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HD181906: a low signal-to-noise ratio target of CoRoT

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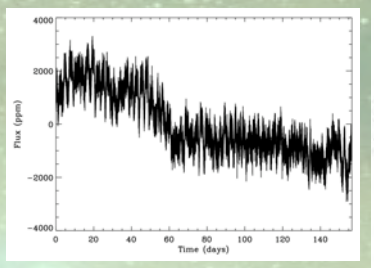
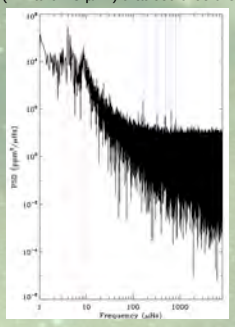
Abstract

HD181906 is an F8 star (Teff ~6530 K, Mass ~1.22 $M_\odot$ and R ~1.5 $R_\odot$) observed for 156 days by CoRoT during the first long run of the centre direction. Analysis of the data reveals a spectrum of solar-like acoustic oscillations. However, the faintness of the target (v~7.65) means the S/N in the acoustic modes is quite low, and this low S/N leads to some complications in the analysis.
We have been able to infer the mean surface rotation rate of the star (~4 μHz) with a differential rotation similar to the Sun, the inclination angle (in the range 40 to 50 degrees), the large separation of the p modes (~85 μHz), and therefore also the "ridges" corresponding to overtones of the acoustic modes. In addition to presenting these results, we shall also discuss analysis undertaken to extract individual frequencies, and to tag angular degrees of the modes.

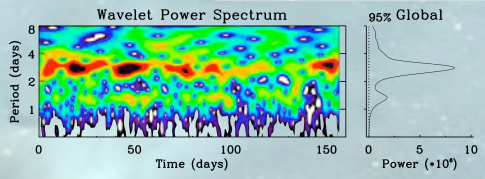
Data set & PSD

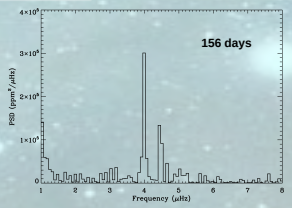
- HD181906 is one of the main target of the first 156-d long run in the centre direction..
- The cadence of the light curve has been interpolated to 32 seconds (HELREG data).
- The light curve has been corrected of low-frequency trends in the CCD as well as some outliers.
- The duty cycle achieved is above 93% with most of the holes being a consequence of the crossing of the South Atlantic Anomaly (SAA). Harmonics of the rotation period at 161.7 μHz are clearly visible in the PSD (blue dotted lines).
- In the PSD, there are 2 peaks at very low frequency (~ 4 and ~8 μHz) that could be the signature of the averaged surface rotation.

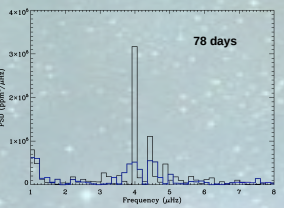




Averaged surface rotation rate





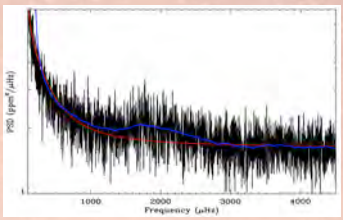


- The Global Wavelet Power Spectrum (Torrence & Compo 1998) shows that most of the energy is located in a peak at 2.81 days with a first harmonic at 1.4 days.
- Spots-fitting technique (Mosser et al. 2009) gives a rotation frequency around 4.2 μHz, with some differential rotation.
- The PSD shows two thin peaks at 4 and 4.45 μHz (2.9 and 2.6 days)
- By splitting the light curve in two 78-days chunks:
  - Power spread in the second half with 3 main peaks in a range 3.1 to 2.3 days. The main peak is smaller, which is also visible in the time-frequency diagram).
  - If this is due to surface differential rotation, this star would have a slightly higher differential rotation than the Sun.

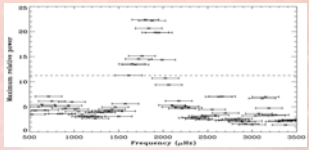
This information coupled to the observed V sini~16 km/s gives an inclination angle for the star around 45° ± 10°; value also obtained by the spots-fitting method.

P-mode spectrum

From scale laws (Kjeldsen & Bedding 1995; Samadi et al. 2007) we obtain estimations of: ν_{max}= 1.2-1.75 mHz; Δν =67-87 Hz; A=4.9-5.3 ppm

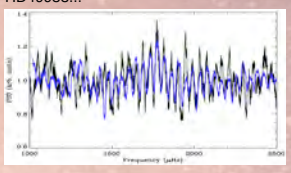


PSD corrected from the orbital harmonics and smoothed by a boxcar function of 3.6 μHz. The red line corresponds to a fitting of the background. The blue line is the PSD of the star heavily smoothed by a boxcar of 370 μHz. An excess of power due to the p-mode is clearly seen.



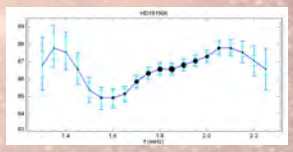
The systematic analysis of the Power Spectrum of the power spectrum (PSPS) in pieces of 300 μHz shifted by 100 in a window centered at the theoretical expected Δν allows the detection above a 95% threshold of the p-mode band between 1.5 and 2.2 mHz

Several methods have been used to obtain an estimation of the large separation: autocorrelation, PSPS, cross-correlation with HD49933...



Smoothed power density spectrum of HD181906 (black) and HD49933 (blue) shifted by 20mHz and with proper offset and scaling.

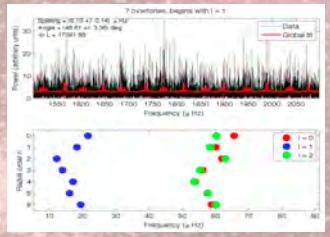
Large separation ≈ 83-90 μHz (depending on the region observed).



Variation of the large separation with frequency using the autocorrelation function following Roxburgh et al. 2009 and Mosser et al. 2009.

The maximum amplitude (rms in ppm per radial mode, according to Kjeldsen et al 2008, modified) is ~ 2.9 ± 0.3 ppm

- A global fitting approach has been used to determine p-mode characteristics (Appourchaux et al. 2008).
- Groups of fitters have used different approaches:
  - Using the full PSD
  - Cutting the full time series in independent chunks and:
    - averaging them
    - using the Joint power statistics (Sturrock et al. 2005)
- Different approaches of the model to be fitted:
  - Fixing the inclination angle and the splitting or not
  - Fitting only l=0 and 1 or l=0,1, and 2
  - Linewidth:
    - 1 for every large separation (as in Appourchaux et al. 2008)
    - A single one for all the modes
  - Including or not Bayesian constraints:
    - On the small spacing
    - On the linewidth (to avoid fitting spikes)
  - Fitting 5, 7 and 9 overtones
  - Two scenarios depending on the tagging of the ridges.



Example of a global fitting over 7 overtones. In this particular example, a global amplitude and a single linewidth have been used.

Conclusions:
All the fitters mostly converge towards the same fitted frequencies inside the uncertainties in spite of the different techniques used. Unfortunately, the likelihood ratio between the 2 scenarios does not allow us to disentangle between them.

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- **Samadi et al. 2007, A&A, 463, 297**
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