Detection and characterisation of oscillations above the acoustic cut-off frequency in 91 Kepler stars

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Abstract

Whilst oscillations with frequencies less than the acoustic cut-off frequency are trapped within stellar interiors, higher frequency oscillations are not, and so become travelling waves. The interference between these high frequency waves produce an observable, sinusoidal structure in the power spectrum of the star, above the cut-off frequency. These high frequency oscillations are known as pseudo-modes, and are the focus of our study. We have written an algorithm to detect these pseudo-modes, following on from the work of Jimenez et al. (2015), who extends analysis of the pseudo-mode region beyond the Sun to six Kepler stars. In our algorithm, we take a power spectrum of the power spectrum (PSxPS) for a range of frequencies in which we would expect to observe the pseudo-modes, and search for a statistically significant peak. This method has been applied to 91 solar-type stars (ranging in mass from 0.8-1.5 M), using KASOC data from NASA's Kepler mission. In addition, we search for temporal frequency shifts in the pseudo-modes. It has been found in the Sun that pseudo-mode frequencies vary in anti-phase with the solar magnetic cycle, and so we expand this search to our stellar candidates. We utilise the methodology of Kiefer et al. (2017) by obtaining frequency shifts through the generation of a cross-correlation function (CCF) between the periodograms of a reference time segment, and successive time segments. For the Sun, the variation in pseudo-mode frequencies is larger than the corresponding change in p-mode frequency throughout the solar cycle. Pseudo-modes, therefore, may represent a powerful tool for studying stellar magnetic activity cycles.

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