K2 Rotation and Asteroseismology for an F-type star with 37 years of Activity Records

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The magnetic variability of Sun-like cool dwarf stars was firmly established with the observations of chromospheric Ca II H and K line emission in a 37-year observation program (1966–2003) at the Mount Wilson Observatory (MWO) (Wilson, 1978; Baliunas et al., 1995). The MWO HK photometer measured the 1 Å emission in the H & K line cores relative to nearby continuum bands, in a relative emission measure known as the S-index. Decades-long observations of ∼100 stars put the 11-year solar cycle into a broader stellar context. Though progress has been made in explaining the solar cycle in terms of a magnetohydrodynamic dynamo, significant uncertainties remain in the processes responsible for converting torroidal field into poloidal field, and a satisfactory *ab initio* model proceeding from fundamental physics does not yet exist (e.g. Charbonneau, 2010). Stellar observations can provide new tests of stellar dynamo theory only when (1) the star is well-characterized, so that we know the dynamo model *inputs* (2) the magnetic variability is observed on long time scales, so that we know the dynamo *outputs*. Obtaining the latter is observationally expensive, as there is no substitute for a long time series. The F9V star HD 106516 has 37 years of MWO observations, providing an excellent record of the dynamo output via the S-index. New *Kepler K2* observations of this star would provide significantly improved characterization of its dynamo inputs – rotation, mass, radius, and age – making this target a useful benchmark for dynamo studies.

Precision *Kepler K2* photometry of HD 106516 in campaign 10 (Jul 26 to Sep 20 2016; 57 days) can be used to (1) firmly establish the mean rotation period (2) determine surface rotational shear using periodogram and spot-modeling techniques (3) detect low-degree oscillation modes and derive precise mass, radius, and age from asteroseismic modeling. (4) model the passage of surface spots to estimate the inclination of the rotation axis and the latitude of migrating spots.

Rotation has previously been measured for HD 106516 in Donahue et al.

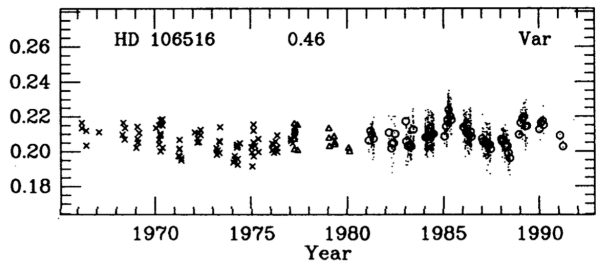

Figure 1: Mount Wilson S-index time series for HD 106516, from Baliunas et al. (1995).

(1996) using a seasonal periodogram analysis on the Mount Wilson Observatory S-index record. They found a mean rotation of 6.75 days in 5 seasons with detected rotational modulations. The min-to-max spread in rotation 0.38 days can be interpreted as a sign of differential rotation. Kepler K2 campaign 10 data is therefore expected to cover several rotations, and spot modeling of the light curve (e.g. Lanza et al., 2014) can reveal an "instantaneous" differential rotation, complete with spot sizes and latitudes from the model fit. Differential rotation obtained from such an analysis can be compared to the previous results of seasonal mean rotation, increasing our understanding of this important dynamo ingredient.

One-minute cadence observations are required for asteroseismic modeling. As a bright (Kp $\sim$6) F9V-type target, detection of acoustic oscillations suitable for use asteroseismic analysis is probable (Chaplin et al., 2014; Metcalfe et al., 2014). Precise asteroseismic mass, radius, and age can then be determined from model fits to stellar evolution codes, which can be furthur constrained by readily available spectroscopic measurements for this bright target.

As of this writing, no Mount Wilson star with decades of Ca II HK observations has been observed by *Kepler*. HD 106516 has an activity record from 1966-2003, which includes $\sim$10 years of previously unanalyzed observations. The existence of this rare record of long-term variability ensures the legacy value of *Kepler K2* observations of this target. This target was not submitted for consideration in the Guest Observer call for proposals because the award amount for a one-target proposal was not enough to justify the work involved in preparing a formal proposal. However, it is our sincere hope that the *Kepler* Director will seriously consider the above case for observing HD 106516, a rare overlap between *Kepler* observation fields and a Mount Wilson HK target.

Object	J2000 Right Ascension (deg)	J2000 Declination (deg)	Kp (mag)	Cadence (min)	Proper motion ("/yr)		extent (arcsec)	Comments
					δRA	δDec		
228720824			6.055	1				