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# Beyond transits: finding non-eclipsing binaries with Kepler through pulsational phase modulation

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## Abstract

We present a method for finding binaries among pulsating stars that were observed by the Kepler Mission. We use entire four-year light curves to accurately measure the frequencies of the strongest pulsation modes, then track the pulsation phases at those frequencies in 10-d segments. This produces a series of time-delay measurements in which binarity is apparent as a periodic modulation whose amplitude gives the projected light travel time across the orbit. Fourier analysis of this time-delay curve provides the parameters of the orbit, including the period, eccentricity, angle of ascending node and time of periastron passage. Differentiating the time-delay curve yields the full radial-velocity curve directly from the Kepler photometry, without the need for spectroscopy. We show examples with delta Scuti stars having large numbers of pulsation modes, including one system in which both components of the binary are pulsating. We also compare RV curves obtained through this method with those inferred from spectroscopic monitoring. The method is straightforward to automate, thus radial velocity curves can be derived for hundreds of non-eclipsing binary stars from Kepler photometry alone. Results for the full set of Kepler delta Scuti binaries will be discussed.

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