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New solar oscillator strengths from Kiev

Abstract

We briefly review the Kiev program for determining oscillator strengths of Fraunhofer lines from the optical solar spectrum. It has recently resulted in a new compilation of *gf*-values for nearly two thousand lines (Gurtovenko and Kostik 1989).

The Solar Photosphere as a Furnace

The solar photosphere may be regarded as a natural furnace from which Fraunhofer lines originate in order to enable the measurement of their oscillator strength. As such a furnace, the photosphere provides important advantages:

- the number of measurable lines is large;
- the measurable lines are often precisely the ones needed in composition studies of other stars;
- the furnace properties are rather well known.

In contrast, laboratory measurements used to have very large errors until the precise Oxford measurements became available (*e.g.* Blackwell *et al.* 1982), while such high-precision data exist for only a few lines which mostly are less suitable for stellar abundance determinations, being too strong or located in the overly crowded blue and violet spectral regions (see Grotrian diagrams in Rutten 1983 or Rutten and Kostik 1988).

The disadvantage of the solar photospheric furnace is that all errors in the employed modelling of the solar line formation propagate into the derived *gf*-values. *A priori*, one would expect such modelling errors to be quite large. Firstly, decades of solar radiative transfer research have resulted in detailed understanding of solar line formation, indicating that departures from LTE are non-negligible but difficult to quantify for many lines and spectral species (see Mihalas 1978 and Vernazza *et al.* 1981). Second, the solar photosphere is obviously inhomogenous. It displays granulation as a result of vigorous convective overshoot (see Rutten and Severino 1989), producing large variations on small spatial and short temporal scales. It bounces up and down in an intricate small-scale pattern of appreciable amplitude set by the tens of thousands of global *p*-modes which interfere together. It is pervaded by magnetic fields, largely confined in very slender kilogauss "fluxtubes" which contain an internal photosphere distinctly different from the surrounding plasma. Larger-scale organization exists also, both for the velocity patterns and for magnetic activity phenomena—again contributing to lateral inhomogeneity. Third, atomic parameters necessary in the modelling (even if that delivers the unknown radiative transition probability) are woefully lacking: bound-free probabilities, collision cross-sections, damping "constants" *etc.* are mostly unknown.

Surprisingly, solar *gf*-determination employing simple standard plane-parallel modelling assuming the validity of LTE and using "microturbulent", "macroturbulent" and "damping enhancement" fudge parameters to take care of the inhomogeneities and atomic unknowns works astonishingly well. The classical example was set by Holweger (1967); it has been followed in many studies since—including the Kiev ones.

The Kiev Program

A program of determining empirical oscillator strengths from the optical solar spectrum was started at Kiev in the early eighties. Its first results were two extensive lists of Fe I *gf*-values (Gurtovenko and Kostik 1981a, 1981b). They were found to be of good quality, both in comparisons with laboratory data (Wiese 1983, Cowley and Corliss 1983) and in studies of their internal consistency (Rutten and Kostik 1982, Rutten and Zwaan 1983, Rutten and Van der Zalm 1984, Rutten and Kostik 1988).

The latter studies have also led to understanding of why such simplistic fits are actually so good (typically better than 0.1 dex or 25%); see the review by Rutten (1988b) for explanation, Rutten and Van der Zalm (1984) for recipes and Rutten (1988a) for examples. In fact, they are so good that the issue can be turned around: patterns in the internal consistency of such fits can be useful diagnostics of solar line formation.

The New Kiev Compilation

The success of these earlier Fe I lists have led to continued effort at Kiev. Very recently, Gurtovenko and Kostik (1989) have published a new compilation of solar *gf*-values, specifying oscillator strengths for 1958 lines from 40 chemical elements. Diagnostical analysis is in progress; first results are given in Gurtovenko *et al.* 1989.

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