Measuring detailed properties of stars and exoplanets

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Asteroseismology – the study of stellar oscillations – is a relatively new and growing research field in astrophysics. The analysis of frequencies and other properties of stellar oscillations (see figure 1) allows us to constrain fundamental parameters of stars such as density, mass, radius, age, rotation period and chemical composition.

Oscillations are found in stars of all masses and essentially all stages of evolution. The amplitudes and phases are controlled by the energetics and dynamics of the near-surface layers and the frequencies are determined by the internal sound-speed and density structure of the star. Observationally, the frequencies can be determined with extremely high accuracy compared to any other quantity relevant to the internal properties of the stars. Analysis of the observed frequencies, including comparison with computed stellar models, allows determination of the properties of the stellar interiors as well as global stellar properties. Typically, one can determine the stellar mean densities to an accuracy of 1%, radii to 2–3%, masses to 5%, and ages to 5–10% of the main-sequence lifetime. For rotating stars, the angle of inclination can also be determined.

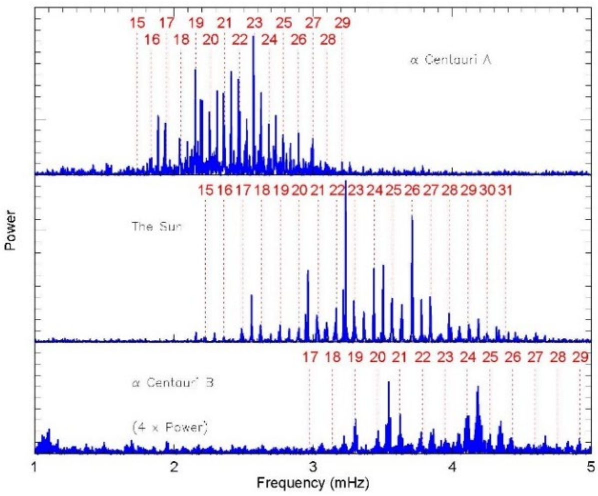

Figure 1. The power spectrum of oscillations in the stars α Cen A [1], the Sun and α Cen B [3]. The fiure shows the details of the p-mode frequency structure, and indicated is the so-called large frequency separations for each star, which contain information on the stellar mean density.

Planetary transits (when an exoplanet will cross the disc of the host star) and the occultations (when the exoplanet passes behind the disc of the star) is a geometrical effect that in general will scale with the absolute size of star (the stellar radius). The transit depth in the light curve is determined as the relative dip in the light curve during transit (see figure 2). The transit depth is a direct measure of the relative size of the exoplanet. Apart from the transit depth one can also measure the accurate orbital period for the exoplanet as the time difference between the centre of two transits in the light curve.

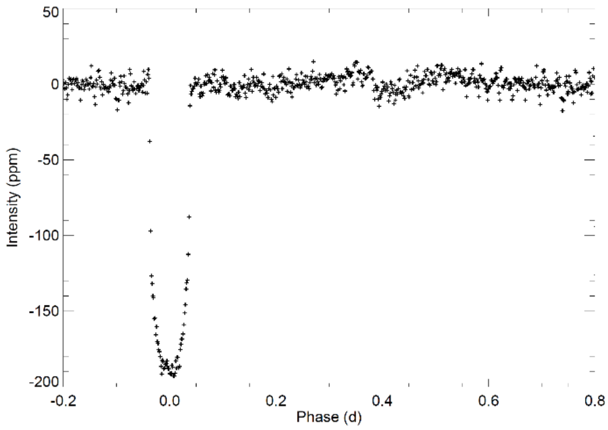

Figure 2. An example of an exoplanet transit in the star Kepler-10 [2]. The relative depth of the transit can be used to determine the relative size of the exoplanet (R(planet)/R(star) = 0.01254 ± 0.00013).

If we combine asteroseismology with planetary transit measurements one can obtain very accurate absolute values for the properties of both the host star as well as the exoplanet in orbit around a given star. Those measurements can be used to test structure and evolution of stars and exoplanets in a large number of specific cases. In this talk I will discuss detailed measurements of stars and exoplanets and present some of the results which are obtained by use of high-quality time series data from space combined with ground-based spectroscopy. I will also discuss and demonstrate why and how international research collaborations are essential for the success of those research activities.

Key words: stars, exoplanets, space missions, asteroseismology

References

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