CUSTOM APERTURE OBSERVATIONS OF THETA CYG, THE BRIGHTEST STAR OBSERVABLE BY KEPLER

Joyce Guzik
Los Alamos National Security, LLC
GO40014

At visual magnitude 4.5, the F4 main-sequence star theta Cyg (KIC 11918630) is the brightest star that falls on active silicon in the Kepler CCD field of view. Custom aperture observations of theta Cyg requiring 1800 pixels in Quarters 6 (June-Sept. 2010) and 8 (January-March 2011) revealed solar-like oscillations spanning at least 17 radial orders. The brightness of theta Cyg allows for ground-based high-resolution spectroscopy to obtain abundance, rotation, effective temperature and surface gravity constraints. Angular diameter measurements from interferometry combined with HIPPARCOS parallax measurements give excellent constraints on the luminosity and effective temperature. With an effective temperature around 6600 K, theta Cyg falls near the border in the Hertzprung-Russell diagram between the gamma Doradus pulsating variables with gravity-mode pulsations driven by the convective blocking mechanism at the base of the convective envelope, and solar-like oscillators with pulsations driven stochastically by convection at the top of the convective envelope. While no gamma Doradus gravity modes have been observed so far in theta Cyg, possibly because of low-frequency background that may result from granulation, stellar activity, or instrumental effects, a longer time series of observations may reveal such g modes. Finding the first hybrid gamma Dor/solar-like oscillator would be valuable in confirming the pulsation driving mechanism that depends on the convection zone depth, constraining convection and diffusive settling models, and even to inform the solar abundance problem, as the convection zone depth is sensitive to differences in element mixtures. A longer time series of Kepler observations is necessary to make use of the solar-like oscillations, as with only the existing Kepler data, the peaks in the power spectrum are wide as modes are heavily damped (as is true for other well-studied solar-like F stars Procyon and HD 49933), and so the mode identification is ambiguous between modes of degree l = 0, 2 and l =1, 3. A longer time series will also realize the potential to study mode lifetimes and understand why the theory for mode amplitudes and lifetimes for solar-like oscillations in G-type stars does not work as well for F stars, to resolve the rotational splitting in the less damped lower frequency modes to study differential rotation, and use seismic signatures to infer the envelope convection zone base. If gamma Dor g modes are found, these also have potential to constrain the convective core size and core overshoot. A long-enough time series on theta Cyg may allow us to follow changes in the frequencies to discover and study a possible magnetic cycle. We propose a continuous time series of custom aperture observations of theta Cyg for as long as possible (to the end of the Kepler mission and through the Extended Mission). We will carefully process the pixel data to optimize the chance to find g modes, and to study granulation and stellar activity. We will use the combined data to obtain accurate p-mode frequencies, mode identifications, amplitudes, and lifetimes. We will work with a large group of colleagues to obtain constraints from recent spectroscopic and interferometry observations and combine them with the frequency information for stellar modeling and asteroseismology.