Kepler Observations of Two WDs Inside the ZZ Ceti Instability Strip

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We propose short-cadence observations in Field 3 of the K2 *mission of two high-probability pulsating WDs with colors inside the empirical ZZ Ceti instability strip, as identified from the Sloan Digital Sky Survey.*

As they cool, white dwarf (WD) stars with hydrogen-dominated atmospheres pulsate as DAVs (a.k.a. ZZ Ceti stars) when they reach the appropriate effective temperature to foster a hydrogen partial-ionization zone, which efficiently drives global oscillations. This range of temperatures empirically spans roughly $12{,}600-11{,}100$ K for canonical-mass ($0.6\,\mathrm{M}_{\odot}$), $\log g = 8.0$ WDs (Gianninas et al. 2011, ApJ, 743, 138). Pulsating WDs provide an important glimpse into the interior of the future of the vast majority ($> 97\%$) of all stars in our Galaxy, including our Sun.

Since the ZZ Ceti instability strip is defined by temperature, color selection is an excellent predictor of variability. Our team discovered all DAVs in the original *Kepler* mission, which has led to exquisite insight into WD interiors (e.g., Greiss et al. 2014, MNRAS, 438, 3086). We have applied the same photometric selection methods to *K2* Field 3, and have identified two WDs on silicon with colors consistent with the empirical ZZ Ceti instability strip. We have high confidence in our selection: Our candidates are $> 95\%$ probability DAs (see Girven et al. 2011, MNRAS, 417, 1210). Additionally, we have two nights in 2014 July with the ISIS spectrograph on the 4.2 m WHT on La Palma which we plan to use to derive the atmospheric parameters of these two objects to determine their place in the ZZ Ceti instability strip.

Our two targets have colors well within the instability strip, as shown in Figure 1, and likely pulsate (although we were unable to obtain sufficient ground-based photometry to confirm variability before this proposal deadline). Every new DAV we can observe with *Kepler* adds value, since it brings us that much closer to statistically significant studies of WDs with ensemble asteroseismology (e.g. Chaplin et al. 2011, Science, 332, 213). To date, there are only six pulsating WDs with more than two weeks of *Kepler* observations. With typical pulsations ranging from $100 - 1400$ s, we require **short-cadence** observations of these two WDs. Minute-cadence *K2* observations have the added benefit of catching transits/eclipses of the WD, revealing any unresolved double-degenerate binaries or even planetary companions.

Even if our WDs do not pulsate, *K2* observations will prove extremely valuable, as they will put unprecedented limits on lack of variability near the instability strip. Better defining the boundaries of the ZZ Ceti instability strip helps us to understand the driving conditions for WD pulsations. The blue edge where pulsations turn on is fairly well predicted by theory, and has been successfully estimated by both convective period arguments (Brickhill 1991, MNRAS, 252, 334) and full non-adiabatic calculations (e.g., Winget et al. 1982, ApJ, 252, L65). However, a theoretical understanding of the physical mechanism which dictates how pulsations shut down in WDs remains elusive (e.g., Van Grootel et al. 2012, A&A, 539, A87). In the past, variability has been assessed by relatively short ($2 - 3$ hr) observations, generally to limits of $0.2 - 0.6\%$. Some ZZ Cetis pulsate at lower amplitude, many with maximum pulsation amplitudes of $0.1 - 0.3\%$, and several WDs "not-observed-to-vary" have later been confirmed to pulsate with further observations (e.g., Castanheira et al. 2010, MNRAS, 405, 2561). We predict *K2* would set limits of roughly 500 ppm (0.05% relative amplitude) using 75 d of data, an order-of-magnitude improvement from the ground.

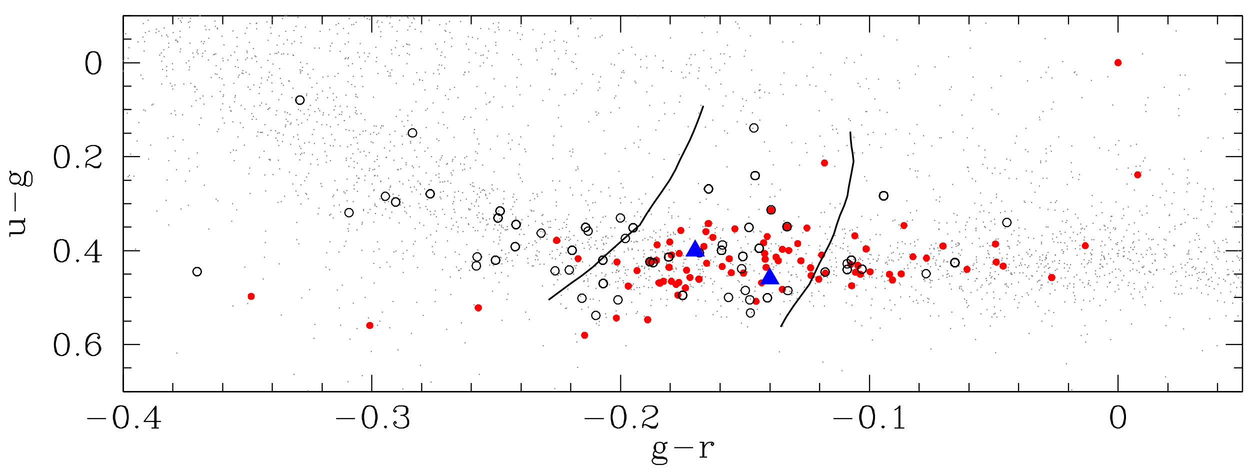

Figure 1: Our two targets in the u-g, g-r plane, which sit within the empirical boundary of the ZZ Ceti instability strip (black lines). The large blue triangles are our candidates, the red points are confirmed DAVs from Mukadam et al. (2004, ApJ, 607, 982), and the open circles are non-variable WDs from that same work, to median limits of 0.4% relative amplitude. The gray points are spectroscopically confirmed WDs from SDSS (Kleinman et al. 2013, ApJS, 204, 5).