ESF – Science Meeting – Final Report

1 GREAT-ESF Workshop on Comparative Stellar Spectrum Modelling - Summary

The *GREAT-ESF Workshop on Comparative Stellar Spectrum Modelling* took place on 23 – 24 Aug 2010 at the Department of Astronomy of the University of Vienna. It was organized by the proposers and convenors, T. Lebzelter and U. Heiter, and endorsed by the GREAT-ESF network working group "Stellar atmospheres" as well as the IAU working group on Abundances in Red Giants. Funding was provided by the ESF, as well as the Robert F. Wing support fund at Ohio State University. The workshop had 33 participants, including 16 speakers.

2 Description of the scientific content of and discussion at the event

Accurate stellar parameters are important for studying the chemical evolution of the Galaxy, as well as other applications of data from the upcoming Gaia mission. Parameters determined by analysis of high-resolution spectra have great potential but are suffering from systematic uncertainties due to inadequate physics of model spectra and different approaches and methods used for analysis.

The aims of the workshop were to identify key areas where model spectra can and should be improved, and to determine the influence of different analysis methods on the outcome of stellar spectrum analysis. In the context of Gaia/GREAT, giant stars play an important role, since they will probe the Galaxy to large distances. They also have cool and extended atmospheres, which are particularly difficult to model. The focus was therefore on the analysis of giant star spectra.

The workshop itself was preceded by considerable efforts from the convenors and speakers in the form of a spectrum analysis experiment. In advance of the workshop, four high-quality spectra for four different stellar parameter combinations were prepared, and sent to several participating groups in a format which did not include information on the stellar parameters. Two of the spectra were observations of two giant stars in the optical wavelength range (490 to 890 nm) with a spectral resolution of 80000 and a signal-to-noise ratio of about 500. The other two spectra were calculations in the infrared wavelength range (1545 to 1568 nm), with a simulated resolution of 70000 and a simulated signal-to-noise ratio of 125.

The spectra were accompanied by auxiliary data, namely a list of reference atomic line data, although the experiment participants were free to use their own atomic line data. Also, detailed instructions were provided, with information on the spectrum format and quality, and approximate V–I, J–K, and V–K colors for each star. The experiment participants were asked to find the "best-fitting" model spectrum for each of the provided spectra, using their respective stellar atmosphere and stellar spectrum modelling codes. They were also asked to provide estimates of T_{eff}, $\log g$, [Fe/H], Ca and Si abundances, and the C/O ratio for each target, based on their modelling.

In total, 13 groups participated in the experiment, and 11 of those were able to participate in the workshop, where they presented their results. Two of the participants sent their

results, and they were presented by one of the convenors. A major part of the two workshop days was thus dedicated to discussing the results of the spectrum modelling experiment. The experiment participants were divided into three groups, according to similar modelling codes being used (group 1: MARCS based, group 2: ATLAS based, group 3: PHOENIX, CODEX and others). Each "group session" consisted of about 20 min long presentations by each speaker, as well as a 30 min discussion of the methods and results between all workshop participants.

The experiment presentations were complemented by general presentations on stellar atmosphere modelling, properties of the target stars, spectral line data, infrared observations, and the Gaia mission. Also, two special discussions were held, focussing on the advantages and disadvantages of different analysis methods, and on how to proceed after the workshop.

As a result of these discussions, it became clear that a second spectrum comparison experiment was needed, in order to interpret the results of the workshop experiment. The set-up and coordination of this second experiment was decided (see next section).

Also, the experiment participants agreed on preparing a publication for a refereed journal, which will summarize the outcome of the workshop. Possible journals as well as a preliminary structure for the article were discussed. The publication will include the outcome of the first and second spectrum modelling experiments, as well as a summary of the workshop discussions. All presentations and discussions were recorded using an audio device, which will aid the paper preparation.

3 Assessment of the results and impact of the event on the future direction of the field

The remarkable achievement of this workshop was to bring together a rather large number of experts in the field. In particular the pre-workshop experiment provided a rare opportunity for a direct comparison of a variety of stellar spectroscopic analysis methods, which shed some light on the uncertainties in stellar parameter and abundance determination.

The parameters estimated by the different groups participating in the spectrum modelling experiment showed in part significant differences. The presentations and discussions made clear that the spectrum analysis procedure is a complex process involving a range of free parameters. A direct comparison of the results was not possible in all cases, because of differing initial assumptions for some of the parameters. In order to be able to interpret and compare the results, it was agreed that each group should calculate a spectrum covering the whole optical wavelength range with a fixed set of parameters. Only the spectral line data were allowed to vary, because the effort for adapting a homogenized data set for each code would have been too great.

A new set of instructions was sent to the different groups shortly after the workshop, and all test spectra were collected by the end of September. A compilation and graphical representation of the direct spectrum comparison was sent to all participants. A discussion of the presentation of the workshop results and the follow-up experiment is ongoing.

While the outcome of this workshop will not solve all problems related to spectrum analysis of cool giant stars, the documentation of the experiments will contribute to a more realistic assessment of systematic errors in future parameter and abundance work.

GREAT WORKSHOP ON COMPARATIVE MODELLING OF STELLAR SPECTRA

DEPARTMENT OF ASTRONOMY, UNIVERSITY OF VIENNA, AUSTRIA

MONDAY, August 23 2010

09:00 Introduction - Heiter / Lebzelter

09:30 Results 1 - MARCS based
    On the MARCS models - Eriksson
    Eriksson
    Plez
    Lebzelter / Nowotny

11:00 Coffee break

11:30 Results 1 - continued
    Worley
    Abia
    Merle

12:15 Discussion

12:45 Lunch

13:45 Results 2 - ATLAS based
    On the ATLAS models - Heiter
    Neilson
    Norris
    (Mora)
    Peterson

15:25 Discussion

15:50 Coffee break

16:20 Special discussion:
How to find the best fit

17:00 Paper preparation for experiment
    participants

19:30 Workshop dinner

TUESDAY, August 24 2010

09:00 Results 3 - PHOENIX, CODEX
    and others
    Short
    Ireland
    (Tsuji)

10:15 Discussion

10:45 Comparison of spectrum modelling
    results to fundamental parameters
    of the target stars – Heiter / Wittkowski

11:15 Coffee break

11:45 Atomic data: New, planned, and needed - Wahlgren
    VADMC - a Virtual Atomic and Molecular Data Centre - Heiter
    CRIRES-POP - Lebzelter

13:00 Lunch

14:00 The perspectives of Gaia:
    millions of spectra - Thevenin

14:30 Summary discussion -
    where we are / what should
    be done?

16:00 End of workshop