Kepler Photometry of Numerous Cepheids and Cepheid-Like Supergiants (At Last!)

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Although prized for the reliability of their pulsations, and widely viewed as laboratories to study sustained and consistent radial pulsation modes, there are several examples of additional variability in Classical Cepheids (Cepheids hereafter) when observations of high enough cadence and precision are possible. Some excellent examples of what can be achieved, given sufficient data, are briefly summarized in Evans et al. (2014):

1) Kepler photometry of the fundamental mode Cepheid V1154 Cyg ($P_{pulsation}$ = 4.93-days) has revealed "period flickering" – shifts in consecutive times of maximum light as large as ~10–30 minutes – throughout the *Kepler* dataset (almost 600-days of data were used in the study). Further, amplitude variations of ~2–6-mmag and variations in light curve structure were also found (Derekas et al. 2012). Before *Kepler* observations began, studies had reported a *possible* 0.08 second per year increase in the period of V1154 Cyg, but the scatter of the data could also easily allow for a constant period (Turner et al. 1999), and there was no suspicion of possible amplitude variability.

2) *MOST* photometry of the 3.73-day Cepheid RT Aur and the 3.15-day, first overtone Cepheid SZ Tau showed similar behaviors to what was found in V1154 Cyg. First overtone Cepheids are known to show larger scatter in long-term period and amplitude studies and accordingly, over the brief *MOST* dataset, SZ Tau showed amplitude changes as large as 30-mmag. It's also important to note that each Cepheid was only observed for less than 20-days with *MOST*; just 1/4th of the expected *K2* Field 0 timespan.

Studies such as those of *Kepler* and *MOST* have revealed unexpected behaviors in these few Cepheids but, unfortunately, V1154 Cyg is the only Classical Cepheid in the primary *Kepler* field and *MOST* is rather restricted in the number of targets it can observe. Now, however, **the *K2* mission can at last achieve high-precision, continuous photometry of numerous Cepheids.** This will allow us to detail their intricate behaviors over a range of pulsation periods, amplitudes and pulsation modes (e.g. fundamental, first overtone, bump resonance…). We can begin applying detailed variability studies (such as the *Eddington-Plakidis* test for random pulsation period changes) to a more statistically significant sample, and drawing broader conclusions about the Cepheid class of pulsating variables.

We're very excited about the scientific potential of known Cepheids in the *K2* fields, but the instability strip region of the HR diagram is not occupied solely by Cepheids. There are also non-variable supergiants (NVSs) in and around the instability strip. Cepheids have a large range of brightness amplitudes: Polaris, for example, currently varies by ~60-mmag and, a decade ago, varied by only ~20-mmag. Ultra-low amplitude Cepheids like Polaris are somewhat rare, but *K2* allows us to search numerous "Cepheid-like supergiants" and determine if they are undergoing minimal radial pulsations that have so far eluded detection – shedding light on the dividing line between Cepheids and NVSs by showing if ultra-low amplitude Cepheids are perhaps more common than originally thought.

For this proposal, we conducted searches for known Cepheids along with non-variable F-G supergiants in a circle of 12-degrees radius centered on Field 0. We propose *K2* photometry of 37 Cepheids and 25 F-G supergiants. Happily, we have already been observing four of the Field 0 Cepheids for the past 3–7 years as part of the *Secret Lives of Cepheids* program (and one of the targets has also been approved for *BRITE-Constellation* photometry). This program was originally designed to search for long-term (yearly) changes in Cepheid pulsations (Engle & Guinan 2012), and the *K2* mission offers the absolute best way of now expanding our program to search for short-term and cycle-to-cycle pulsation modulations.

In summary, the K2 mission promises a ground-breaking view of Cepheids that has only been available for a very limited number of targets until now, revolutionizing our understanding of this fundamentally important class of pulsating variables.

References:

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