The CoRoT-GES collaboration

First Results

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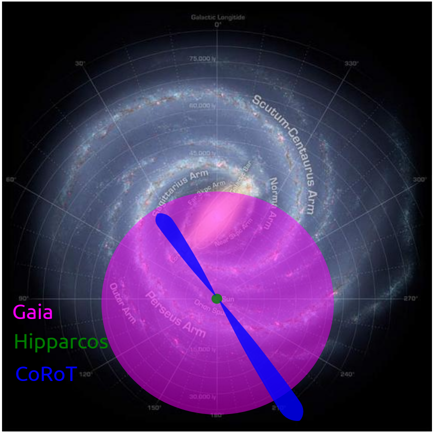
November 13, 2014

Galactic Archaeology

Some of the most important ingredients for investigating our Galaxy are:

1. Accurate element abundances
2. Accurate ages
3. Accurate distances
4. Large number of stars



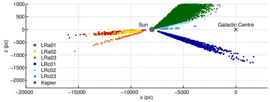
What we can use, while we are waiting for GAIA?

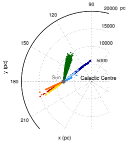
SOLAR LIKE OSCILLATING GIANTS!

Some of the most important ingredients for investigating our Galaxy are:

1. Accurate element abundances → ASTEROSISMOLOGY
2. Accurate ages → ASTEROSEISMOLOGY
3. Accurate distances → ASTEROSEISMOLOGY
4. Large number of stars → 5000 RG targets in CoRoT and Kepler fields

CoRoT-team wrote different observing proposals in the last years (not accepted...), nowadays asteroseismology is among the most promising projects in different surveys: GES, APOGEE, GALAH, RAVE, 4MOST





SOLAR LIKE OSCILLATING GIANTS - SCALING RELATIONS

Thanks to two simple scaling equations, seismic observables $\nu_{\max}$ and $\Delta\nu$, provide a DIRECT estimate of the Mass and Radius of the star (Kallinger et al.2010):

$$\frac{M}{M_\odot} \simeq \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{\rm eff}}{T_{{\rm eff},\odot}}\right)^{3/2} \quad (1)$$

$$\frac{R}{R_\odot} \simeq \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right) \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2} \left(\frac{T_{\rm eff}}{T_{{\rm eff},\odot}}\right)^{1/2} . \quad (2)$$

- Uncertainty on M $\sim$ 10%
- Uncertainty on R $\sim$ 3%
- Tests ongoing: interferometry (Huber et al. 2012); Hipparcos parallaxes (Silva Aguirre et al. 2012); OC NGC6791 (i.e. Miglio et al. 2012 and Sandquist et al.2013), eclipsing binaries, etc

SOLAR LIKE OSCILLATING GIANTS - log(g)

From the scaling relations it is possible to derive log(g).

$$\log g = \log g_{\odot} + \log\left(\frac{\nu_{\rm max}}{\nu_{\rm max,\odot}}\right) + \frac{1}{2}\log\left(\frac{T_{\rm eff}}{{\rm T}_{\rm eff,\odot}}\right). \qquad (3)$$

- Weak dependence on Teff (Δ *Teff* of 100K $\rightarrow$ Δ log(g) of 0.004 dex)
- High precision: uncertainty of $\sim$ 0.03 dex
- Refining atmospheric parameters and abundances by fixing the log(g)to the seismic value (Valentini et al. 2012; Morel,Miglio, Valentini et al. 2014; Huber et al.2013; T. Masseron talk)

SOLAR LIKE OSCILLATING GIANTS - Distances

From the radius determination it is possible to derive distance (i.e. Miglio et al. 2013):

- R from asteroseismology + Teff → L
- Apparent magnitude + Bol. Corrections + Extinction → l
- $d^2 \, \alpha \, \frac{L}{l}$
- uncertainty 10-15% (up to 5% with high quality data)

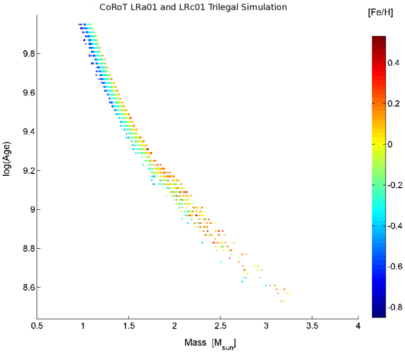
$$\log d = 1 + 2.5 \log \frac{T_{\rm eff}}{T_{\rm eff,\odot}} + \log \frac{\nu_{\rm max}}{\nu_{\rm max,\odot}} + \quad (4)$$

$$-2 \log \frac{\Delta\nu}{\Delta\nu_{\odot}} + 0.2(m_{\rm bol} - M_{\rm bol,\odot}), \quad (5)$$

d is expressed in pc, $m_{\rm bol}$= apparent bolometric magnitude, $M_{\rm bol,\odot}$= absolute solar bolometric magnitude.

SOLAR LIKE OSCILLATING GIANTS - Ages

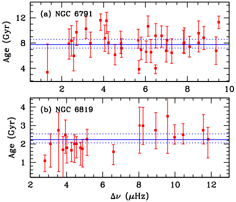
Mass + [Fe/H]→ Age (Miglio 2012). Uncertainty of ∼ 30%.
MODEL DEPENDENT!!



PARAM tool (da Silva et al. 2006, Rodriguez et al. 2014) optimized for deriving ages using seismology.

SOLAR LIKE OSCILLATING GIANTS - Ages

Basu et al. 2011 compared ages derived using seismic M with those obtained from iscochrones fitting for the OC NGC6791 and NGC6819: agreement between the two methods.



(Basu et al. 2011)

Better constraints can be obtained when the evolutionary stage is known: error ∼15%!

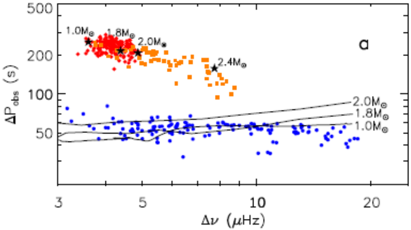
Since the age of a RG depends on the time spent in the MS, and hence on the Mass and metallicity, an accurate calibration of the seismic age in the MS can provide a sound base for calibrating ages in the RG phase. (Silva-Aguirre et al. 2014).

Using individual frequencies it is possible to derive ages for MS stars with a precision of ∼ 5% (Silva Aguirre 2013).

SOLAR LIKE OSCILLATING GIANTS - Evolutionary Status

Thanks to asteroseismology it is now possible to distinguish H-shell burning stars from those that are also burning He in the core.
Mosser et al 2011: CoRoT data (period separation of mixed modes vs $\Delta\nu$).

Unknown details of stellar evolution and structure!



Bedding et al., Nature 2011

* Good quality light curves

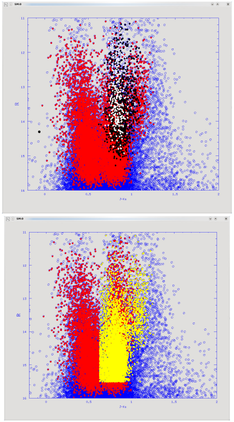
The Imput Catalog

CoRoT RG group provided to GES a list of 6846 targets:

- Priority 1: 283 (evolutionary status from sismology)
- Priority 2: 1196 (sismo available)
- Priority 3: 3985 (possible sismo from new LC)
- Priority 4: 1381 (phot. selected RG - no sismo)

UVES: U580

GIRAFFE: HR21, HR15, HR10



Images provided by J.Montalban.

Requirements

Setups:

- UVES: U580
- GIRAFFE: HR10+HR21, HR15

SNR requirements:

- UVES: SNR > 100
- GIRAFFE: SNR > 50

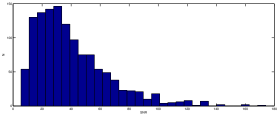
Element abundances

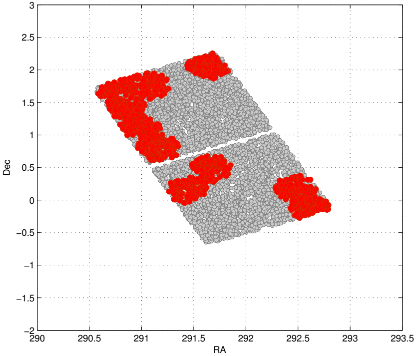
- GIRAFFE : Fe, Ti, Ca, Si, Mg, Mn, Co, Cr, Ni, V, Y, Zr, Li.
- UVES: alpha elements (O, Mg, Si, Ca, Ti), s-elements (Ba and Y), iron peak elements (Fe, Ni, Mn, Cr), and also Na, Al and Li. C CH C2 Swan (0,1) band head (very high SNR).

Observations

LRc01 field is 1 x 2.5 deg, FLAMES instrumental FOV is 25 arcmin.
In DR2 there are 1115 stars from the imput list - 10 fields.

- 38 observed with UVES
- 1077 observed with GIRAFFE

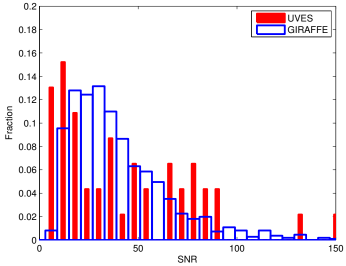




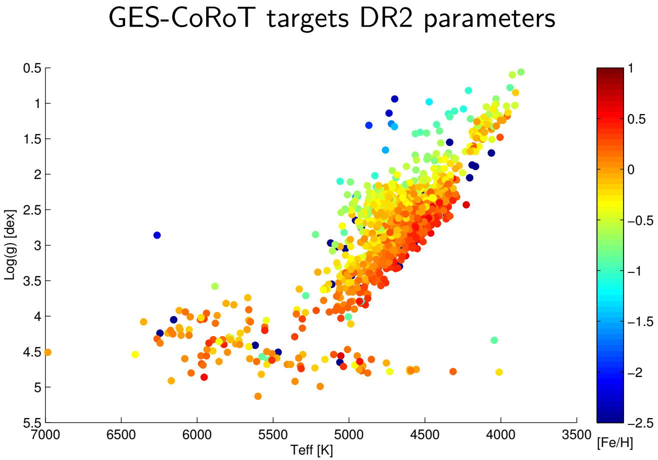
Observations

In DR2 there are 1115 stars from the CoRoT-GES imput list.

- 67 List 1
  (26 UVES, 41 GIRAFFE)
- 337 List 2
  (6 UVES, 331 GIRAFFE)
- 651 List 3
  (6 UVES, 645 GIRAFFE)
- 56 List 4
  (GIRAFFE)

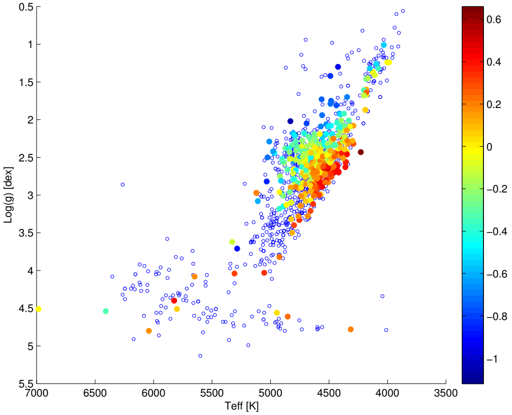


DR2 data


GES-CoRoT targets DR2 parameters
Log(g) [dex]
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
7000
6500
6000
5500
5000
4500
4000
3500
Teff [K]
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
[Fe/H]

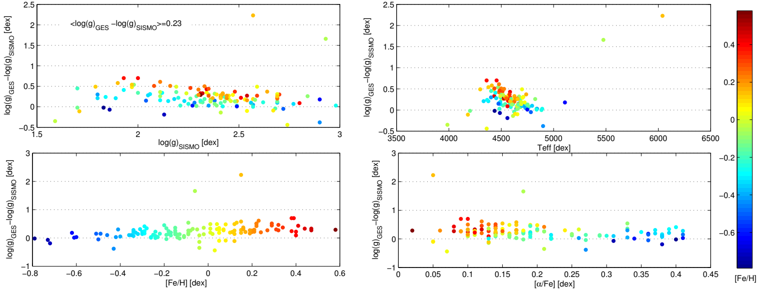
DR2 data: refined atmospheric parameters

505 GES-CoRoT targets DR2 parameters



DR2 data

505 targets with seismic data available from the new Light Curves.
log(g) from GES vs log(g) from seismology



See talk of T.Masseron

DR2 data

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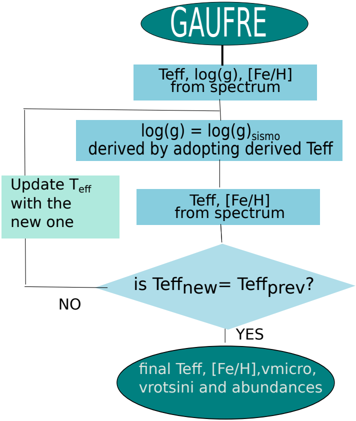
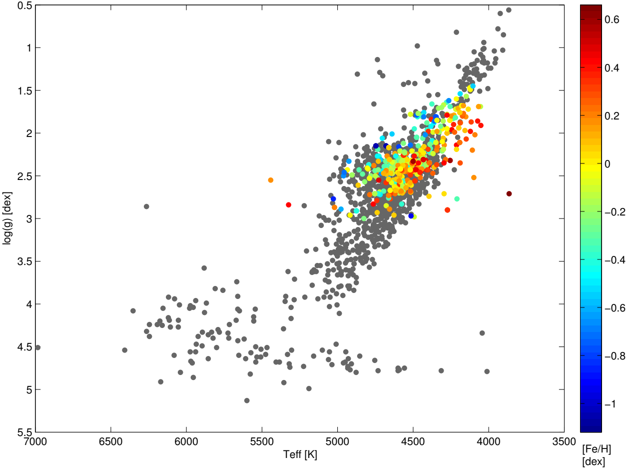


Valentini et al.2013
See talk of T.Masseron

DR2 data: refined atmospheric parameters

505 GES-CoRoT targets DR2, refined



DR2 data: Abundances

505 GES-CoRoT targets DR2 refined.
Element abundances available in DR2:

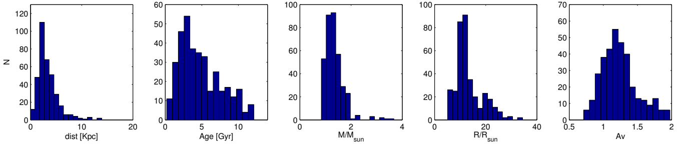
- GIRAFFE:
  Alpha-elements: Ca, Mg, Si, Ti
  s-proc: Y
  Iron-peak:Fe,V, Co, Cr
  Others: Al, Li
- UVES:
  Alpha-elements: Ca, Mg,O, S, Si, Ti
  r-proc: Eu
  s-proc: Y, Zr, Ba, Ce
  C, N, O
  Iron-peak: Cr, Fe, Mn, Ni, Sc, V, Co
  p-proc: Cu, Zn
  others: Na, Mo, Li

Mass, Radius, AGE, Reddening, orbital parameters

M, R, Age, Av

For each star we run PARAM (Rodriguez et al. 2014) using $\nu_{\max}$, $\Delta\nu$ and refined Teff and [Fe/H].

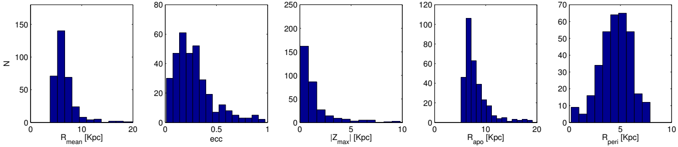
$\rightarrow$ 436 stars



R_{mean}, ecc, Z_{max}, ...

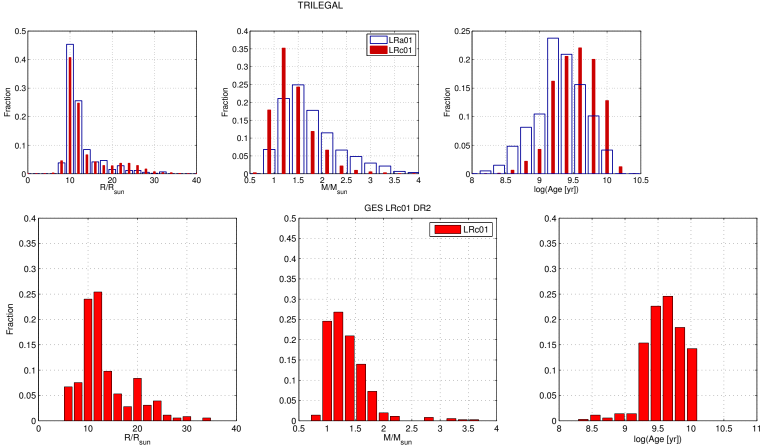
Proper motions from UCAC4, errors on orbital parameters via montecarlo simulation

$\rightarrow$ 358 stars

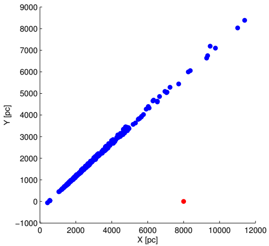


Are these 358 stars representative for the population in LRc01 field?

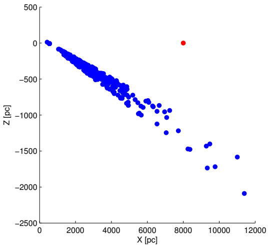
Comparison TRILEGAL (Miglio, Chiappini, Morel et al. 2013) and GES (using PARAM - Rodriguez et al. 2014)



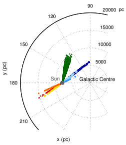
Distances



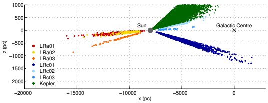
Y [pc]
X [pc]
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
0
2000
4000
6000
8000
10000
12000



Z [pc]
X [pc]
500
0
−500
−1000
−1500
−2000
−2500
0
2000
4000
6000
8000
10000
12000

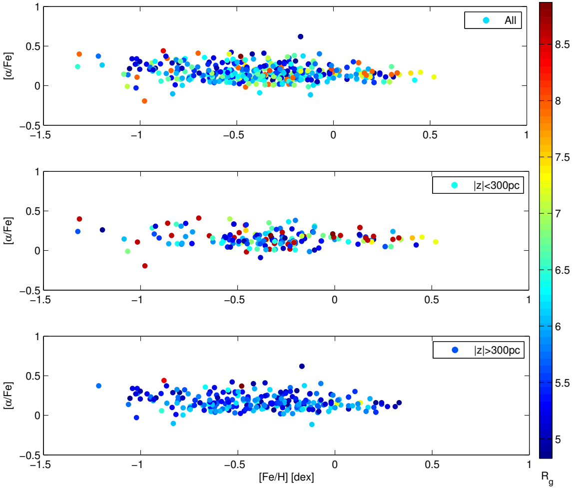


90
120
150
180
210
20000 pc
15000
10000
5000
Sun
Galactic Centre
y (pc)
x (pc)



1000
500
0
−500
−1000
−1500
−2000
z (pc)
Sun
Galactic Centre
LRa01
LRa02
LRa03
LRc01
LRc02
LRc03
Kepler
−20000
−15000
−10000
−5000
0
x (pc)

FeH vs [alpha/Fe]



Conclusions

We have a sample of stars with accurate atmospheric parameters, M, R, Age, Av, distances and orbital parameters!!

	BEFORE	WITH ASTEROSEISMOLOGY
GIRAFFE Teff [K]	100	65
UVES Teff [K]	70	55
GIRAFFE log(g) [dex]	0.20	0.03
UVES log(g) [dex]	0.12	0.03
GIRAFFE [Fe/H] [dex]	0.10	0.08
UVES Teff [Fe/H] [dex]	0.09	0.05
GIRAFFE [elem.] [dex]	0.20	0.08
UVES [elem.] [dex]	0.08	0.05
Mass	-	10%
Radius	-	6%
Age	>80%	<30%
Dist.	-	<15%

592-WE Heraeus Workshop

"Reconstructing the Milky Ways history: Spectroscopic surveys, Asteroseismology and chemo-dynamical models"

1-5 June 2015, Bad Honnef (Germany)

`https://escience.aip.de/592-WE-Heraeus-Seminar`


AIP Leibniz-Institut für Astrophysik Potsdam

Home Science Speakers Registration Participants Program Venue & Accomodation

592. WE-Heraeus-Seminar – 1st to 5th June 2015

Reconstructing the Milky Way's History: Spectroscopic Surveys, Asteroseismology and Chemodynamical Models

Venue:

Physics Center Bad Honnef

Hauptstrasse 5

53604

Bad Honnef (near Bonn, Germany)

The Physics Center is run by the Deutsche Physikalische Gesellschaft e. V. (DPG) and is supported by the

Wilhelm und Else Heraeus Stiftung

This seminar is generously funded by the Wilhelm und Else Heraeus-Stiftung.

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Potential adopted

In the adopted model the mass distribution of the Galaxy is described as a three component system: a spherical central bulge with an Hernquist (1990) profile, a disk with a double exponential law density profile (Quinn 1986) and a massive spherical halo with a logarithmic profile for the dark matter and a stellar halo profile (Helmi 2000). The gravitational potential is fully analytical, continuous everywhere and has continuous derivatives, in order to make the integration faster but with an high numerical precision. Results in agreement with Bovy 2014 version of Galpy.