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On the quality of stellar atmosphere parameters and abundances derived from spectroscopy

Ch. Stütz, N. Nesvacil, L. Fossati and D. Shulyak

Institute for Astronomy of the University of Vienna,
Türkenschanzstraße 17, 1180 Vienna, Austria

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Abstract. Abundance analyses are usually performed by empirical methods. The existing semi-automatic software packages mostly are strongly dependent on an initial or fixed set of fundamental parameters and the set of lines provided by the researcher. Furthermore the implemented iterative process of fitting certain lines or regions of a star's spectrum often ignores the parameters' physical meaning. Thus, the accuracy of the derived results and moreover the comparibility of different investigations are in many cases left to the researchers judgement. However, several attempts to study how uncertainties in single fundamental or line parameters translate to the precision of abundance determination have been successfully conducted. We started to investigate the combined effect of variations in effective temperature, surface gravity, microturbulence, line blending, metallicity (i.e. abundance pattern) together with the number of atomic lines used.

Our aim is to be able to make quantitative statements on this general uncertainty in abundance analysis and to define a way to automate determination of fundamental parameters and element abundances whilst: providing a traceable measure of accuracy for the results; being not restricted to a certain instrument, resolution or object; minimizing the effort of preparation.

Key words: stars: chemically peculiar – stars: abundances – techniques: spectroscopic

1. Introduction

Abundance analysis of chemically peculiar stars, whether it is done via measuring equivalent widths or fitting synthetic spectra, is highly nontrivial. Additionally to the usual uncertainties of observations, the reduction process and insecure atomic parameters, also the classical model atmospheres and line synthesis are less accurate in describing these stars' atmospheres. Furthermore we cannot blindly trust photometric calibrations, since these have been derived for so called normal stars. As a consequence, when analysing CP stars, it becomes mandatory to reevaluate the fundamental atmospheric parameters such as $T_{\rm eff}$, $\log g$ and $v_{\rm mic}$ at each iterative step of the abundance analysis. All of the mentioned error sources have been investigated already, but mostly just for some special object and in the sense of maximum deviation, and more important their combined effect did not enter into the uncertainty of the final abundances.

Thus, the overall quality of the derived results and, moreover, the comparability of different investigations are in many cases left to the researchers judgement. We intend to put this on a more impartial basis.

2. Method

Using LLmodels (Shulyak *et al.*, 2004) and ATC (Stütz *et al.*, 2006) we generated a multidimensional grid of sets of atomic line fits around the spectroscopically derived parameter set (Fossati *et al.* in press) of the Am star HD 73730. The dimensions of our grid is 7000 – 9000 K ($\Delta = 200$) and 3.2 – 4.8 dex ($\Delta = 0.2$) in $T_{\rm eff}$ and $\log g$ respectively. The other parameters we want to explore were varied within the following intervals: $v_{\rm mic}$ [1,4] km s^{-1}, number of selected lines via the maximum allowed line blending (BF) [0,90] %, metallicity ($[N_{\rm metal}/N_{\rm tot}]$) of the atmospheric models [-1,+1].

3. Discussion and goals

We tested our methods against whether certain relations (assuming LTE, line abundance has to be uncorrelated with $\log_{10}$(linedepth) or excitation potental, etc.) hold for the spectroscopically determined set of fundamentals. As expected, these assumptions and approximations which have been applied in many abundance analyses over the past years, proved to be valid. However, it seems that for the single relations the solution is far from being unique but an optimum value can be determined. Analysing these patterns should tell us about structure and sizes of typical uncertainties we can expect from abundance analyses and which sets of lines are generally best to use for certain purposes. We can also compare the classical technique to straightforward chi-square line profile fitting.

An automatic routine for selecting atomic lines suitable for an abundance analysis according to the approximate type of a star, its observed spectrum and the line blending has been developed and will be advanced along with this study.

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