Photometric Measurements of Hα in the Cepheid Variable CD Cygni

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stars: individual (CD Cyg) ; stars: variables: Cepheids; techniques: photometric; techniques: spectroscopic

In Joner & Hintz (2015) an Hα index was introduced, modeled after the well-established Hβ index (Crawford 1960) and providing a direct measure of the strength of the Hα line. Transformations were provided by Joner & Hintz (2015) to allow equivalent width and surface temperature to be determined. Their data were collected spectroscopically with the 1.2 m McKellar telescope at the Dominion Astrophysical Observatory (DAO), with the configuration described in the original paper. Beginning in 2010 June, a number of Cepheid variables were added to the observing campaign. The star CD Cygni was observed 109 times from 2010 June until 2018 October, with a maximum of 18 observations in any given year. This provides a fairly poor cadence to see subtle changes in the light curve from cycle to cycle. Therefore, we began a purely photometric campaign to monitor a collection of Cepheids, looking for any long term changes. Our goal was to determine if a small telescope could reproduce spectroscopic results from the 1.2 m telescope at DAO, with better time resolution.

In Spring 2017, Brigham Young University (BYU) began the implementation of several small robotic telescope systems on the observation deck of the Eyring Science Center. The first of these systems uses a Vixen VMC200L 8 inch optical tube with focal ratio of *f*/9.75 and a Finger Lakes Instrumentation MicroLine ML3200 camera, with 2184 × 1472 pixel resolution and 6.8 μm pixel size. The limited light-gathering power of an 8 inch telescope was the primary motivation for taking photometric observations in lieu of spectra. Data were taken on a total of 41 Cepheids through 2017 and 2018, using both the Hα system detailed in Joner & Hintz (2015), as well as the Johnson *V* filter. The data were reduced using standard procedures in IRAF, and differential photometry was performed using VPhot, for each filter. We then phased these measurements with known periods taken from the literature using Period04. For the few Cepheids with unknown or poorly resolved periods, we created Lomb–Scargle periodograms from the *V* filter data using Peranso (Paunzen & Vanmunster 2016) to isolate likely periods and rephased the data accordingly.

As an example of our results we present our findings for CD Cygni, a fairly bright star with $V = 8.35$ and whose variations were first detailed in Leiner (1924). The General Catalog of Variable Stars (Samus et al. 2017) reports a current period for CD Cygni of 17.073967 days; the resultant light curves from phasing with this period are shown in Figure 1. As the figure shows, *V* filter photometric observations taken with the 8 inch telescope at BYU (middle right) phase up well, producing a clear light curve. The individual Hα filter curves (top left and top right) also phase well, though scatter in the narrow filter is larger. The Hα index curve (middle left) also shows some evidence of regular pulsation, though by comparison to the spectrophotometric observations from DAO (bottom left), the curve is significantly more scattered. This is not surprising given the combination of a deep absorption line with the small FWHM of 29.6 Å (Joner & Hintz 2015) of the narrow Hα filter. However, it should be noted that the amplitude of the two curves are similar at a little over 0.1 mag. Finally, we used the calibrations in Joner & Hintz (2015) to produce a phased temperature curve (bottom right).

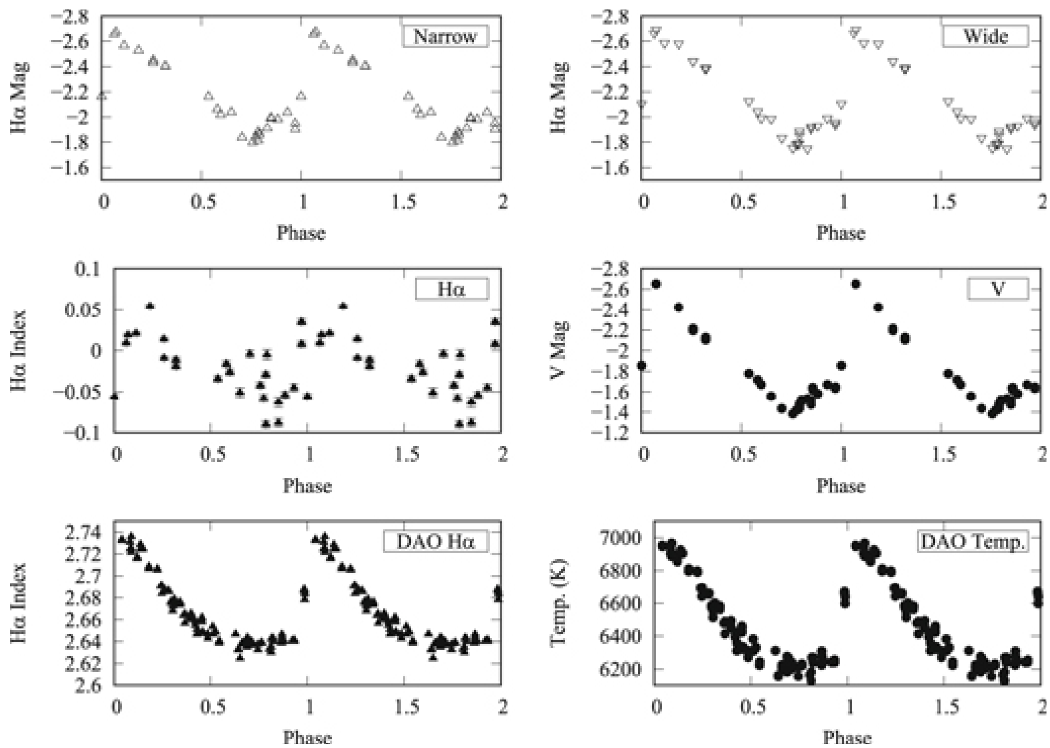

Figure 1. Differential light curves for CD Cyg using a period of 17.073967 days. The different panels show curves in the (1) narrow Hα filter, (2) wide Hα filter, (3) Hα index, (4) *V* filter, (5) Hα index from DAO observations (calibrated), and (6) temperature from DAO observations (calibrated). The data used to create this figure are available.

From this preliminary work, we feel that with more attention to obtaining sufficient signal in the narrow Hα filter, it would be possible to generate high quality curves of the Hα index for a number of Cepheids, even with such a small telescope. This may require that we focus on only the brightest Cepheids to ensure the highest possible signal.

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