Research Networking Programmes

Exchange Visit Grant - Scientific Report

Interferometric Observations of Benchmark Stars for the Gaia mission and the Gaia-ESO survey

These will provide constraints on effective temperatures that are independent from traditional spectroscopic and photometric techniques.

Application Reference number: 4947

1) Purpose of the visit:

The main purpose of the research visit was to assist in delivering precise atmospheric parameters of stars observed by two large surveys: the astrometric space mission Gaia and its ground-based spectroscopic follow-up Gaia-ESO. The European Space Agency's astrometric Gaia satellite will over a five-year period, repeatedly measure the positions of more than a billion stars in our Galaxy. And the spectroscopic follow-up programme Gaia-ESO will provide chemical compositions for a subset of the Gaia stars. The determination of fundamental astrophysical parameters and elemental abundances for stars is among the main challenges for Gaia. In order to deliver precise atmospheric parameters of stars observed by the surveys, a carefully selected sample of stars that are used as calibrating standards in the Gaia mission and the Gaia-ESO Survey were observed using optical interferometry. The interferometric observations are ideal since they provide precise direct measurements of angular diameters, and thus deliver accurate direct determination of effective temperatures that are independent of traditional spectroscopic and photometric techniques. The directly determined effective temperatures are necessary for testing and improving stellar-atmosphere models and synthetic spectra that are required for the correct assessment of the atmospheric parameters of the Gaia sources.

Dates of the research visit:
04/05/2015 - 05/07/2015 - two months

2) Description of the work carried out during the visit

During the exchange visit the following tasks were carried out:

1. Data reduction of obtained data from the extended and consistent interferometric study using the AMBER instrument at the Very Large Telescope Interferometer (VLTI). The proposal 'Interferometric Observations of Benchmark Stars for the Gaia Mission and the Gaia-ESO Survey' was awarded 84 hours and was ranked by the OPC with priority A (Principal Investigator; I. Karovicova - applicant; ID: 094.D-0572).

   The AMBER instrument operates in the near-infrared. Interferometry in the near-infrared is the best method to probe the physical conditions near the stellar photosphere. The interferometric observations were carried out in the medium resolution mode (MR, R 1500) from October 2014 till March 2015. The MR mode in the H band (1.54 μm-1.82 μm) gives the highest angular resolution and includes a spectral channel at 1.7 μm that is almost free of molecular contamination and allows us to accurately measure the continuum diameter itself separated from the CO and H_2O bands. This allows the most accurate value of the $T_{\rm eff}$ to be recovered. For the AMBER data reduction the *Amdlib* package with the yorick interface was used (provided by the Amber consortium and the Jean-Marie Mariotti Center).

2. Data calibration in collaboration with Dr. M. Wittkowski (ESO)

3. Preparation of an observing interferometric proposal for selected targets from our extended sample in order to obtain additional information in collaboration with the members of the Gaia-ESO Survey group prof. G. Gilmore, Dr. P. Jofre, Dr. C. Worley, Dr. A. Hourihane (all IoA) together with Dr. M. Bergemann (MPIA) and Dr. K. Lind (UAO) and other Gaia-ESO Survey members.

4. Preparation of Observation Blocks (OBs) for our follow-up AMBER/VLTI program. The interferometric proposal: 'Interferometric Observations of Benchmark Stars for calibrating large stellar surveys of the Milky Way.' was as well as the previous proposal ranked by the OPC with priority A (Principal Investigator; I. Karovicova - applicant; ID: 096.D-0219). The observation will be again carried our using the interferometric AMBER instrument at the VLTI. The observations will be collected during the observing period P96 (October 2015 - March 2016). The stars will be observed in the medium resolution mode (MR, R 1500) in the H band (1.54 μm-1.82 μm).

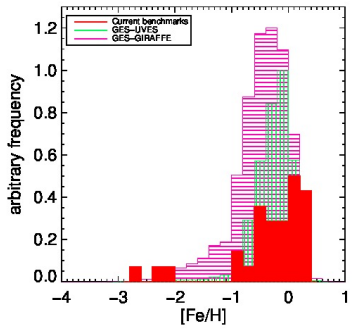

Figure 1: Fig. 1: Arbitrary frequency versus metallicity. The ping color shows regions observed by Gaia-ESO (GES) GIRAFFE Survey, the green color - GES UVES, the red region shows original Benchmark stars (observed and analyzed by various methods). The aim of our proposal is to observe stars with metallicities between Fe/H= -0.7 and -3.1 targeting poorly interferometrically studied regions.

3) Description of the main results obtained

1. The data from the proposal ID: 094.D-0572 have been reduced using the *Amdlib* package with the yorick interface provided by the Amber consortium and the Jean-Marie Mariotti Center.

2. The data have been preliminary calibrated.

3. An interferometric proposal using the CHARA array has been submitted (the CHARA proposal 'Interferometric Observations of Benchmark Stars for calibrating large stellar surveys of the Milky Way' has be approved in the mean time and the observations have been scheduled. The observations will be conducted in September 2015 with total of 6.5 nights of observations). The targets were selected in collaboration with scientists of the host institute prof. G. Gilmore, Dr. P. Jofre, Dr. C. Worley, Dr. A. Hourihane as well as Dr. M. Bergemann (MPIA) and Dr. K. Lind (UAO) and other Gaia-ESO Survey members. The stars were selected from our catalog with various types of complementary information available, e.g. asteroseismic surface gravities (log(g)) and ages, high-resolution spectra taken at different facilities worldwide (VLT, Keck, Calar-Alto 2.2m telescope), parallaxes, with a wide coverage of the parameter space: $T_{\rm eff}$, log(g), and [Fe/H], etc. In this proposal, we focus on the interferometric observations of 22 metal poor stars from our complete sample. Our targets are specifically selected to cover part of the HR-diagram poorly studied with interferometry previously (Fig 1). The targets were selected based on the following selection criteria: a) accurate parallaxes ; b) suitable angular diameters; c) high-resolution spectra available, optimally including optical and near-IR ranges (i.e. UVES, CRIRES, HARPS); d) preliminary estimates of stellar parameters from spectroscopy; e) a wide coverage of the parameter space: the selected stars sample $T_{\rm eff}$ from 4400K to 7300K, $\log(g)$ between 0 and 3, and [Fe/H] from -3.1 to -0.7 (special focus on metal poor stars).

4. Preparation of the Observation Blocks (OBs) for our follow-up AMBER program with title: 'Interferometric Observations of Benchmark Stars for calibrating large stellar surveys of the Milky Way.' The OBs have been submitted.

4) Future collaboration with host institution

The collaboration is very successful and will surly continue in the future. New observations and new proposals are planned (CHARA observation in September 2015 and PIONIER/AMBER proposal with submission deadline October 2015). The results are very promising thus this project will not only greatly contribute to improving the data analysis of Gaia and the Gaia-ESO Survey, it will also impact the entire astronomical community. Because to understand the structure and evolution of our Galaxy, a single sample of golden standard stars allowing consistent cross-calibration between different large stellar surveys is crucial. Our study contributes significantly towards reaching this goal.

5) Projected publications / articles resulting from the grant

A paper consisting results mentioned above is in preparation. ESF is going to be acknowledged in the publication.

6) Outcome and benefits of the research visit

Outcome of the previous visit founded by the GREAT grant in 2014:
Successful observing proposal with 84 hours of VLTI observations, Principal Investigator; I. Karovicova - applicant; ID: 094.D-0572: 'Interferometric Observations of Benchmark Stars for the Gaia Mission and the Gaia-ESO Survey'.

The host institution did particularly benefit from the rare observational expertise, data reduction skills and experience with the analysis of interferometric data of the applicant. The close collaboration with the applicant assists the scientists of the host institution with the implementation of the results delivered by interferometric observations, and in the determination of fundamental astrophysical parameters of selected benchmark stars.