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ORIGINAL ARTICLE

The red-giant CoRoT target HR 7349

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Abstract HR 7349 is a bright [$V = 5.8$] red giant observed by CoRoT in the seismofield of the first long run. The outstanding CoRoT light curve allowed the detection of several solar-like oscillation modes (both radial and non-radial). On top of these seismic constraints, our observational knowledge on HR 7349 benefits as well from a precise parallax and detailed spectroscopic constraints. We present all the observational constraints that are available for the theoretical modelling of this most promising target.

Keywords Stars: oscillations · Stars: variables · Stars: interiors

1 Introduction

The analysis of the oscillation spectrum provides an unrivaled method to probe the stellar internal structure. High-precision spectrographs have led to a rapidly growing list of solar-like oscillation detections in main-sequence and giant stars (see e.g. Carrier et al. 2008). In a few years we have moved from ambiguous detections to firm measurements. Among these, only few are related to red giants, e.g. ξ Hya, Frandsen et al. 2002, ϵ Oph, Ridder et al. 2006 and η Ser, Barban et al. 2004. Barban et al. (2007) interpreted the signal found in the 28 days of continuous MOST observations of ϵ Oph as radial modes with relative broad modes profiles

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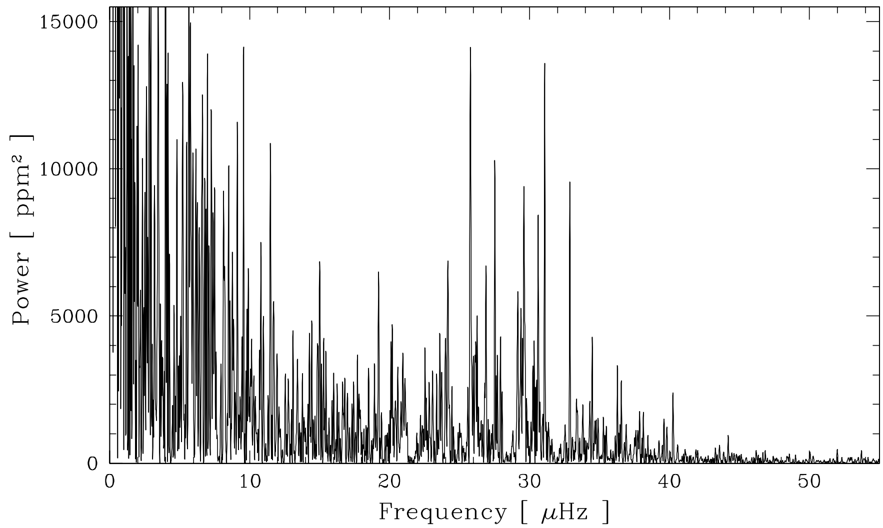

Fig. 1 Power spectrum of the giant star HR 7349 which was observed during the first 150d-long run (Lrc01) in the CoRoT seismofield

corresponding to short mode lifetimes. On the other hand, Kallinger et al. (2008) re-examined the MOST data and found at least 18 radial and non-radial modes with significantly longer mode lifetime. Long and nearly uninterrupted time series are thus needed to unambiguously characterize the oscillations in red giants: recently, CoRoT observations give us the first unambiguous identifications of p-modes in red giants (see e.g. Ridder et al. 2009; Hekker et al. 2009; Kallinger et al. 2009).

2 Seismic constraints: CoRoT observations

HR 7349 has been observed with the CoRoT satellite during 5 consecutive months with one measurement every 32 seconds. The power spectrum of this time series is shown in Fig. 1. Oscillation modes are clearly visible between 20 and 40 μHz with a regularity near 1.7 μHz corresponding to half the large separation. The 380760 measurements lead to a "high-frequency" noise (60–80 μHz) of only 5 ppm.

In the power spectrum, each mode is composed of several peaks which is the clear signature of a finite lifetime shorter than the observing time span. In order to determine the mode frequencies, as well as amplitude and lifetime of the modes, we fitted the power spectrum using a Maximum Likelihood Estimation (MLE) method (see e.g. Appourchaux et al. 1998). When fitting all modes without fixing the width of the Lorentzian envelope, we clearly saw that the fit was not robust enough to give an accurate determination of all mode parameters. The method was thus to first find a mean value for the Lorentzian width and to fix this mean value for all modes. The determined mean is 0.25 ± 0.06 μHz, which corresponds to a mode lifetime of $14.7^{+4.7}_{-2.9}$ d. The extracted frequencies are shown in Fig. 2.

3 Spectroscopic constraints

We used the line analysis code MOOG, Kurucz models and a high-resolution FEROS spectrum (see Fig. 3) obtained in June 2007 to carry out an LTE abundance study of HR 7349. The effective temperature and surface gravity were estimated from the excitation and ionization equilibrium of a set of iron lines taken from the line list of Hekker and Meléndez (2007). We obtain $T_{\rm eff} = 4790 \pm 80$ K and $\log g = 2.78 \pm 0.16$ dex. The abundances are computed from classical curve-of-growth techniques: $[{\rm Fe/H}] = -0.08 \pm 0.10$ dex while the abundance pattern of the other elements with respect to Fe is solar within the errors (see Fig. 4).

4 Astrometric & photometric constraints

Even for such a bright star, the interstellar extinction in the direction of the galactic center is not negligible. From the HIPPARCOS parallax $\Pi = 9.64 \pm 0.34$ mas (van Leeuwen 2007) and the value of $(B{-}V) = 1.093$ in the HIPPARCOS catalog, an absorption of $A_V = 0.185$ mag is derived for the region of the star (Arenou et al. 1992), which corresponds to an $E_{B-V} = 0.052$. Combining the magnitude $V = 5.809 \pm 0.004$ (Geneva photometry), the HIPPARCOS parallax, the solar absolute bolometric magnitude $M_{\rm bol,\odot} = 4.746$ (Lejeune et al. 1998) and the mean bolometric corrections $BC = -0.40 \pm 0.04$ mag ($BC = -0.42 \pm 0.06$ mag according to Flower's calibration, (1996) and $BC = -0.38 \pm 0.05$ mag by Alonso et al. 1999), we find a luminosity for HR 7349 of $L = 69 \pm 6\, L_\odot$.

We also determined a photometric temperature given by the relation in Alonso et al. (1999) using the dereddened color index $(B{-}V)$ and found 4704 ± 110 K, which is in agreement with the spectroscopic value. We finally adopt a weighted-mean temperature of 4760 ± 65 K.

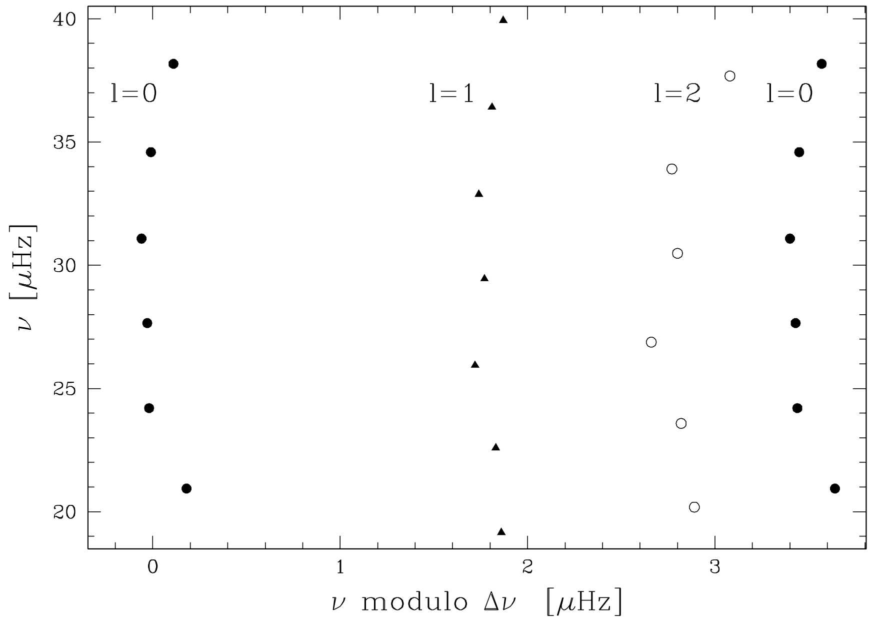

Fig. 2 Echelle diagram of the significant frequencies. Three separate vertical ridges, interpreted as $l = 0$, 1 and 2 modes, clearly appear in the diagram

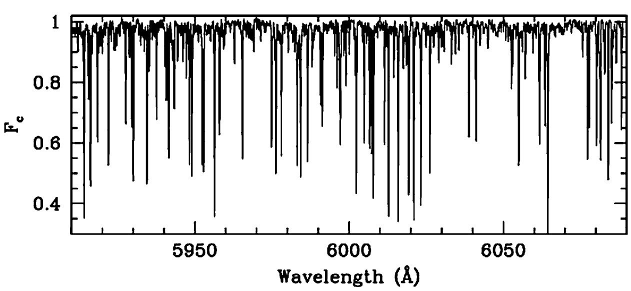

Fig. 3 A high-resolution spectrum of HR 7349 was obtained with FEROS

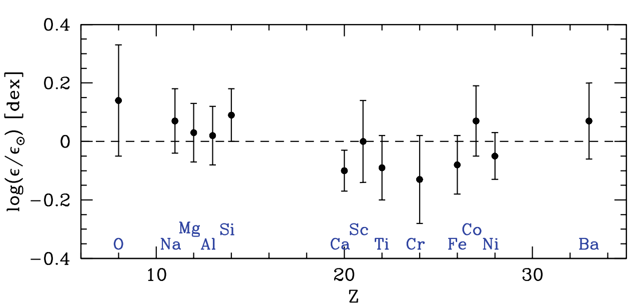

Fig. 4 Abundance pattern (deviations in dex relative to the solar abundances of Grevesse and Sauval (1998)). The Ba element is put to $Z = 33$ (instead of 56) for the reason of readability

HR diagram showing the location of HR 7349 with the 1 and 2-sigma error boxes in T_{eff} and L is shown in Fig. 5. Red lines represent evolutionary tracks of different mass computed with the code ATON (Ventura et al. 2008). The initial chemical composition assumed is $Z = 0.02$ and $Y = 0.278$, a mixing-length parameter $\alpha_{\text{MLT}} = 1.9$ was adopted.

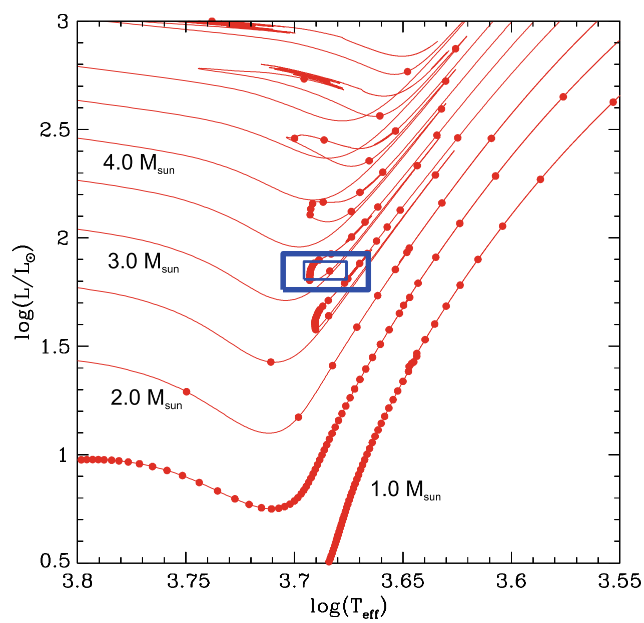

Fig. 5 HR diagram showing the location of HR 7349 with the 1 and 2-sigma error boxes in T_{eff} and L (*thin* and *thick blue lines*). *Red lines* represent evolutionary tracks of different mass. *Red points* represent time intervals of 10 Myr

5 Conclusion

The numerous and precise observational constraints available for HR7349 (seismic and non seismic) make this star a most promising target for a first detailed theoretical modelling of a solar-like pulsating red giant.

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