Modelling of the RGs KIC 003758458 and KIC 009882316 by means of asteroseismology with Kepler

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ABSTRACT: We have analysed oscillations of the red giants stars KIC 003758458 and KIC 009882316 observed by *Kepler*. The data consists of the first seven quarters (except Q6 for KIC 003758458) of science operations of *Kepler*. A Lomb-Scargale algorithm is used to generate the power spectrum. We have estimated directly from the power spectrum the mean large frequency separation and the frequency of the maximum oscillation power. We use the scaling relations to estimate the preliminary asteroseismic mass, which will be confirmed with grid of stellar models calculation. Stellar models are calculated with CESAM2k evolution code. We calculate the oscillation frequencies of p mode of degree *l=0, 1, 2* and *3* and the frequency differences of a large number of models along the evolutionary tracks using LNAWENR linear, non-radial, non-adiabatic oscillation code. The estimated values of large frequency separation, the frequency of the maximum oscillation power, and mass for each stars are given below. For the effective temperature we have chosen the KIC value.

Global oscillation analysis

The signal due to granulation is modelled by a modified Lorentzian-like function, first introduced by Karoff (2008). The contribution of the other surface phenomena (such as stellar activity, faculae, etc.) to background signal is included in a white noise component. The power excess hump from stellar oscillations is approximately Gaussian, so the complete spectrum is modelled by:

$$P(\nu) = P_n + \frac{4\sigma^2\tau}{1+(2\pi\nu\tau)^2+(2\pi\nu\tau)^4} + P_g \exp\left(\frac{-(\nu_{\max}-\nu)^2}{2\sigma_g^2}\right)$$

For the fitting of the power density spectrum of KIC 003758458 and KIC 009882316 with the model given by that equation we used Maximum Likelihood Estimator (Appourchaux 2003) and we have obtained the values 71.13 microHz and 176.09 microHz for the frequency of maxumum oscillation power.

The analysis of the power spectrum was performed by adopting the peak-bagging method based on the fit of Lorentzian profiles to the power density spectrum using Maximum Likelihood Estimators (MLE) (Appourchaux et al. 1998). The power spectrum was smoothed with a Gaussian and the frequencies of the peaks above a threshold that was set at 0.99 confidence were used as initial starting values for the fitting with Lorentzians. We first computed a guess value for the large frequency separation using power spectrum auto-correlation method in the region of p-mode power excess. Then, we have identified the l=0 peaks (and, immediately, the l=2 peaks) in the power spectrum. The mean large frequency separation are found to be 5.87 microHz and 13.58 microHz, respectively.

The power spectrum in the region of p-mode excess power was modelled as a background noise component similar with that used in Expression (1) and a sum of Lorentzian profiles. Thus, the total power from the stellar oscillations is described as:

$$P(\nu) = P_n + \frac{4\sigma^2\tau}{1+(2\pi\nu\tau)^2+(2\pi\nu\tau)^4} + \sum_{i=1}^{n} L(\tau_i, H_i, \nu_i)$$

The Lorentzian profile is defined as

$$P_{Lorentzian}(\nu) = L(\tau_i, H_i, \nu_i) = \frac{H_i}{1+(2\pi\cdot(\nu-\nu_i)\cdot\tau_i)^2}$$

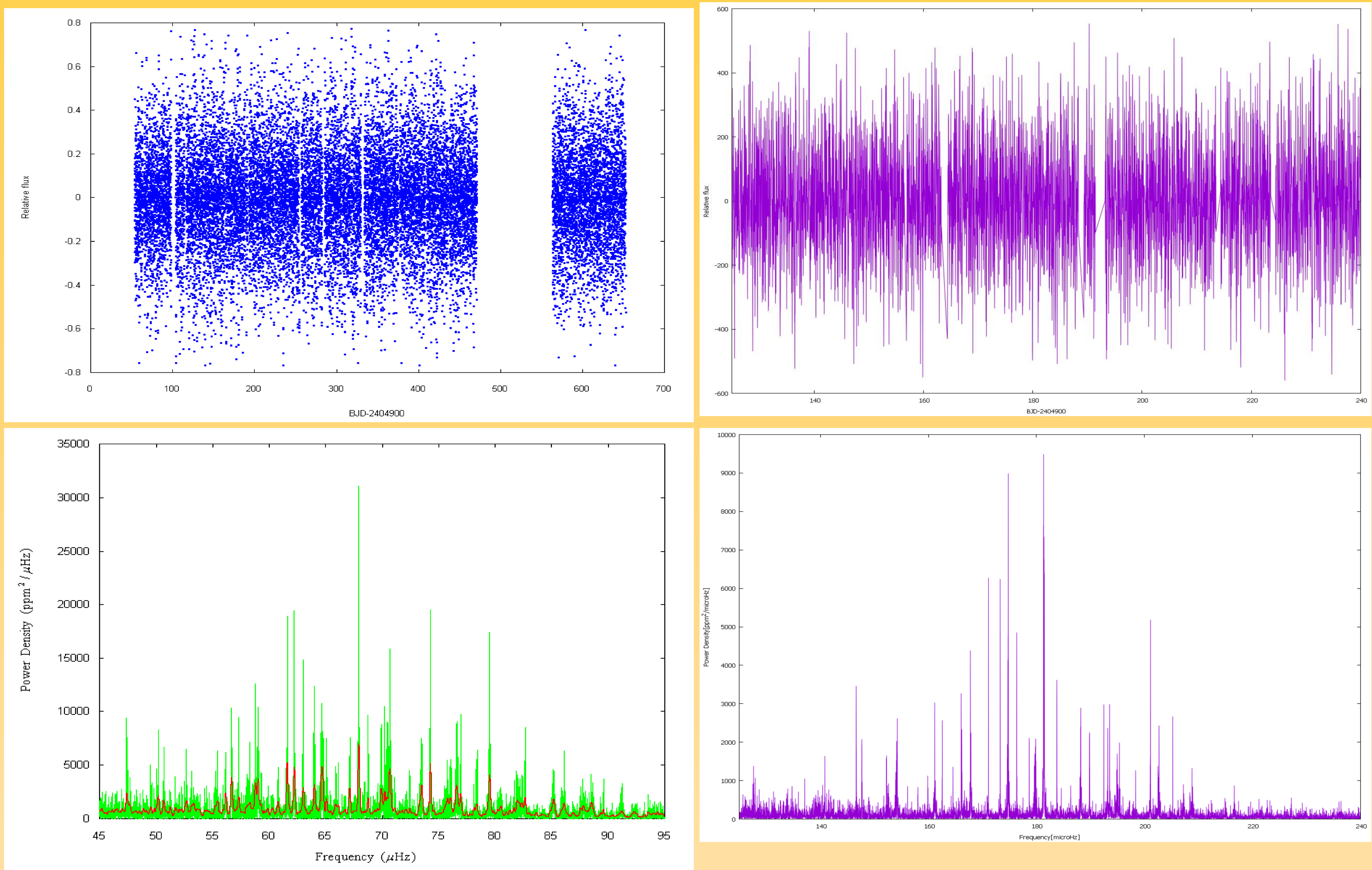

Fig. 1 **Top panels: Light curve corrected for slopes and discontinuities, cleaned for obvious outliers and normalized to the mean value, for KIC 003758458 (left) and KIC 009882316 (right). Bottom panels: Power Spectrum Density in the region of p mode excess bump of the two stars.**

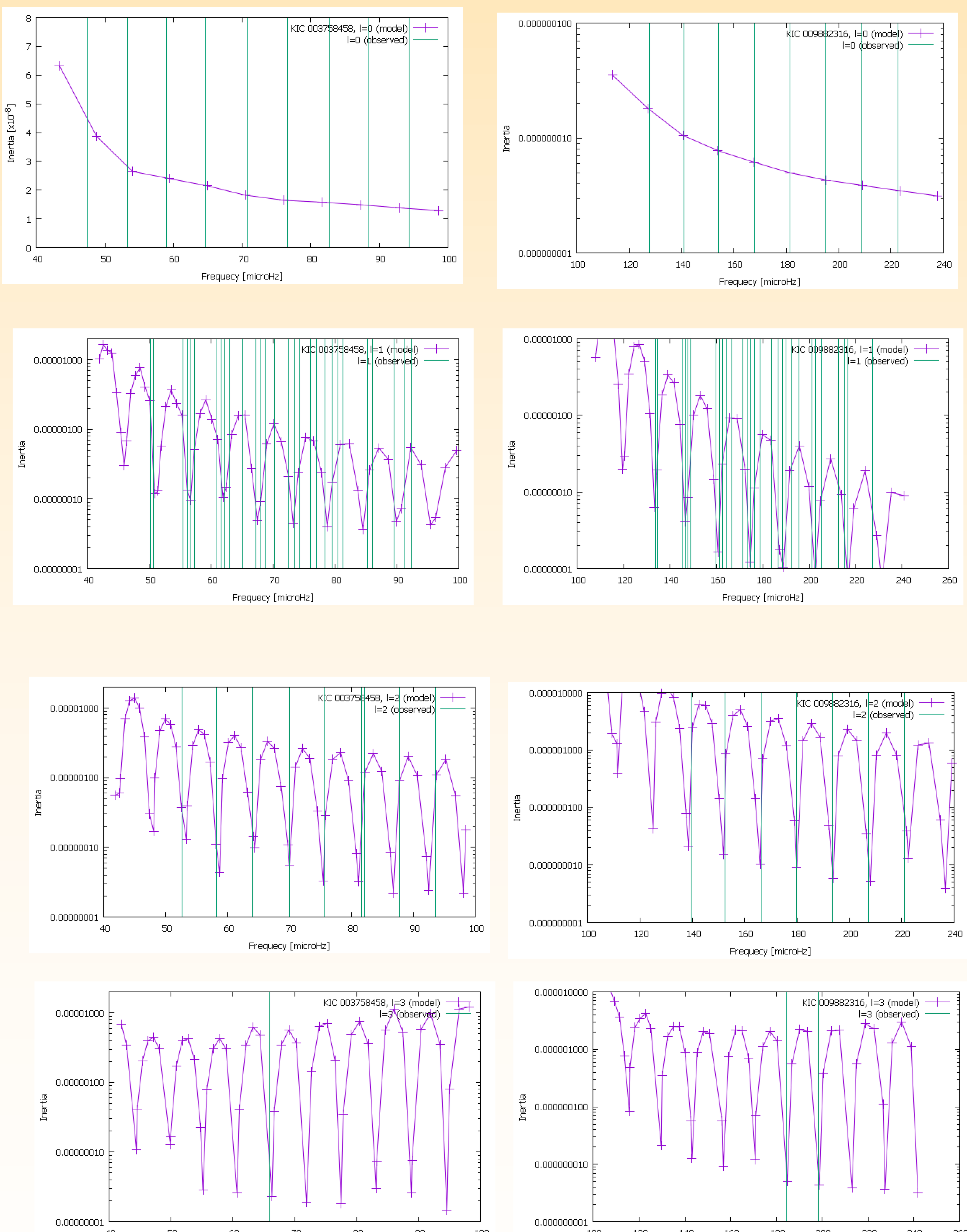

Fig. 2 **The frequencies of the best fitting stellar models together with the observed frequencies for the two stars.**

Stellar modelling

We computed radial and nonradial eigenfrequencies with mode degree *l* up to 3 for models of intermediate-mass stars from 1.20 to 1.60$M_\odot$ in steps of 0.01$M_\odot$ for KIC 009882316 and from 2.5 to 2.76$M_\odot$ in steps of 0.01$M_\odot$ for KIC 003758458. The initial metal mass fraction Z=0.004 to 0.01 and initial hydrogen Y = 0.21 to 0.28. The mixing length parameter is free between 1.3 and 2.0.

For the effective temperature, surface gravity and metallicity we considered the KIC values: 4909 K, 2.547 and -0.069 for KIC 003758458 and 5093 K, 3.227 and -0.41 for KIC 009882316.

We selected as the best fit models for the two stars the models that fit best the observed radial frequencies and are situated in the error box of effective temperature and surface gravity.

Table 1 Fundamental stellar parameters for KIC 007358458 and KIC 009882316 as found for the best fitting model.

	KIC 003758458	KIC 009882316
Effective temperature [K]	4962.83	5097.53
Luminosity [$L_\odot$]	66.069	16.904
Radius [$R_\odot$]	11.95	5.289
Mass [$M_\odot$]	2.74	1.57
Log g [g cm s^{-2}]	2.72	3.187
Age [Gyr]	0.32	2.03
Mixing Length Parameter [Hp]	1.575	1.649
Metallicity [Z]	0.01	0.005

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