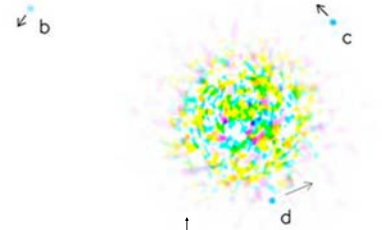


In-depth asteroseismic analysis of HR8799 the host of the first direct-imaged exoplanetary system

A.-N. Chené (NRC-HIA), E. Kambe (OAO), D. Wright (ROB), P. De Cat (ROB), C. Marois (NRC-HIA), MOST team

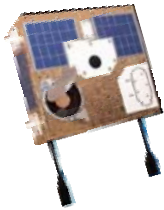


The three planets HR8799b, c and d observed at Keck Marois et al. (2008)

Rationale:

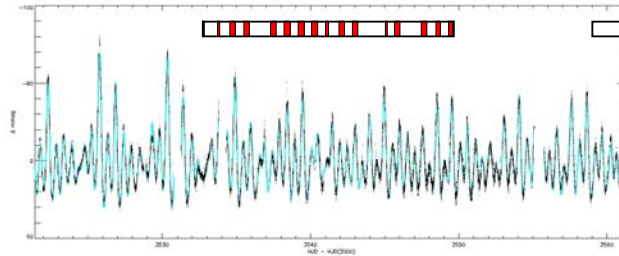
Direct imaging of the HR8799 system (Marois et al. 2008) was a major achievement in the study of exoplanets. However, determining the masses of the companions depends crucially on the age of the parent star. Fortunately, HR8799 is a Gamma Dor variable and asteroseismology may provide an independent age constraint. The orbital inclination, useful for the fit of the companions' orbit, may also be determined.

MOST Photometric Observations:



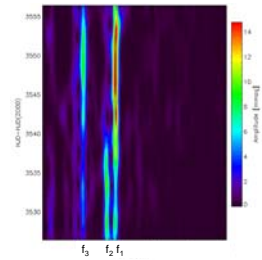
MOST

- First Canadian space telescope
- 10 cm aperture
- 1024x1024 CCD
- Precision of ~1 ppm ($v \sim 6$)
- Orbital period : 100 min



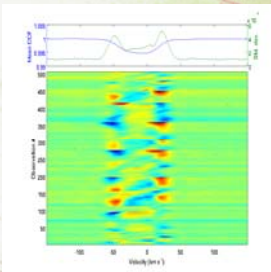
Photometric analysis

- 42 days of quasi-continuous observations (black points)
- More than 45 frequencies identified (cyan curve)
- Coordinated with ~1000 spectra (black rectangles)
- ~510 spectra from OAO (red filled rectangles)
- Total amplitude of 100 mmag (hard from ground!!!)



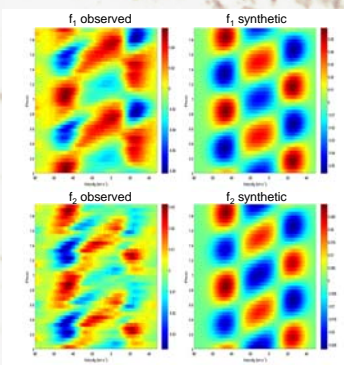
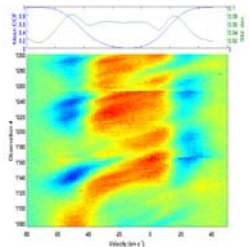
- 3 independent frequencies identified
- The Short-Time Fourier Transform ($STFT$) shows the evolution of the frequencies
- f_2 seems to disappear during the run!
- Investigation of the many other frequencies in progress
- Possible variations in *amplitude and phase*

Multi-site Spectroscopic Campaign



~1740 spectra were obtained with **Okayama Astronomical Observatory** (~510 spectra!), Xinglong Observatory, Tautenburg Observatory, Observatoire de Haute-Provence, Mercator, ESO-2.2m, McDonald, Lick Observatory and Dominion Astronomical Observatory over a time-span of two years.

The figure on the left shows clear line-profile variations observed in the OAO spectra. On the right is the same, but for only ~3 days observed continuously from 4 different telescopes.



Four (4) independent frequencies have been found (including f_1 , f_2 and f_3 from photometry), and preliminary mode identification gives $l=1$ and $m=1$ for f_1 and f_2 .

This figure shows the line-profile variability folded with f_1 and f_2 , after pre-whitening the spectra of the other identified frequencies. On the left is the observed variability and on the right, the variability expected for $l=1$ and $m=1$ for f_1 and f_2 .

The current determination of the orbital inclination from asteroseismology is significantly larger than the one found from the orbit of HR8799's companions. However, with $v \sin i \sim 40$ km/s, if i is small (i.e. lower than 30°), f_{rot}/f_{puls} is high and the usual custom tools for asteroseismic analysis may not be appropriate!

Future Work:

After complete determination of the pulsation modes found with the photometry and the spectroscopy, the interior of HR8799 will be modeled using the most up-to-date models for Gamma Dor Stars and, ideally, HR8799 will be placed in the HR diagram. Also, an asteroseismic tool including fast rotation velocity may be used in order to get a better constrain of the orbital inclination. Finally, possible amplitude and phase variations and frequency disappearance will be investigated.