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Classification of Stellar Variability with Kepler Data

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Abstract: The Kepler mission has observed over 150,000 stars and provided us with their light-curves, an extremely valuable tool that we use to decide which type of variability these stars appear to have. In order to achieve this we calculate and study the evolution of some simple statistical characteristics such as the standard deviation and then try to find appropriate factors that can indicate the different kinds of variability. Afterwards we have to find the relationship of our results with the stellar physical characteristics which was ignored at first.

1 Technical Details

The data we use are the PDC light-curves from the Kepler data archive after a low degree polynomial normalization in order to connect all the quarters together.

It is known for a light-curve that:

$$\sigma \sim error \sim \overline{x}^{0.5} \Rightarrow \sigma_{norm} \sim error_{norm} \sim \overline{x}^{-0.5} \tag{1}$$

The first variability factor, called relative rms (v), is the standard deviation of the light-curve divided by its median error. This factor is not proportional to the mean value of the light-curve so it is not affected by the apparent magnitude and can represent the level of stellar activity.

As an example, Fig.1 shows two Kepler stars of the same physical characteristics of which the second appears to have a variation while the first does not. The first star has larger rms only because of its magnitude but the second has larger relative rms because of its intrinsic variability.

Table 1: The rms of two Kepler stars seen at Fig.1

name	rms	v	mag	Teff	log(g)
kplr005262885	-3.26	0.06	15.566	5524	4.543
kplr005437806	-3.60	0.22	13.775	5512	4.59

Apart from the light-curve we also used the v-curve, constructed by the values of v calculated in sections of 7 days time range. The second factor, called activity rms (vv), is the standard deviation of the v-curve divided by its mean value. This factor is not proportional to the mean value of the v-curve so it is not affected by the activity level and can represent the variation of stellar activity.

2 Results

Fig.2 shows the relationship between the two variability factors excluding the KOI and the eclipsing binaries and containing only the dwarf stars, defined by the formula [2]:

$$log(g) > \begin{cases} 4 & \text{if} \quad Teff < 4250 \\ 5.2 - 0.00028 * Teff & \text{if} \quad Teff \epsilon (4250, 6000) \\ 3.5 & \text{if} \quad Teff > 6000 \end{cases} \tag{2}$$

This plot helps us clearly distinguish the different regions of stellar variability:
1. a) Abrupt, non periodic changes e.g. flares or eclipses (Fig. 4)
1. b) Large scale changes with unstable amplitude
2. a) Fast rotating stars
2. b) Periodic changes with small period and stable amplitude
3. Normal high variability stars of each spectral type [1]
4. Normal low variability stars of each spectral type [1]
5. Red giants region (not visible)

Finally Fig.3 proves that the percentage of high-variability stars decreases with temperature until 6000K and then rises again until 7000K. Above this limit there are not enough stars for a reliable conclusion.

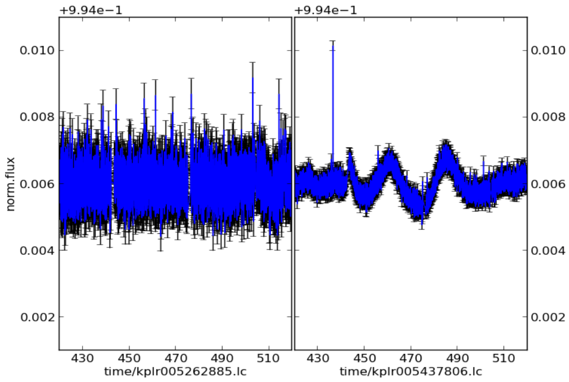

Figure 1: The rms of two Kepler stars

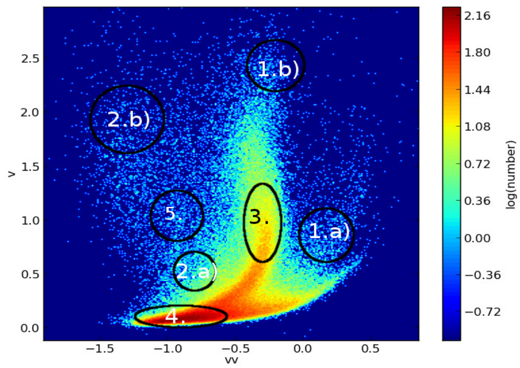

Figure 2: Population distribution by v and vv

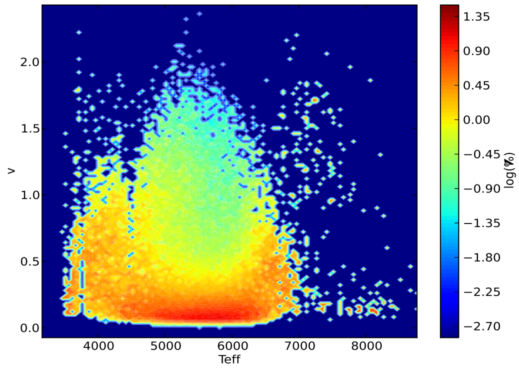

Figure 3: Percentage distribution of Kepler stars by temperature (Teff) and activity (v).

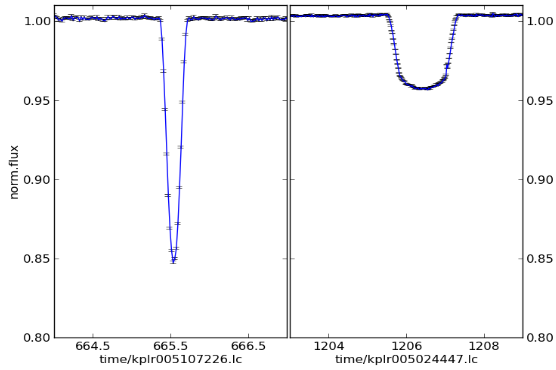

Figure 4: Two transit-like events from stars not included in KOI or eclipsing binaries lists.

References

[1] McQuillan, A., Aigrain, S., & Roberts, S. 2012, A&A, 539, A137

[2] Ciardi, D. R., von Braun, K., Bryden, G., et al. 2011, AJ, 141, 108

[3] Basri, G., Walkowicz, L. M., Batalha, N., et al. 2011, AJ, 141, 20