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Test of a new method for seismic indices and granulation parameters extraction

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Abstract. In the framework of the data base project *SSI* (Stellar Seismic Indices[b]), we have developed and tested a new method aiming at optimizing the simultaneous measurement of both the seismic indices characterizing the oscillations ($\Delta\nu$, ν_{max}) and the indices characterizing the granulation signature. Here, we describe this method which is intended to take advantage of the *MLE* (maximum likelihood estimate) algorithm combined with the parametrized representation of the red giants pulsation spectrum following the Universal Pattern [6]. We report its performances tested on Monte Carlo simulations.

The objective of the data base project *SSI* is to provide oscillations and granulation characterization for a large set of solar-like pulsators (from the main sequence to the red giant stage), for the stellar community and beyond. Our pipeline is intended to be as robust, automatic and efficient as possible. Several methods already exist in the litterature. They generally address specifically the characterization of oscillations [8], [1] or of granulation [4], [2].

We are interested in both aspects and in order to characterize them simultaneously, we developed a new method that we call *MLE+UP*, for *Maximum Likelihood Estimator + Universal Pattern*. It determines all parameters of the granulation and the seismic oscillations from the maximum likelihood estimator fit of the power spectrum. Uncertainties are derived from the inversion of the Hessian matrix. The model used is composed by three components: one for the granulation, one for the oscillation pattern and one for the white noise (the photon and instrumental noise).
For the granulation, we use a Lorentzian-like profile of the form $L(\nu) \propto P/[1 + (\pi\tau\nu)^{\alpha}]$, with P, the height of the Lorentzian ; τ, the characteristic time of the evolution of the granulation and α, the slope of the decay. For the oscillation pattern, we use the parametric description of red giant pulsation taken from the Universal Pattern [6], caracterised by ν_{max}, the frequency of the maximum height in the power spectrum ; $\Delta\nu$, the mean large separation, corresponding to the distance between two consecutive orders at fixed degree and A, the height of the Gaussian envelope of the universal pattern. Finally, for the white noise we use a constant. This method will be discribed with more details in a futur paper.

In order to test the performances of our method, we simulated light curves using the same model described in the previous paragraph. For each set of parameters, we produce sets of 1000 simulated light curves, varying ν_{max} from 10 to 130 μHz by steps of 20 μHz (other parameters accordingly, following scaling laws), for observation conditions representative of CoRoT faintstars data ($T = 150\ d$, $dt = 512\ s$, $m_v = 13$ star).
Results are illustrated in Fig. 1, where, for seismic and granulation parameters, we present relative

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[b] Data base project SSI (Stellar Seismic Indices) is part of SPACEINN project (www.spaceinn.eu) `http://ssi.lesia.obspm.fr/`

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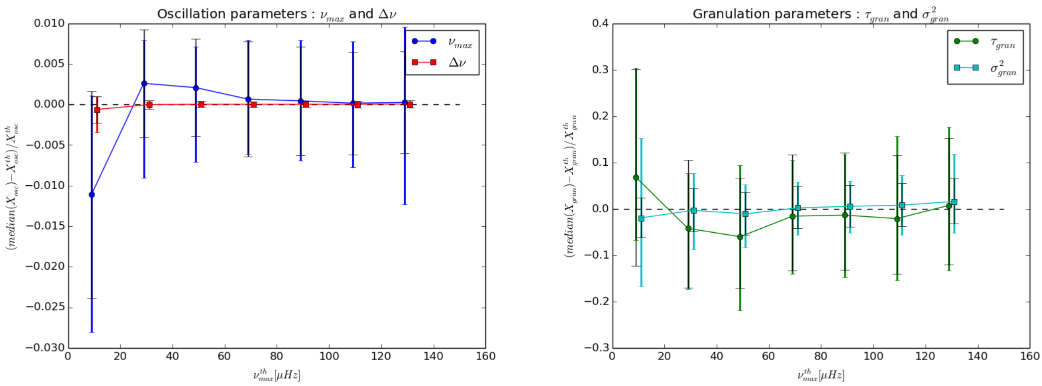

Fig. 1. Relative difference with the input value for oscillation (*Left*) and granulation (*Right*) parameters as a function of the input ν_{max}. The color error bars correspond to the dispersion of 68% of 1000 realizations. The black ones correspond to the formal errors.

differences with input values as a function of the input ν_{max}.

Generally speaking, biases, taken as the distance between the median and the input value (full square and circle), are small (below 1%) and not significant regarding the dispersions of the results (color error bars). This is what we expect because we use the same model in the simulations and in the algorithm.

On the left figure, we see that ν_{max} has a dispersion about 1% generally. Regarding $\Delta\nu$, we get dispersions about 0.03% from ν_{max} = 30 to 130 μHz, slightly greater for $\nu_{max} = 10\ \mu Hz$ ($\sim 0.3\%$). For both ν_{max} and $\Delta\nu$, formal errors are found compatible with dispersions.
On the right figure are presented the results for the granulation parameters τ and σ^2, which characterises the amplitude of the granulation ($\sigma^2 = P/[2\tau\alpha \sin(\pi/\alpha)]$). τ shows a dispersion between 10 to 15% (asymetric in the case of $\nu_{max} = 10\ \mu Hz$). In the case of σ^2, the dispersion is about 7%, up to 15% for $\nu_{max} = 10\ \mu Hz$. Here again, formal errors are compatible with dispersions

These tests valid our method and uncertainties estimation. We are currently using this new method on a large set of CoRoT targets in order to analyse the stellar granulation as well as to improve the scaling relations between the granulation and oscillation parameters.

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