Anomalous high-amplitude peaks in the Fourier spectra of Kepler red giants

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Introduction

The red giants examined in this study were first noted in the early days of Kepler to exhibit anomalous high-amplitude peaks in addition to solar-like oscillations. These peaks were initially thought to be mixed modes. With more data, the narrowness of the peaks indicated they were likely to be caused by binarity. This interpretation is favoured by the presence of harmonics and subharmonics in many targets, as in Fig. 1. The peaks are present at such low frequencies that any binary companion would be orbiting within the red giant's convective envelope, forming a common envelope system. It is also possible that these are hierarchical triple systems, with a compact binary orbiting a red giant (Derekas et al., 2011), although there is not yet any evidence to support this. We focus on detecting and discounting cases where a background or foreground compact binary has contaminated the light collected from the red giant.

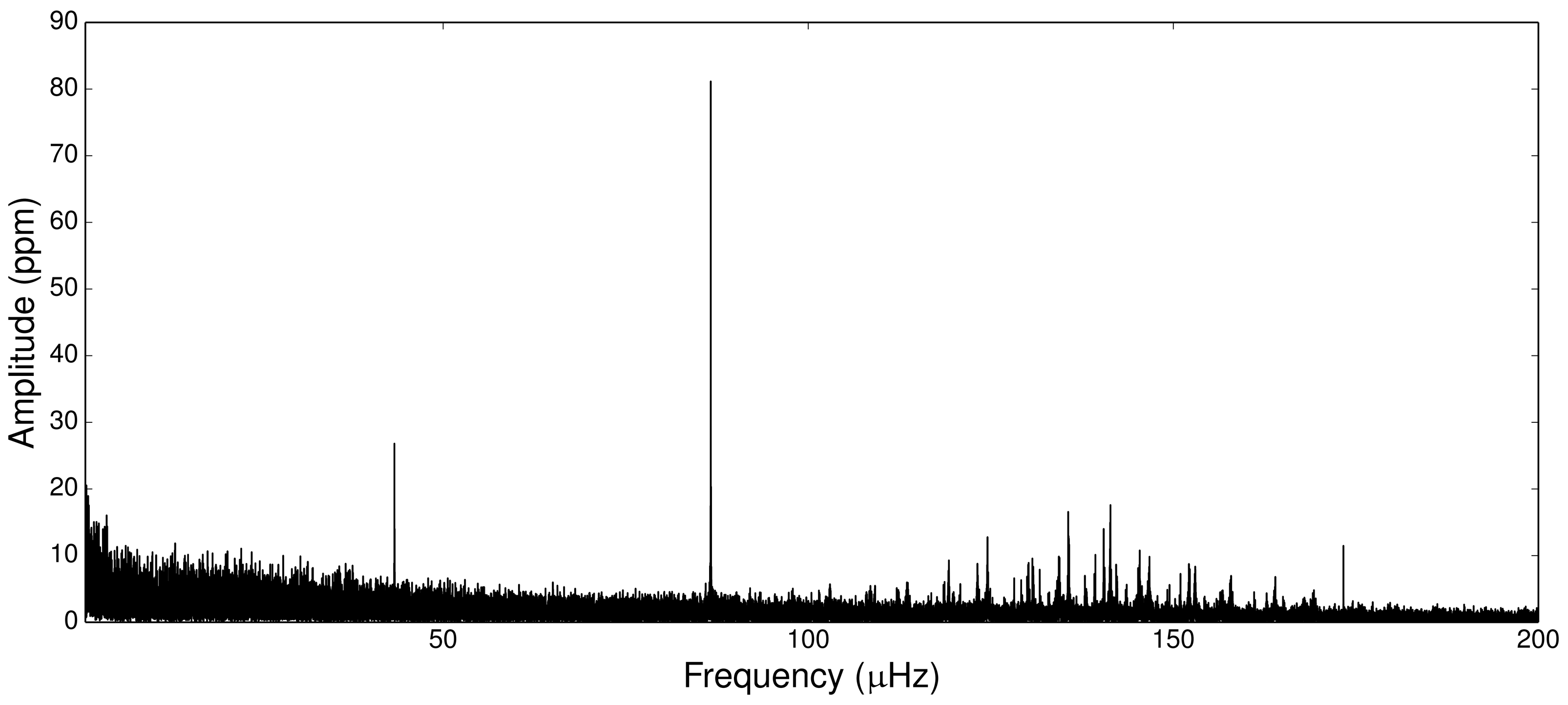

Figure 1: The amplitude spectrum of KIC 4350501, the first noted red giant with an anomalous peak (Bedding et al., 2010). Oscillations are visible at 140 μHz.

Analysis

Using the frequency of the anomalous high-amplitude peak, we phase-folded each star's time series. Most phased curves displayed ellipsoidal variation, reinforcing the idea that these peaks are due to binarity. We examined Kepler target pixel files (TPFs) by taking a Fourier transform of each 4" pixel (Fig. 2). If the source of the anomalous peak was clearly offset from the target star, it was classed as a blend. We also calculated difference images (as in Bryson et al., 2013) of the TPF postage stamps at different phases. The majority of blends in our sample (Fig. 3) were contaminated by bright stars further than 4" from the target. We synthesised a model population of the Kepler field using Galaxia (Sharma et al., 2011) and found that the rate of blends within 4" is very low. This implies that most of the remaining stars are likely to be physically associated systems.

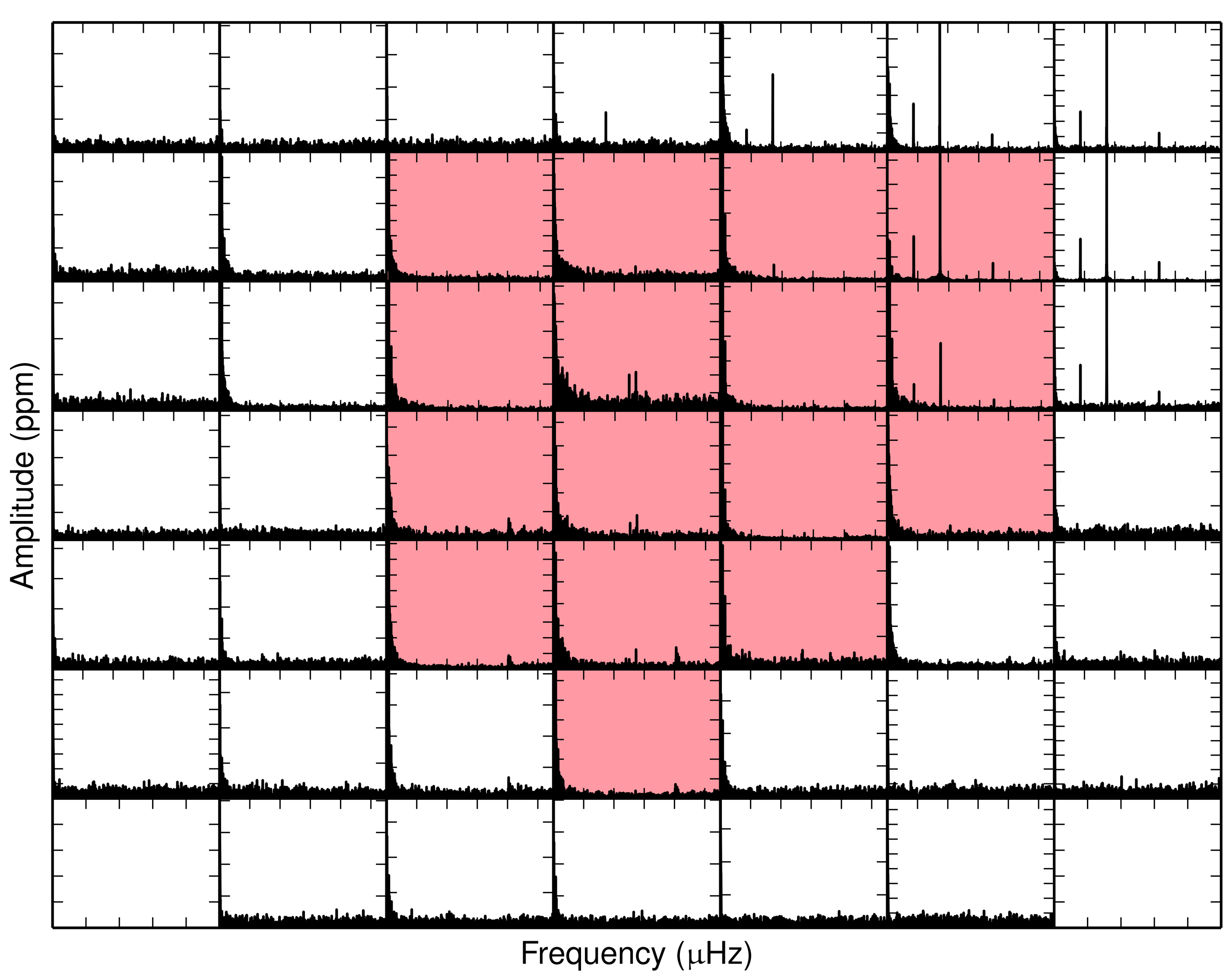

Figure 2: The Kepler postage stamp around KIC 4350501. The shaded area indicates the target aperture. Amplitudes are not to scale. Note the contamination from the top right area of the TPF.

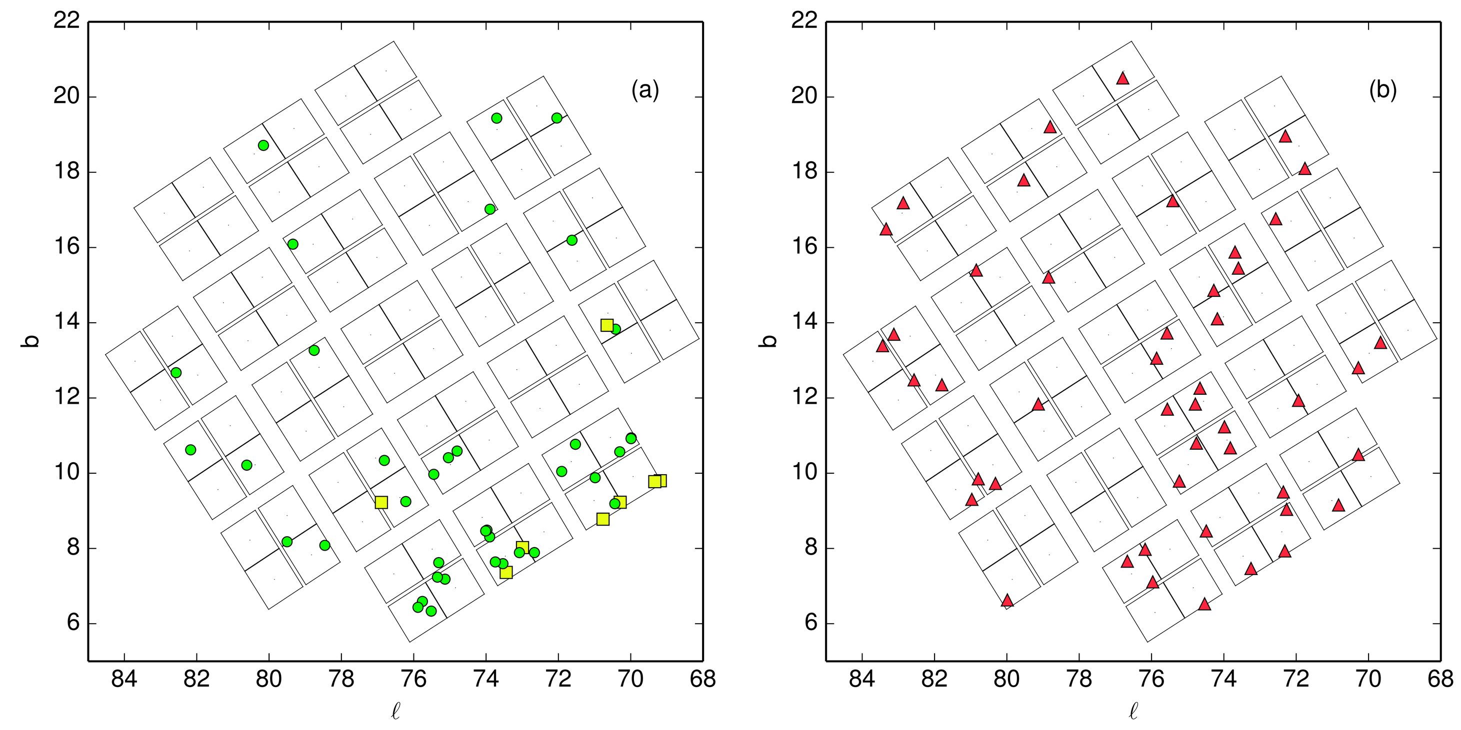

Figure 3: Panel (a) shows red giants with anomalous peaks that were found to be blends. In the case where a Kepler light curve was available to confirm this blending, the star is indicated by a yellow square. Panel (b) shows the population of red giants which exhibit an anomalous peak and are not blends.

Discussion & Conclusions

From a sample of 93 red giants with anomalous peaks, 46 could be categorised as blends. For 7 of those, we were able to confirm the sources of contamination with the analysis of Kepler light curves of nearby stars. There is a higher density of stars at lower galactic latitudes and closer to the galactic plane (Fig. 3). At higher galactic latitudes we observe a marked paucity of stars as expected, both in the field itself and in the sample considered in this study. Similarly, the blends follow this pattern. It is noteworthy, then, that the stars that were not discerned to be blends seem to be scattered quite evenly across the FOV.

A cumulative distribution as a function of galactic latitude (Fig. 4) shows that the distribution of unusual red giants is closely matched to a distribution of randomly selected Kepler red giants. Both distributions show a more consistent increase away from the galactic plane, as compared to the distribution of blends, which increases sharply at low galactic latitudes. The difference in distributions points to the possibility that the sample of 47 stars which we did not classify as blends is indeed a population of physically associated systems.

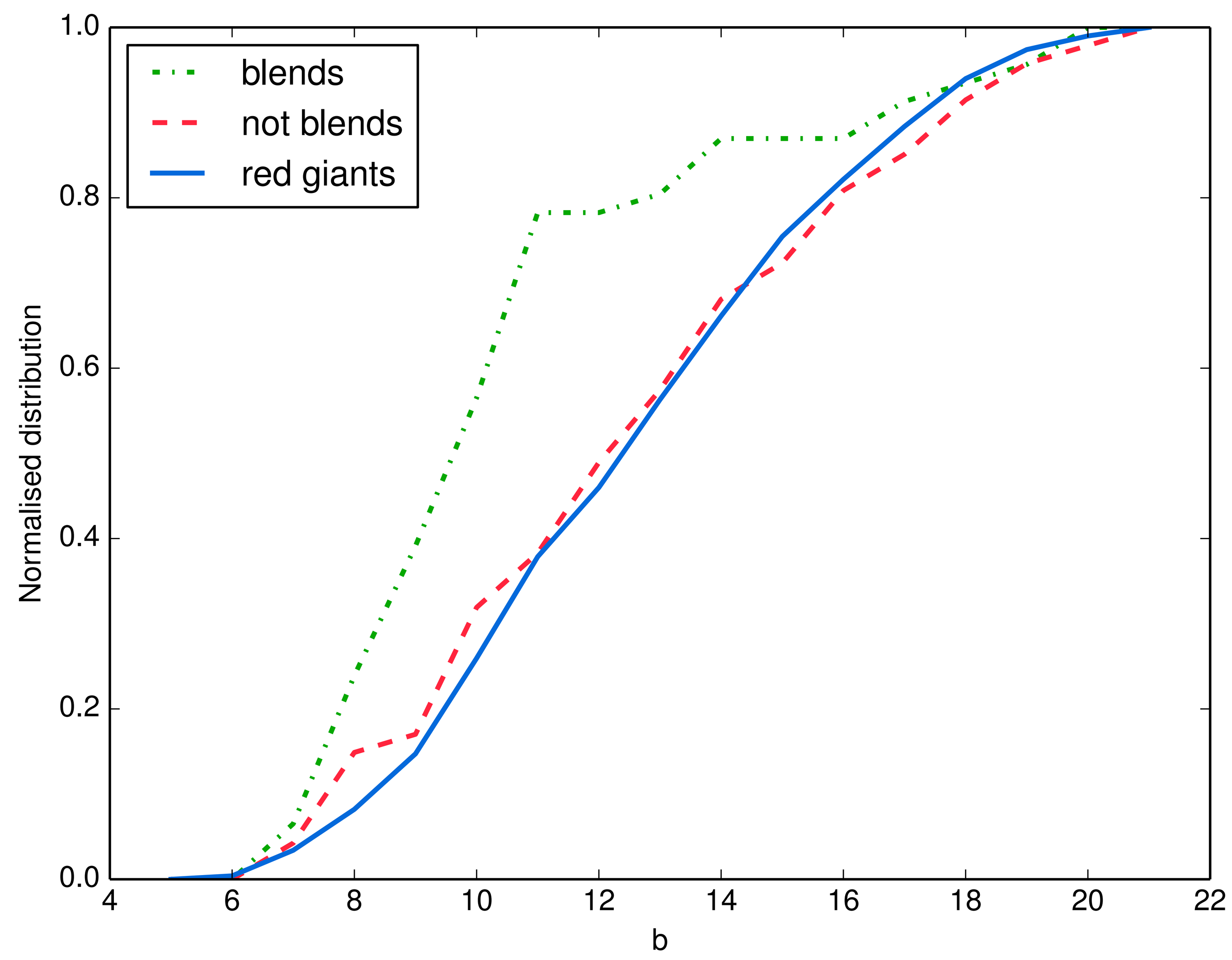

Figure 4: Cumulative distributions of the populations in Fig. 3. The solid blue line shows the distribution of 1000 Kepler red giants chosen at random.

References

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