ESF – Exchange Grant -Final Report

Title of the proposed research project:
Improvements on charcterization of Solar Type stars, chemical abundance derivation applied to ESO-GAIA Survey data.

Applicant: Hugo Tabernero

Institution: Universidad Complutense de Madrid (UCM)

Visited institution: Centro de Astrofísica da Universidade do Porto (CAUP)

Purpose of the visit:

During the stay at the "Centro de Astrofísica da Universidade do Porto" (CAUP), the PhD. student Hugo Tabernero has worked with the exoplanet group led by Dr. Nuno Santos. The aim of this exchange visit was to do the following tasks:

1. Improvement of existent automatic codes to characterize solar-type stars using high-resolution spectra.

2. An automatic code capable of obtaining chemical abundances of several elements.

3. Analysis of a large number of high-resolution UVES spectra from the "Gaia-ESO Survey" (GES) using these automatic codes.

Work carried out during the visit:

1-Characterization of solar type stars (FGK spectral types):

This characterization implies the derivation of stellar atmospheric parameters: Effective temperature ($T_{\rm eff}$), Surface gravity (log g), metallicity ([Fe/H]), and the microturbulent velocity (ξ).

For that purpose a seminar was devised to put in common the methodologies employed by each previously existing codes from the collaborating institutes: *StePar* (Tabernero et al. 2012) and the code from CAUP (Santos et al. 2004, Sousa et al. 2008). Both codes employ any previously selected Fe I-II line list to derive the stellar atmospheric parameters. Our methodology relies on stellar atmospheric models, such as KURUCZ (Kurucz 1993) and MARCS (Gustaffson et al. 2008). In addition, we use some additional tools for the treatment of chemical abundances (MOOG: Sneden 1973 or TURBOSPECTRUM: Álvarez & Plez 1998).

We got started the improvements on both codes. First of all, we wanted to compare the speed of the codes. Also we studied the worst conditioned cases (specially very cool stars). For these stars we made tests with the Sousa et al. (2008) Fe I-II line list and the specially selected line list from Tsantaki et al. (2013).

StePar tends to be faster since the maximum number of computations done is in the worst case less than the CAUP automatic code. From this point, we discovered that it is possible to truncate the number iterations to make the code from CAUP faster without loosing any precision in the parameters derived.

In the case of very cool stars both codes tend to be very slow, and sometimes they get very unphysical results. It is possible to correct these “wrong” results by removing very intense/weak lines.

2-Automatic code for obtaining chemical abundances:

The determination of chemical abundances from several chemical elements from a given star requires prior knowledge of the stellar atmospheric parameters. Once these parameters are known it is possible to obtain its chemical composition for each element. To perform this task it is necessary to make use of abundance treatment codes, such as MOOG (Sneden 1973), and TURBOSPECTRUM (Álvarez & Plez 1998).

An automatic code was implemented to carry out this task. The code was meant to deal automatically with larges amounts of data. This is applicable to the data coming from the “Gaia-ESO Survey” (GES).

The code obtained can produce consistent results with previous studies (such as Reddy et al. 2006). We also decided to treat different types of stars differently, by choosing different spectral lines for different types of spectra.

In the end we decided to employ one set of lines for the dwarf stars, and another line list for giant stars. With these in mind we are capable of treating large amounts of data, for several chemical elements. We can expand and change the choice of elements and line lists with total freedom without needing to alter the already constructed code.

3- “Gaia ESO Survey” (GES) data:

GES, “Gaia-ESO Survey” is a European collaboration whose objective is to observe 100,000 Milky Way stars. The GES survey will cover different structures of our Galaxy (from Halo to the disk stellar

forming regions). It is intended to acquire kinematical and chemical information from Milky Way stars.

The GES collaboration obtains data from observations at the European Southern Observatory (ESO). The observations make use of the VLT telescope in combination with UVES and GIRAFFE spectrographs. The observing program started in January 2012, and will continue for 5 more years. A total of 300 nights has been granted (Gilmore et al. 2012), periodical data releases of data and results to the public are scheduled in a six-month basis.

During the stay we have computed chemical abundances for some chemical elements, since they have to be derived for the first six months of the GES data.

Main results obtained:

- For characterization of solar-type stars we have compared the capabilities of the codes from both institutions. The codes are essentially equal, we have tested computing times and some ill-conditioned problems and worked on possible solutions for them.

- An automatic code for deriving elemental abundances for several elements has been constructed. The code can deal with large amounts of data.

- Interchange of the “Gaia ESO Survey” line lists from both groups to improve the existing ones.

- The student Hugo Tabernero has given two seminars: The first one was about the characterization of solar-type stars and the second one about his PhD thesis. Serving both of them as good practice for the future thesis defence.

Future collaboration:

The future collaboration will be consistent of the interchange of analyzed results from “Gaia ESO Survey” data, before submitting them to the GES collaboration. This will improve results and provide a better understanding of them.

Projected publications/articles:

A paper related to the selection of Fe I-II to provide a self line list to be used within the “Gaia ESO Survey”, it will be send to Astronomy and

Astrophysics Journal. This work is lead by Sérgio Sousa (CAUP) and it is done in collaboration with other people working on the “Gaia ESO Survey”.

References:

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