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Accurate Atomic Data for Galactic Surveys

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Atomic data and their accuracy are the *ACHILLE´S HEEL* of stellar parameter determination, since CHEMICAL ABUNDANCES and radial velocities are directly dependent on the accuracies of transition probabilities (oscillator strengths) and wavelengths [1].

> "Some physicists are now pointing out the irony that multimillion-dollar projects are producing data that cannot be analysed because of a failure to support much cheaper lab work on the ground. They have a point, and support for lab-based research that can decipher such spectra should be increased."
>
> — *Nature* Editorial. 27 Nov. 2013

Laboratories have been strongly encouraged to measure new ACCURATE values of atomic parameters!!

Gaia-ESO Survey (GES)

The **IRON spectrum** is of vital importance to obtain **stellar metallicity**. A study of the Fe I spectrum within the GES spectral range revealed over 500 lines that are strong and unblended in stellar spectra.

449 lines were good candidates for study
167 had inaccurate atomic data
120 were **absent** from the literature

Existing oscillator strengths VS New Laboratory Measurements

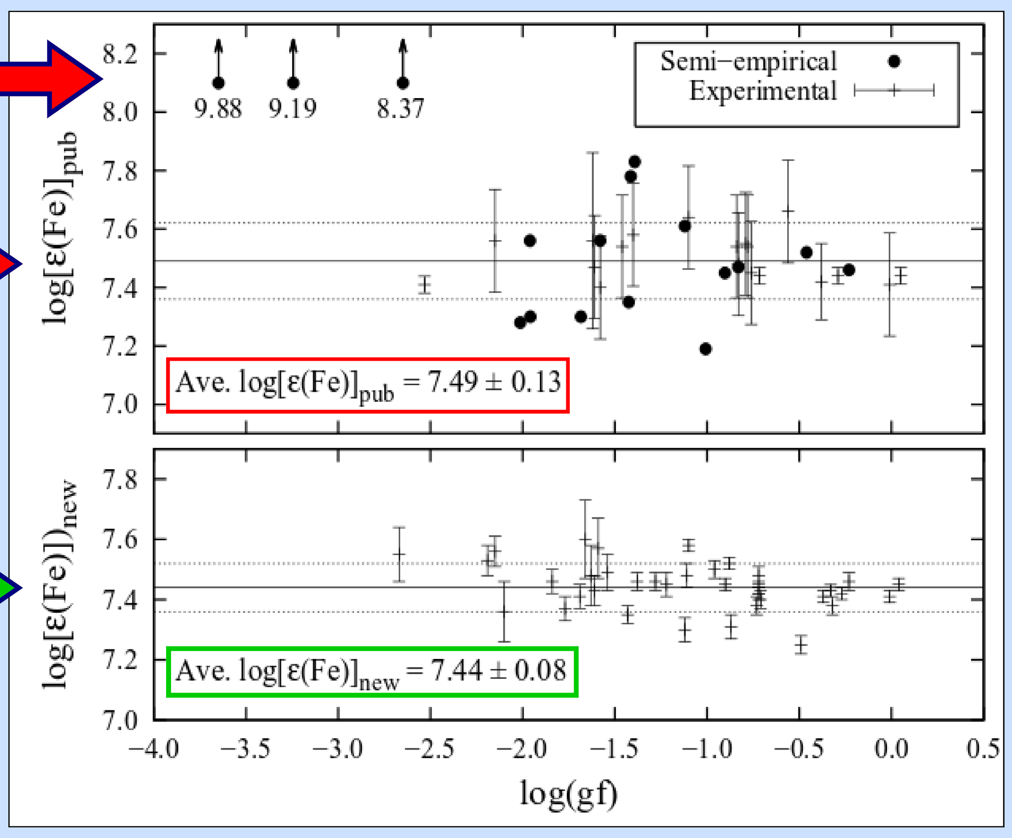
During the last years, our group has measured **new OSCILLATOR STRENGTHS (f-values)** for hundreds of transitions of **Fe I** in the laboratory [2-4]. Around 50 of them are urgently needed by GES.

To assess their impact on stellar spectral syntheses, we determined line-by-line solar Fe abundances for those that are unblended in the Sun and have good broadening parameters and continuum placement.

Older semi-empirical calculations show a large scatter. **Weak lines** have poor f-values.

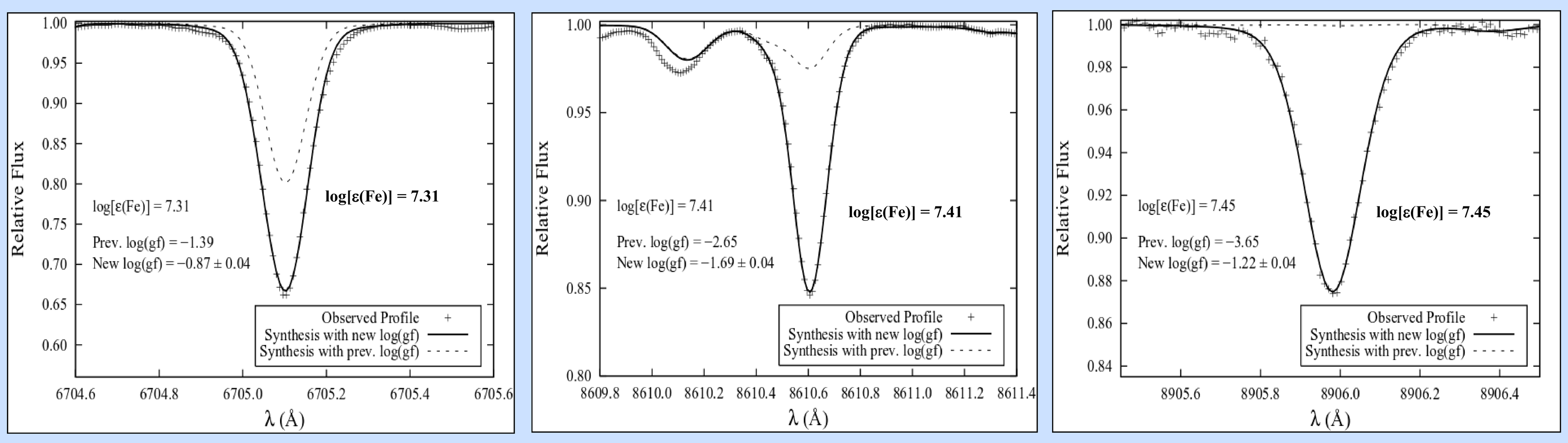
Some **older experimental data** are accurate and precise, but many are accompanied by large uncertainties.

Our new lab measured log(gf)-values have smaller uncertainties and show less scatter. The mean abundance agrees well with recent values taken from the literature.



Improved Solar line synthesis from accurate log(gf)-values

The plots below illustrate three sample line profiles to measure the Solar Fe abundance (log[ε(Fe)]). The values in bold were obtained by fitting with our new log(gf)-values. The dotted line shows the profiles that would have been obtained for these abundances with the best previously published log(gf)-values.



SDSSIII / APOGEE Survey

Several tens of new Fe I log(*gf*)s for lines important to the analysis of SDSSIII/APOGEE spectra were measured in the H-band (1.5—1.7 μm) [5].

Gaia- Future Data Releases

We would like to launch an appeal to **COLLABORATE** with all those astronomers and research groups working on Gaia who need **ACCURATE ATOMIC DATA.**

We can provide new accurate laboratory measured spectroscopic data

Including: **TRANSITION PROBABILITIES** (oscillador strengths, log(gf)), **WAVELENGTHS** and **ENERGY LEVELS** for many target elements.

Hollow cathode lamps and Penning sources are available to study neutral (I), singly- (II), and doubly-ionised (III) spectra.

Spectral range: **140 nm - 5 μm**
Resolving power: **2 000 000** at 200 nm

How do we obtain transition probabilities (oscillator strengths)?

We combine Branching fractions (BFs) measured from high resolution emission spectra with upper level lifetimes (τ) obtained from laser induced fluorescence.

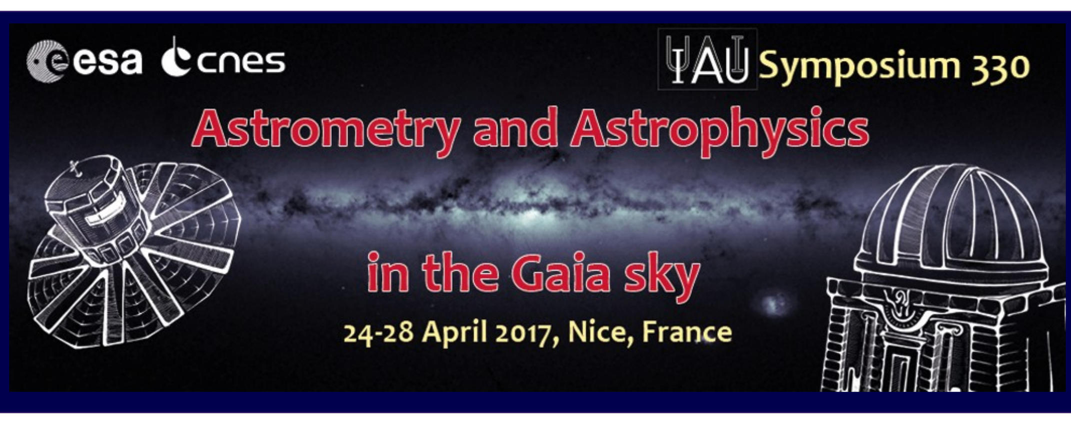
$$A_{21} = \frac{BF_{21}}{\tau_2}$$

Other data available from laboratory spectra

TYPE OF DATA	POTENTIAL USES
Line wavelengths	**Cosmoslogy**: Variations of fundamental constants
Atomic energy levels	**Astrophysics**: Improved theoretical modelling of lines
Hyperfine splitting parameters	**Astronomy**: Improved stellar synthesis
Molecular absorption **cross-sections**	**Exoplanets/Early Earth**: Atmospheric chemistry
Studies of Isotopes and Isotopologues	**Chemical evolution** of stars, galaxies, planets etc.

Bibliography

[1] Bigot, L. and Thévenin, F. 2006, MNRAS, **372**, 609.
[2] Ruffoni, M. P., Den Hartog, E. A., Lawler, J. L., et al. 2014, MNRAS, 441, 3127.
[3] Den Hartog, E. A., Ruffoni, M. P., Lawler, J. L., et al. 2014, ApJS, 215:23.
[4] Belmonte, M. T. , Den Hartog, E. A., Pickering, J. C. et al. 2017. (Manuscript in preparation).
[5] Ruffoni, M. P., Allende-Prieto, C., Nave, G., & Pickering, J. C. 2013, ApJ, 779, 17.



More information is available online: www.sp.ph.ic.ac.uk/~julietp/FTS/

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