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Investigating the properties of granulation in the red giants observed by *Kepler*

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Abstract. More than 1000 red giants have been observed by NASA/Kepler mission during a nearly continuous period of ~ 13 months. The resulting high-frequency resolution (< 0.03 μHz) allows us to study the granulation parameters of these stars. The granulation pattern results from the convection motions leading to upward flows of hot plasma and downward flows of cooler plasma. We fitted Harvey-like functions to the power spectra, to retrieve the timescale and amplitude of granulation. We show that there is an anti-correlation between both of these parameters and the position of maximum power of acoustic modes, while we also find a correlation with the radius, which agrees with the theory. We finally compare our results with 3D models of the convection.

1. Analysis

Among the targets of the *Kepler* mission, a large number of red giants are being followed for asteroseismic and astrometric purposes with a long-cadence sampling (29.4 min). The study of these stars is already giving very interesting results (e.g. Beck et al. 2011; Bedding et al. 2011)

We analyzed ~ 1000 red giants for which we could detect solar-like oscillations, see Hekker et al. (2011). First, the data were processed as described by García et al. (2011) to remove drifts, instrumental effects, and jumps. To remove the signature of instrumental signals with periods longer than the expected granulation time scale for red giants, we applied a triangular smooth with a width of 10 days that filters out periodicity > 10 days.

The granulation signal in these red giants was fitted by six teams (Huber et al. 2009; Hekker et al. 2010; Kallinger et al. 2010; Mathur et al. 2010, D. L. Buzasi and B. Mosser private communications). All the methods are based on the Harvey-like function (Harvey 1985):

$$P_{\rm H}(\nu) = \frac{4\sigma^2\tau_{\rm gran}}{1+(2\pi\nu\tau_{\rm gran})^{\alpha}}\ , \qquad (1)$$

in which $P_{\rm H}(\nu)$ is the total granulation power of the signal at frequency ν, σ is the characteristic amplitude of the granulation and α is a positive parameter character-

izing the slope of the decay. We also define the amplitude of the granulation power, $P_{\rm gran} = 4\sigma^2\tau_{\rm gran}$.

To compare the timescales of several methods that have different values of α, we defined the parameter $\tau_{\rm eff}$, as the e-folding time of the auto-correlation function of the temporal signal of the granulation component.

2. Discussion

Fig. 1 (left panel) shows the variation of $1/\tau_{\rm eff}$ vs. $\nu_{\rm max}$, the frequency of maximum oscillation power for one of the six methods. Though the values can be different from one method to the other, the correlations are in agreement and we find that $\tau_{\rm eff} \propto \nu_{\rm max}^{-0.89}$ by taking into account all the methods together. Fig. 1 (right panel) shows the correlation between $P_{\rm gran}$ and $\nu_{\rm max}$ for the same method as the left panel. If we take into account the results of all the methods together, we find that $P_{\rm gran} \propto \nu_{\rm max}^{-1.90}$. These relations are in agreement with the scaling relations (Kjeldsen & Bedding 2011), which suggest that $\tau_{\rm gran} \propto \nu_{\rm max}^{-1}$ and $P_{\rm gran} \propto \nu_{\rm max}^{-2}$.

Using the methodology of Kallinger et al. (2010), we estimated the stellar parameters of 1035 red giants. As predicted from scaling relations for bigger stars, the granulation timescales are larger. We also observe an anti-correlation between $\tau_{\rm eff}$ and log g.

We have computed 37 3D hydrodynamic simulations of the convection as described in Trampedach & Stein (2011) and have compared them with the *Kepler* observations. We find similar trends but the absolute values are different by a factor of 2 for $\tau_{\rm eff}$ and by an order of magnitude for $P_{\rm gran}$. For more details on this study, we refer to Mathur et al. (2011).

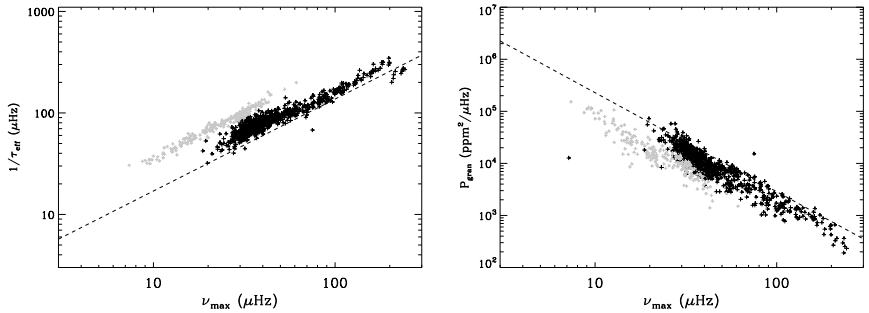

Figure 1. Left panel: Characteristic granulation time scale, $\tau_{\rm eff}$, as a function of $\nu_{\rm max}$ (position of maximum power) obtained by one method (Mathur et al. 2010). Right panel: Granulation power ($P_{\rm gran}$) as a function of $\nu_{\rm max}$ obtained by the same method as the left panel. The light gray points correspond to a second branch picked up by the fitting code (more details are given in Mathur et al. (2011)). The dashed line in each panel is the result of a linear fit of $\tau_{\rm eff}$ and $P_{\rm gran}$ using the six methods all together.

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