

# A Study of the Spectroscopic Variability of Select RV Tauri and Semiregular Stars

Charles Kurgatt<sup>1</sup>, Donald K. Walter<sup>1</sup>, Steve Howell<sup>2</sup>, Jennifer Cash<sup>1</sup>

<sup>1</sup>South Carolina State University, <sup>2</sup>NASA Ames Research Center

## ABSTRACT

RV Tauri and Semiregular variables are not as well behaved as other variables such as Cepheids. The nature of their pulsations and their evolution is not well understood.

We have acquired spectra of several of these objects for the decade 2003-2012 using the Coude Feed Telescope at KPNO. We present our results for two RV Tauri stars (AC Her and R Sct) and two Semiregular types (G Her and Z Uma). We have fit their light curves using AAVSO photometry to more accurately determine their phase as a function of Julian Date over this long time span. This has allowed us to phase-fold all of our spectral observations and obtain a clearer picture of their behavior over a single cycle.

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## BACKGROUND

RV Tauri and Semi-Regular stars are examples of variable stars, a star that is unable to maintain a steady apparent brightness. These changes in brightness may have many causes such as eclipses, stellar rotation, and pulsation. The two types studied here vary in brightness due to pulsations in the physical size of the stars. RV Tauri are distinguished by light curves that alternate over time between deep and shallow minima, possibly due to multiple pulsations of different frequency. Semiregular stars vary in light output with some degree of regularity but not fully regular in amplitude or period.

## DATA SET

Our photometric data was taken from the American Association of Variable Star Observers (AAVSO) database. We have acquired our own high signal-to-noise spectra of these stars since 2003 using the Coude Feed Telescope at Kitt Peak National Observatory (KPNO).

## DATA ANALYSIS

➤ Spectral types and luminosity classes were determined by comparing our spectra to standards in the Jacoby Atlas.

➤ The effective temperature (T) was derived from the spectral type using Gray's temperature calibration.

➤ Photometric data were taken from the AAVSO dataset to determine the apparent magnitude (m) on each date. And the phase of each observation

➤ Stellar distance (d) was derived from the Hipparcos-Tyco parallax database .

➤ The absolute magnitude (M) was calculated using "d" and the distance modulus:  $m - M = 5\log(d) - 5$ .

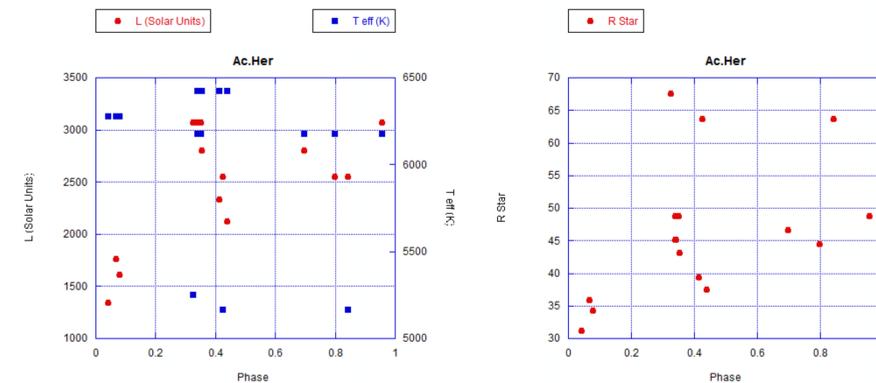
➤ The luminosity (L) was then calculated from:

$$M(\text{star}) - M(\text{sun}) = -2.5\log[L(\text{star})/L(\text{sun})]$$

➤ The radius of the star was calculated from:

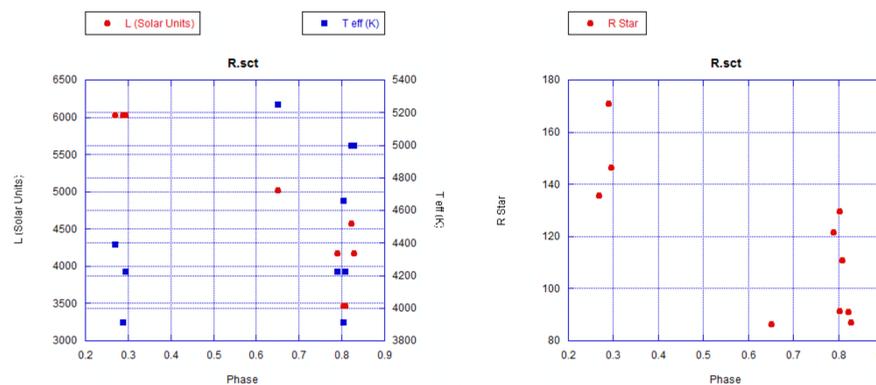
$$R_{\text{star}}^2 = L_{\text{star}} (T_{\text{sun}}^4 / T_{\text{star}}^4) (R_{\text{sun}} / L_{\text{sun}})$$

In solar units, so  $R_{\text{sun}}$  and  $L_{\text{sun}}$  both equal 1



AC Her is classified as an RV Tauri star with a period of 75.29 days. Eleby and Cash's poster describe the fits to the photometric data that led to the phase values shown here. The left plot shows that the luminosity appears to rise and fall rapidly twice during the pulsation cycle of the star. The variation of Teff is less clear. Additional data points are needed to fill in phase gaps.

The plot on the right shows the radius of the star varies in a pattern similar to the luminosity variation, which is not surprising given the factor of 3 in luminosity variation but only a factor of 1.2 in temperature variation.

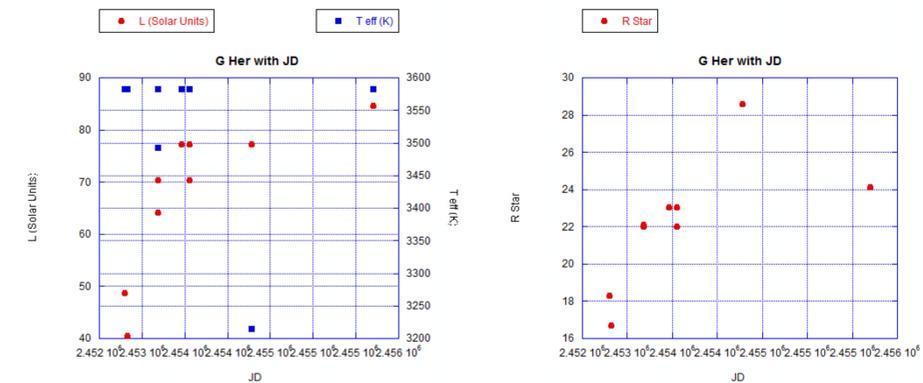


R Sct is classified as an RV Tauri star with a period of 146.5 days. Eleby and Cash's poster describe the fits to the photometric data that led to the phase values shown here. Gaps in the phase coverage between 0.3 and 0.65 make it difficult to determine how the luminosity and Teff vary with time. Additional data points are needed to fill in phase gaps.

The plot on the right shows the radius of the star varies in a pattern similar to the luminosity variation, which is not surprising given the factor of 2 in luminosity variation but only a factor of 1.3 in temperature variation. As with luminosity and temperature, the gaps in the central portion of the cycle make it difficult to draw any conclusions.

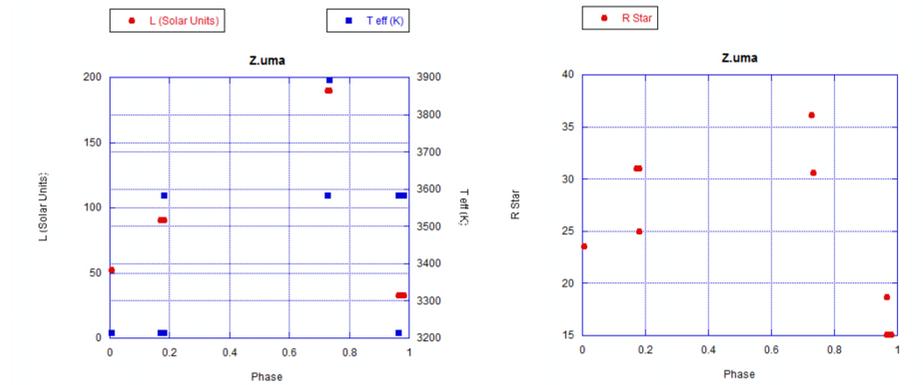
## FUTURE WORK

We have additional spectroscopic data for the time period 2007 to 2012 that is not included in the above work. Once that data is reduced we should have better phase coverage and anticipate being able to make more definitive statements about the variation of these quantities over the course of a single pulsation cycle.



G Her is classified as a semiregular variable with a period of 89.2 days. The plots show the variations as a function of the Julian Date because of the limited phase coverage of the star. The left plot shows that the luminosity appears to rise over time. The variation of Teff is less clear. Additional data points are needed to fill in phase gaps.

The right most plot shows a rise in the radius of the star over time, but this result is uncertain given the large gaps in phase coverage.



Z Uma is classified as a semiregular variable with a period of 195.5 days. The left plot shows that the luminosity appears to rise and fall at least once during the phase cycle, but the gap in data coverage between 0.2 and 0.75 makes it difficult to determine if this is a single or multiple variation. The change in Teff is less clear but it also seems to show a pattern similar to the luminosity. Additional data points are needed to fill in phase gaps.

The right most plot shows a rise and fall in the radius of the star over one cycle, but this result is uncertain given the large gaps in phase coverage.

## REFERENCES

AAVSO data, <http://www.aavso.org>

Hipparcos/Tyco data, <http://simbad.u-strasbg.fr/Simbad>

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Gray, R. O. and Corbally, C. J.; 2009, *Stellar Spectral Classification*; (Princeton: Princeton University Press)

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