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Dear Ms Catherine Werner and all it may concern,

### RE: Final Scientific Report for Exchange Grant 3749

I wish to express my gratitude to the European Science Foundation for their financial support through exchange grant #3749 and formally report on the results eventuating from this grant. My supervisor, Dr Stefan Keller, is an integral part of the SkyMapper team, which is providing a photometric survey of the entire southern sky. SkyMapper has unique design, which allows us to identify rare stellar objects - particularly extremely metal-poor stars (EMPs) - and cleanly separate out different types of stars. Although SkyMapper is still undergoing commissioning, we have begun a collaborative spectroscopic survey on the Australian Astronomical Telescope which takes advantage of SkyMapper's unique strength. This survey, named AEGIS, has been designed to complement the Gaia-ESO Survey (GES) on the ESO Very Large Telescope. I am heavily involved in both the SkyMapper team and the AEGIS group, and I am leading the data reduction and analysis for the AEGIS survey with my own spectral analysis software: SCOPE (Spectral Comparison and Parameter Evaluation).

As EMP stars are notoriously rare, the metal deficient tail of the metallicity distribution remains largely unsampled. With the use of SkyMapper photometry, the GES can reduce any systematic bias towards more relatively metal-rich objects. Moreover, the data analysis techniques employed between AEGIS and the GES are similar in many ways. The purpose of my visit to the Institute of Astronomy (IoA) at the University of Cambridge was to learn about the multiple different analysis techniques being employed for the GES in order to converge on robust solutions, and to pass on lessons learnt from these methods into the AEGIS data analysis. This allows us to expedite the AEGIS analysis, validate our results against multiple independent techniques, and establish a strong, ongoing collaboration between our host institutions.

Throughout the six weeks spent in Europe, I learnt about all the different methods being employed to analyse the incoming GES data. There are on the order of a dozen different groups analysing identical data in parallel. Although most of my time was spent with the group at the IoA, I did spend one week visiting another group in Heidelberg. In the concluding days of my trip there was a GES workshop of spectral analysis held in Nice, which I also attended. All data analysis groups were present at the workshop in Nice. Throughout my entire trip I was naturally as inquisitive as possible in order to learn all the intricacies, strengths and potential pitfalls of each group's method.

My time spent at the IoA was extremely productive. When I arrived I already had an appreciable intuition for automated spectral analysis, but there are intricacies which are generally skipped in published articles, and many reasonable trial-and-error steps which are entirely omitted from those articles. It was excellent to discuss different experiences with various techniques to decipher the most reasonable analysis method.

During my time at the IoA I learnt everything I could about the MATISSE software from Dr. George Kordopatis, and asked many questions that I had come across during my own analysis. I spent an equal amount of time explaining the current analysis methods I was employing, and where I believed the analysis could be improved. Many suggestions arose through these discussions, and I immediately implemented

these whilst at the IoA. With these improvements I re-analysed my existing set of benchmark stars: the S4N and CFLIB spectral libraries, as well as red giant branch stars in ten globular clusters, which are commonly used standards. After implementing these improvements, the outputted correlation between my determined values and the expected values were excellent. Prior to this there were noticeable trends correlated with the surface temperature of the stars. Additionally, through brief programming discussions with Dr. Sergey Koposov, my SCOPE analysis code is significantly faster.

When I arrived in Heidelberg, I visited Professor Norbert Christlieb and his group in the Landessternwarte Königstuhl (LSW) at the University of Heidelberg. They comprise one of the data analysis groups for Gaia-ESO. I familiarised them with SkyMapper's progress, the AEGIS survey, and explained how these surveys feed in to the GES. In a heavily discussion-based presentation, I also outlined (in great detail) the analysis methodology being employed for the AEGIS survey with SCOPE. One of the recognised pitfalls with the analysis thus far was the lack of extremely metal-poor stars in the benchmark spectral libraries we had available. A suggestion was made to use the HERES data from the Hamburg-ESO survey in order to test the accuracy of our results at low metallicities, and Professor Christlieb provided me with all the relevant data to perform these tests. This will help us to effectively identify EMP stars in the AEGIS survey.

Serendipitously, Dr. Haining Li from the LAMOST survey was also visiting Professor Christlieb at the same time. They are performing a spectroscopic survey of unprecedented size, and are also looking to identify EMP stars. I outlined my SCOPE analysis software and suggested they could use this software to identify EMP stars in their sample. At a future date, Dr. Li has offered to provide pilot LAMOST data which will be analysed in tandem with the HERES data at low resolution in order to demonstrate the capability to accurately identify EMP stars from the low resolution LAMOST data.

One of the key points resulting from the spectral analysis workshop in Nice was the need for benchmark stars with known parameters in order to verify analysis techniques. The benchmark stars chosen would provide an additional test for both SCOPE and the AEGIS survey analysis. Professor Gilmore has agreed to provide these observations when they are completed.

There are many ongoing collaborations which have resulted from this grant. Firstly, we have solidified the arrangement and logistics of supplying SkyMapper photometry to the Gaia-ESO target selection group - a collaboration which will extend the length of the Gaia-ESO survey. With our analysis of the benchmark stars being observed for the GES, we will begin to build a reference frame between the AEGIS and GES results, which will only be built upon as both surveys observe a small subset of stars. A well-defined plan exists to verify the capability for the SCOPE software to identify EMP stars at low resolutions employed by both the AEGIS and LAMOST survey. This also allows for a collaboration between the LAMOST, SkyMapper, AEGIS, and GES groups.

This exchange grant has further helped contribute to multiple future peer-reviewed publications, which I am happy to acknowledge. The first of these is a paper describing SCOPE and its usage, which is expected to be published in 2012B. The first paper to employ SCOPE will be for my own data set of ~10,000 stars in the Virgo Overdensity - this analysis has been improved by the lessons learnt during this exchange. As these lessons are passed on to the AEGIS group, I look forward to further acknowledging this grant in the first AEGIS data release paper. Finally, there is an opportunity for incorporating the suggestions and lessons learnt from this trip with the LAMOST data analysis group.

I would reiterate that I found this exchange to be an extremely productive and scientifically engaging. The type of automated spectral analysis required for large surveys like AEGIS and the GES is quite specialised, and there is a wealth of experience within ESO to draw from. There is little substitute for face-to-face debate over the plethora of analysis techniques and mathematical approaches available. I enjoyed my time at the IoA, the LSW, and in Nice, and I thoroughly appreciate the ESF's support.

Yours sincerely and with thanks,

  
Andy Casey