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Title: It takes a village to raise a tide: nonlinear multiple-mode coupling and mode identification in KOI-54
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Abstract: We explore the tidal excitation of stellar modes in binary systems using Kepler observations of the remarkable eccentric binary KOI-54 (HD 187091; KIC 8112039), which displays strong ellipsoidal variation as well as a variety of linear and nonlinear pulsations. We use pulsation phases to determine that the two largest-amplitude pulsations, the 90th and 91st harmonics, most likely correspond to axisymmetric m=0 modes in both stars, and thus cannot be responsible for resonance locks as had been recently proposed. We find evidence that the amplitude of at least one of these two pulsations is decreasing with a characteristic timescale of ~100 yr. We also use the pulsations' phases to confirm the onset of the traveling wave regime for harmonic pulsations with frequencies <~50 Omega_orbit, in agreement with theoretical expectations. We present evidence that many pulsations that are not harmonics of the orbital frequency correspond to modes undergoing simultaneous nonlinear coupling to multiple linearly driven parent modes. Since coupling among multiple modes can lower the threshold for nonlinear interactions, nonlinear phenomena may be easier to observe in highly eccentric systems, where broader arrays of driving frequencies are available. This may help to explain why the observed amplitudes of the linear pulsations are much smaller than the theoretical threshold for decay via three-mode coupling.