Purpose of the visit

The scientific outcome of large-scale surveys strongly depends on the accuracy of the results eventually achieved, and the existence of systematic errors or zero-point offsets may seriously compromise a proper interpretation of the data. It is therefore of utmost importance to validate the contents of the GAIA-ESO Survey (hereafter GES) catalogue by a comparison with the results obtained for a set of benchmark stars using alternative and (nearly) model-independent methods.

Asteroseismic targets may play a pivotal role in this respect, as scaling relations using the seismic observables can be used to estimate the surface gravity to a significantly higher level of accuracy than possible with spectroscopy. A number of empirical tests support this claim (Morel & Miglio 2012, and references therein) and fixing the gravity to the seismic value is now being routinely adopted for the spectroscopic analysis of solar-like pulsators (e.g., Thygesen et al. 2012; Huber et al. 2013).

The GES is currently targeting stars observed by the *CoRoT* satellite in the framework of WG 5 “Calibrators and standards”. Several *CoRoT* red giants in NGC 6633 will also be soon observed by WG 4 “Cluster Stars Target Selection”. Comparing with the asteroseismic results offers the possibility to assess the reliability of the methods currently implemented to determine the stellar parameters and to improve them. Using *CoRoT* stars as calibrators may allow one to secure accurate gravities for the GES targets as a whole. In turn, this would significantly narrow down the uncertainties in the other parameters and abundances.

The main purpose of my visit was to establish a procedure to estimate the gravities of these stars from *CoRoT* data, investigate the precision that can be achieved, and finally compare these estimates with those we have obtained in the context of WG 10 and WG 11 from the analysis of the GES spectra. This was done in collaboration with Dr. Miglio (also a GES co-PI) who is a world-renowned specialist in asteroseismology and seismic scaling relations in particular.

Description of the work carried out during the visit

Radii and masses of solar-like oscillating stars can be estimated from the average seismic parameters that globally characterise their oscillation spectra: the so-called average large frequency separation ($\Delta\nu$) and the frequency corresponding to the maximum oscillation power ($\nu_{\rm max}$).

Although estimating $\log g$ from both $\Delta\nu$ and $\nu_{\rm max}$ involves the use of models, a straightforward relation links the gravity and $\nu_{\rm max}$:

$$\log g = \log g_{\odot} + \log\left(\frac{\nu_{\rm max}}{\nu_{\rm max,\odot}}\right) + \frac{1}{2}\log\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\odot}}\right). \quad (1)$$

This relation is largely insensitive to the effective temperature assumed ($\Delta T_{\rm eff}$ = 100 K leads to $\Delta \log g \sim 0.004$ dex only for Sun-like stars). To first order, the seismic and spectroscopic gravities can therefore be regarded as being completely independent.

The method described in Mosser & Appourchaux (2009) and the pipeline developed by Mosser et al. (2010) were employed to measure the global oscillations parameters $\Delta\nu$ and $\nu_{\rm max}$ from the *CoRoT* light curves of the GES red giants lying in the LRa01 field (towards the anticentre of the Galaxy). We have considered the following procedures to estimate $\log g$:

- $\log g0$: using Eq.1 directly, assuming $\nu_{\rm max,\odot}$ = 3090 μHz (Huber et al. 2013), $\mathrm{T}_{\rm eff,\odot}$ = 5777 K, and our $T_{\rm eff}$ determined spectroscopically in the framework of WG 10 and WG 11.
- $\log g1$: using a Bayesian estimation through isochrone fitting based on evolutionary tracks (da Silva et al. 2006) and considering as observables $T_{\rm eff}$, [Fe/H], $\Delta\nu$, and $\nu_{\rm max}$.
- $\log g2$: using PARAM but considering $\Delta\nu$ as the only seismic constraint.

Table 1: Gravities obtained using the various methods (systematic uncertainties are not considered here). The adopted values are given in the last column.

CoRoT ID	$\log g0$	$\log g1$	$\log g2$	Adopted $\log g$
102688059	2.568±0.023	2.566±0.018	2.562±0.026	2.568±0.027
102689111	2.602±0.023	2.598±0.022	2.601±0.038	2.602±0.023
102716951	2.475±0.023	2.455±0.020	2.414±0.033	2.475±0.066
102717436	3.137±0.023	3.090±0.021	3.021±0.026	3.137±0.105
102720804	2.393±0.023	2.407±0.018	2.430±0.034	2.393±0.049
102721925	2.581±0.023	2.572±0.019	2.575±0.043	2.581±0.027
102725714	2.582±0.023	2.562±0.024	2.511±0.036	2.582±0.073
102726093	2.473±0.023	2.473±0.019	2.463±0.032	2.473±0.030
102729262	2.457±0.023	2.450±0.019	2.441±0.043	2.457±0.034
102736607	2.218±0.023	2.207±0.022	2.221±0.066	2.218±0.025
102738619	3.163±0.023	3.105±0.019	3.021±0.029	3.163±0.123
102741315	2.608±0.023	2.593±0.023	2.551±0.039	2.608±0.063
102751782	2.642±0.023	2.628±0.024	2.577±0.041	2.642±0.069

Description of the main results obtained

The gravities obtained using the various methods are provided in Table 1, while a comparison between the different estimates is presented in Fig.1. For computing the errors, we have assumed as uncertainties: 150 K for $T_{\rm eff}$, 0.2 dex for [Fe/H], 5% for $\nu_{\rm max}$, and finally 2.5% for $\Delta\nu$.

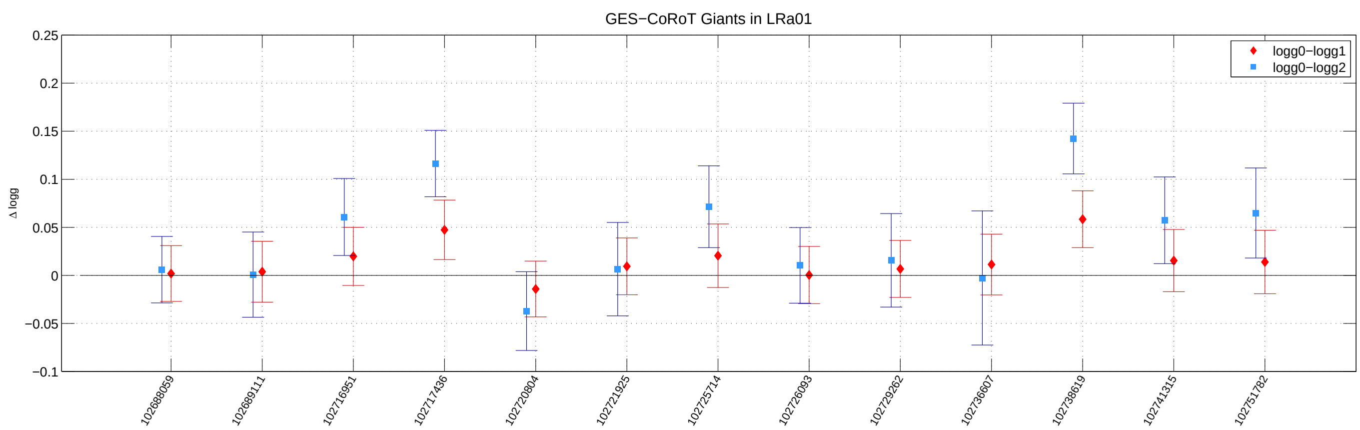

Figure 1: Comparison of $\log g$ determined using under different assumptions (see text).

Except in a few cases, there is a good level of consistency between the values obtained. The determination of the seismic gravity is therefore robust against the choice of the method used. The final $\log g$ value we adopted was that resulting from using Eq.1 alone ($\log g0$). The total uncertainty was determined as the sum of the formal uncertainty in $\log g0$ and the scatter between $\log g0$ and the most discrepant value of the couple $\log g1$-$\log g2$ (both determined using PARAM).

We are determining the parameters of the GES targets using an automated tool based on χ^2 fitting to a library of synthetic spectra (see Valentini et al. 2013). Figure 2 shows a comparison between the spectroscopic and seismic gravities for the 13 *CoRoT* stars. As can be seen, the spectroscopic gravities appear to be systematically underestimated. This is especially the case for two stars, which, however, do not significantly depart from the rest of the sample in terms of gravity, temperature, or metallicity. We are currently investigating the source of this discrepancy to improve the data treatment and/or performance of our algorithms. Much more extensive tests can evidently be performed once a much larger sample is available. We are also examining the effect on the other parameters of freezing in the analysis the gravity to the accurate seismic value.

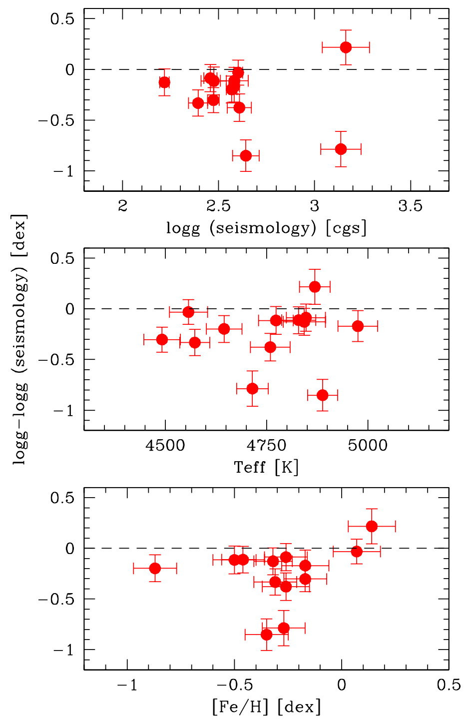

Figure 2: Comparison between the spectroscopic and seismic gravities as a function of the seismic $\log g$, T_{eff} and [Fe/H].

Future collaboration with host institution

Although we have only discussed here data for a dozen *CoRoT* red giants observed in the framework of GES, it is expected that the tests we have presented will be extended to significantly larger samples in the near future. Andrea Miglio and collaborators are presently refining further the methods already developed (particular attention is paid to the systematic errors associated to the use of the scaling relations) and will continue to provide the seismic gravities to the Liège node involved in WG 10 and WG 11. This will provide us with a valuable assessment of the reliability of our spectroscopic results. Upon agreement with WG 5 "Calibrators and standards", these seismic gravities may eventually be made available to the GES consortium at large. The spectroscopic parameters in WG 10 and WG 11 are currently independently determined by a number of groups. The knowledge of the more accurate seismic gravities may help to identify systematic biases in some analyses.

Projected publications to result from the grant

Provided enough spectroscopic data are collected in the *CoRoT* fields, we envisage a paper (in collaboration with Marica Valentini from Liège) discussing the usefulness of solar-like pulsators as calibrators in the context of GES and presenting a thorough comparison between the seismic and spectroscopic gravities.

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