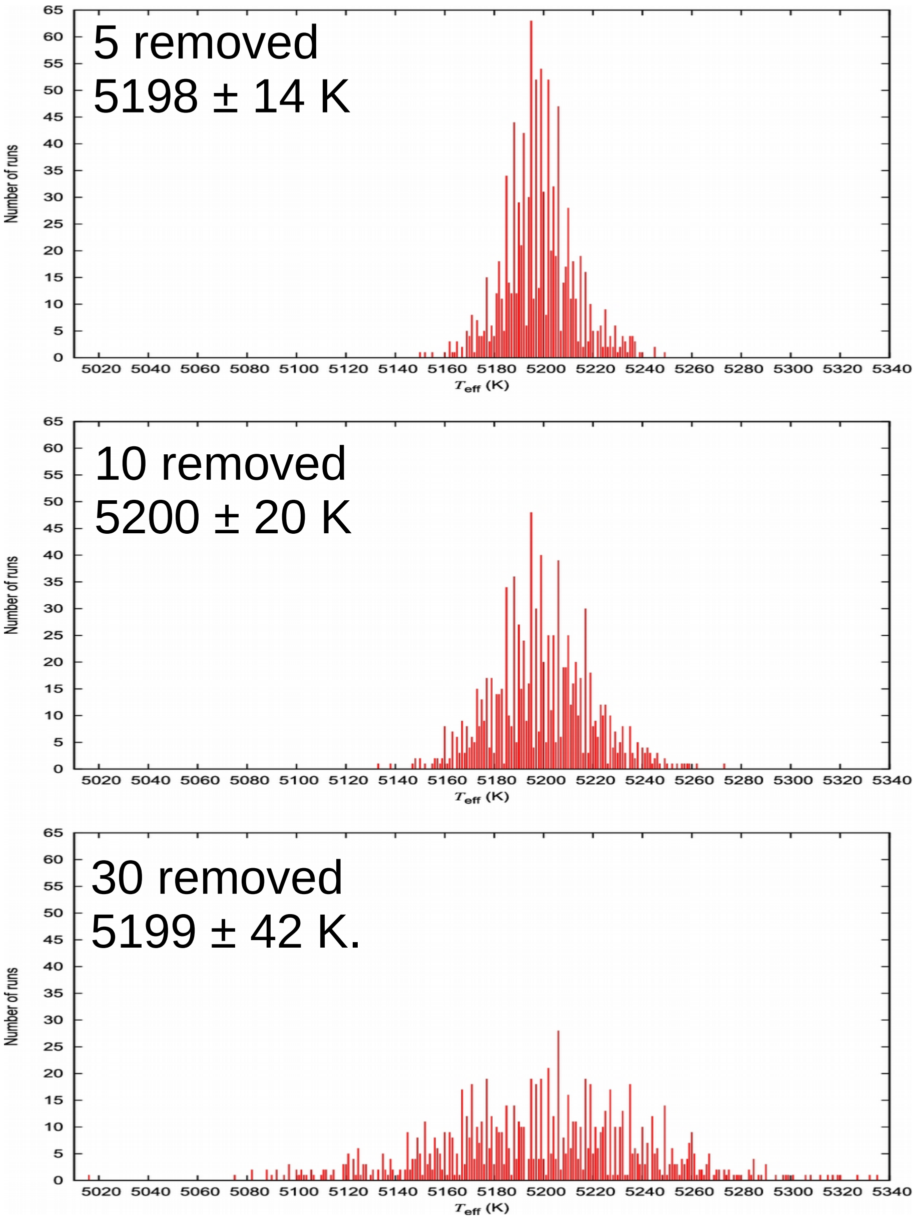
Something else!

Fixing log g



Fixing log g can lead to incorrect other parameters

Choice of Linelist



2017MNRAS.469.4850D

$T_{\rm eff}$ obtained using 72 Fe lines from linelist of 2013MNRAS.428.3164D

"The $T_{\rm eff}$ distribution for 1000 temperature runs of α Cen B with random Fe I lines removed."
2017MNRAS.469.4850D

All lines solution 5197 K

Unphysical Free Parameters

"Indeed, from a purely observational viewpoint we could use a negative mixing-length if that fitted the observational data better!"

Smalley, 2004, IAUS 224, 131

'did Barry Smalley only joke, or was he serious, when he asked, "Could we observers be allowed to use l/H < 0 if it fits the data better?"'

Dworetsky, 2004, IAUS, 224, 499

Need a reality check

- Fundamental stars can give accurate values of T_{eff} and/or log g for selected stars only.
  - Except for the Sun, good to no better than 1~2 %
- Composition is not directly measured
  - Closest is the Sun via solar system material
    - Fe 7.50 ± 0.04 (photosphere) 7.45 ± 0.01 (meteorites)
      Asplund et al., 2009, ARA&A, 47, 481

Everything else is model dependent!

Current Status

- Angular Diameters
  - ~700 in CHARM2 (Richichi et al., 2005, A&A, 431, 773)
    - Not all have sufficient flux measurements
- Binary stars with M and R
  - ~200 in DEBCAT (http://www.astro.keele.ac.uk/jkt/debcat/)
- Asteroseismic log *g*
  - *~500* (Chaplin et al, 2014, ApJS, 210, 1)

Hierarchy of Reference Stars

- Tier 0: The Sun (The absolute reference)
  - $T_{\rm eff}$, log g, abundances [Solar System]
- Tier 1: Fundamental Stars
  - $T_{\rm eff}$ and log g
- Tier 2: Benchmark Stars
  - $T_{\rm eff}$ or log g; both independent of spectroscopy
- Tier 3: Standard Stars
  - Neither $T_{\rm eff}$ nor log g, but well studied spectroscopically

F,G and K Reference Stars

- For example, the GAIA Benchmark Stars
  - 34 Stars with well determined parameters
    - **Not all have fundamental T_{eff} and log g.**

  - See
    - Heiter et al., 2015A&A...582A..49H
    - Blanco-Cuaresma 2014A&A...566A..98B
    - Jofre et al 2014A&A, 564, 133

A lot of effort expended for solar-type stars, but less so elsewhere in HR Diagram – such as A and F stars.

B, A and F Reference Stars

- Several have fundamental parameters, but mostly only T_{eff} (e.g. 2012ApJ...746..101B, 2013MNRAS.434.1321M)
  - Many lack fundamental log *g* values.
    - Can use binary stars (e.g. 2002A&0A...395..601S)
- Comparative studies of Kepler stars have been done (comparing spectroscopy and photometry), e.g.:
  - Molenda-Żakowicz 2013MNRAS.434.1422M
  - Tkachenko et al. 2012MNRAS.422.2960T, 2013MNRAS.431.3685T;
  - Niemczura et al. 2015MNRAS.450.2764N, 2017MNRAS.470.2870N

Complicated by the zoo of peculiarities.

Precision versus Accuracy

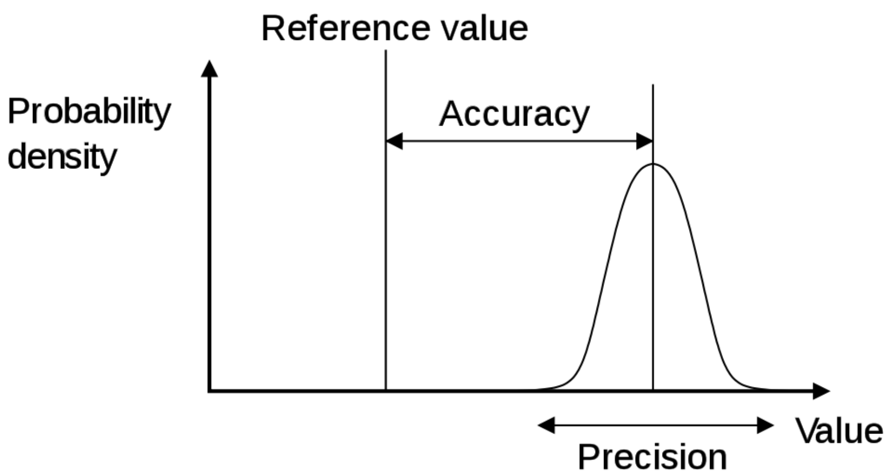
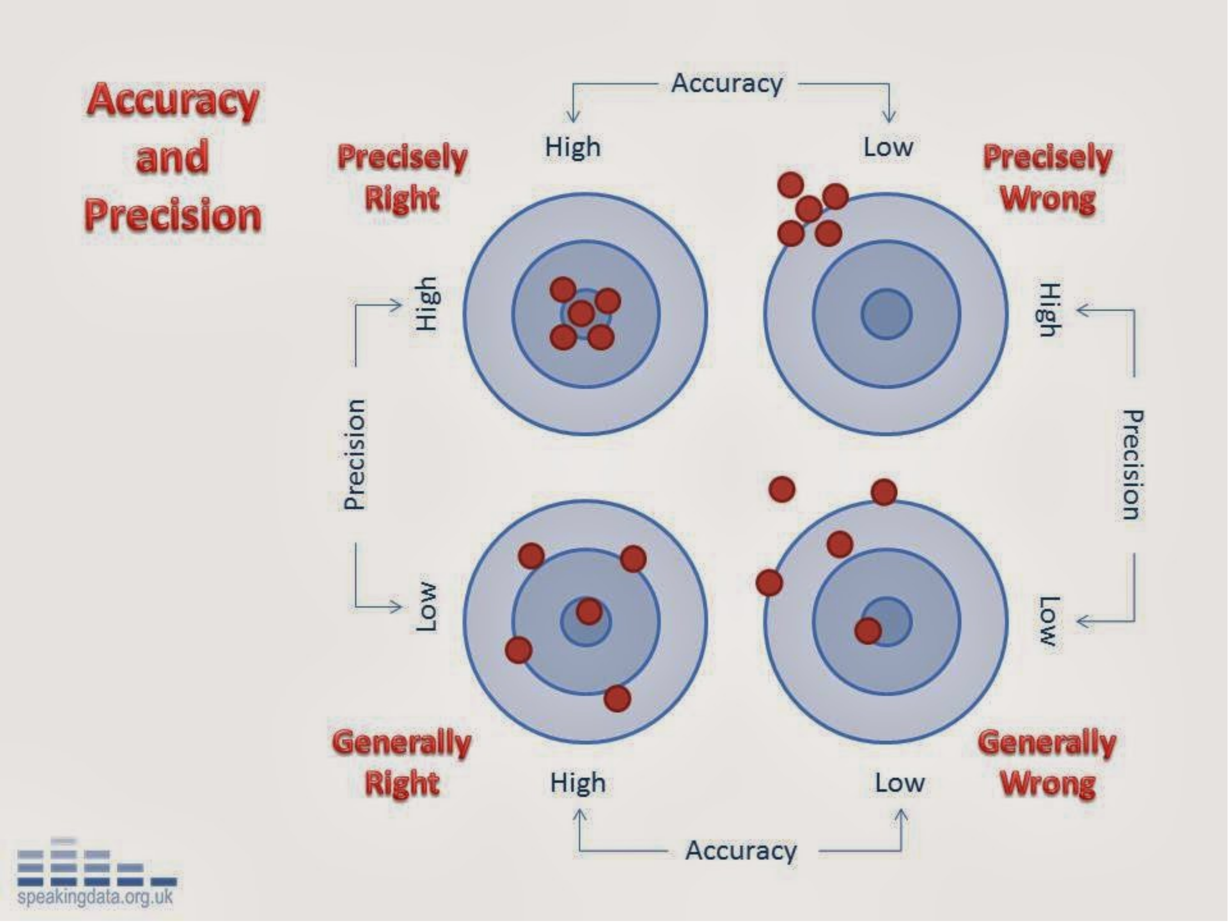


Image: Wikipedia

Errorbars in stellar analyses *usually* reflect that of the how well the model fits to the data and **not** how good is the model.

Current Status



We aim high, but do we hit low?

Outlook

- Improvements to reference stars
  - $\boldsymbol{T_{eff}}$: More angular diameters, more accurate fluxes
  - **Log *g***: More M and R from binaries, given distance and fluxes get L and T_{eff}.
  - Log *g* and R from asteroseismology
    - Not just solar-type stars, need for F, A, B stars.
- Need calibrators for other parameters:
  - Rotation, inclination, turbulence....

Summary

- There are ***(too)*** many factors which influence the results.
- Use as many diagnostics as possible
  - Spectroscopic and photometric
- Realistically the typical errors:
  - $T_{\mathrm{eff}} \pm$ 50~100K
  - log $g \pm$ 0.1~0.2 dex
  - Abundances ± 0.05~0.10 dex

High precision fitting to high S/N data is possible, but overall accuracy of parameters is less certain.