Short Term Apparent Magnitude Variation of Carbon Stars

Scott Hogan, Department of Physics, Astronomy, Geosciences, and Engineering Technology
Dr. Martha Leake, Department of Physics, Astronomy, Geosciences, and Engineering Technology

- **Abstract**

- Carbon stars are luminous red giants of the asymptotic giant branch. They are variable, meaning their magnitudes can change back and forth over periods of time. Carbon stars have been observed to change by many magnitudes in periods of over hundreds of days. The aim of this project is to observe at least four carbon stars, V Ari, R CMi, SY Eri, and V Hya and determine if their magnitudes change in a period of one to two hours. This is continuation of the project done by Eric Burns and Kira Forster as advised and assisted by Dr. Martha Leake. The telescopes used to observe the selected carbon stars, by courtesy of the Southeastern Association for Research in Astronomy (SARA), are located at Kitt Peak in Arizona, Cerro Tololo in Chile, and La Palma in the Canary Islands, and these telescopes were used remotely from VSU in Valdosta, Georgia.

- **Observed Carbon Stars**

SY Eri
RA: 05h 09m 48s
Dec: -05 30' 55''
Variable Period: 96 days
Apparent Magnitude: 8.3-10.8

R Cmi
RA: 07h 08m 43s
Dec: +10 01' 23''
Variable Period: 338 days
Apparent Magnitude: 7.3-11.6

RU Pup
RA: 08h 07m 30s
Dec: -22 54' 45''
Variable Period: 425 days
Apparent Magnitude: 8.1-11.1

Introduction and On-Going Goal: Finding Short Period Variations

During the spring of 2018, Kira Forster and Eric Burns observed about eight carbon stars for variation of magnitude within a short period of time. Their results indicated little to no short term variation, and they concluded that more time and data was needed, about a decade, to observe a significant short term magnitude variation. Using the same methods of observation, data collection, and analysis, we collected new data on three of the eight carbon stars, SY Eri, R CMi and RU Pup to determine if a variation in the magnitude of these carbon stars in the short term can be observed.

Red Giant

Red giant stars are stars that have moved off the main sequence due to hydrogen fusion ceasing in the core of the star. The core then begins to contract, raising the temperature. These temperatures increase the luminosity to as high as 200 times that of the Sun (2000 $L_{\odot}$). This causes the star to sell up to as much as 200 times the Sun's size (200 $R_{\odot}$). Yet this swelling also decreases the surface temperature of the star to below 3,000 K. This causes the star to turn a reddish color. A carbon star is far into its red giant stage in a phase called the Asymptotic Gian Branch (AGB) where deep convection dredges up material from the core region and inverts the carbon-to-oxygen ratio in the outer atmosphere. Carbon stars have masses between 1.5 and 3 solar masses (1.5 – 3 $M_{\odot}$)

Pulsating Variable Star

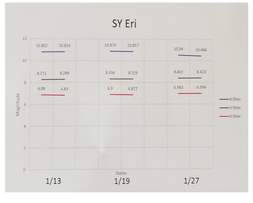
A star is considered to be in equilibrium when light pressure generated by fusion pushes back on the force of gravity. When a star is out of equilibrium it can become a pulsating variable star where the star's radius will shrink and expand over a certain period. These periods can last hours to years depending on the type of variable star. The shrinking and expanding changes the star's surface temperature and luminosity, which results in changes in its magnitude. These stars have very long periods, usually hundreds of days. Of the stars we observed, the periods lasted between 77 – 531 days

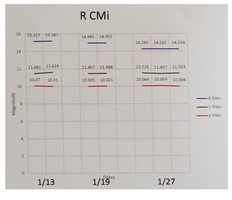
Oxygen-Carbon Ratio and Dredge-Up

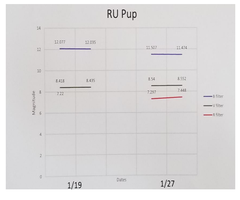
Oxygen and carbon are the third and fourth most abundant elements in the universe respectively. This is seen in stars as well. In the atmospheres of stars, the oxygen-carbon ratio(O/C) is greater than 1. All of the free carbon in these star' atmospheres bonds with oxygen to compounds. A process called dredge-up brings material from deep regions inside the star to the atmosphere. Dredge-up occurs when the convection zone of a star extends down into the star and brings up material that is not normally seen in stellar atmospheres. Stars can go through three dredge-up phases depending on its mass. In the 3rd dredge-up, helium shell flashes cause the convection zone to extend down nearly to the core. This brings up carbon-rich material and can invert the O/C ratio. When the ratio is below 1, the star is a carbon star. Carbon stars use all of the oxygen in bonds and the carbon is free to make different compounds.

Methodology and Results

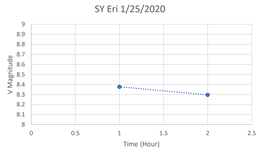
The data on carbon stars first collected by taking time exposure images, with exposure times being 0.5, 1, 10, 60, 120, with CCD cameras on telescopes at Kitt Peak, Arizona, Cerro Tololo, and Roque de los Muchachos, Canary Islands. B, V, and R filters were used with Bessel filters for Kitt Peak and Cerro Tololo, and Cousins and Johnson filters for RM. The images were processed using the Mira Pro program. Processing of images was done by calibrating bias, flat, and dark images. Single Star photometry, using the same program, was used to determine the magnitude of the carbon star. For photometry, a comparison star with a known magnitude in the image field was selected to find the magnitude of the carbon star. Result of data is displayed to the right and compared with data on same three carbon stars, displayed above new data by Hogan, collected and analyzed by the same methodology by Forster and Burns.

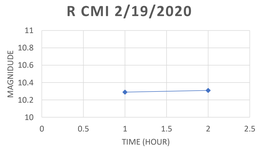


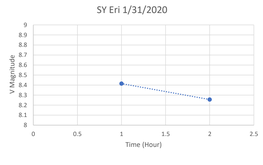


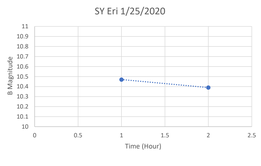


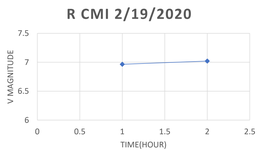
Above: Charts of Data collected by Kira Forster and Eric Burns on January 2018 of carbon stars SY Eri, R Cmi, and RU Pup.
Below: Graphs by Scott Hogan in January and February 2020 of SY Eri, R Cmi, and RU Pup

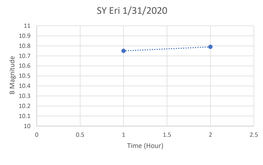












Conclusion

Similar to the concluding remarks made by Forster and Burns in 2018, that their data had slight variation, the data of observations in January and February of 2020 have demonstrated minuscule variation in the apparent magnitude of the observed carbon stars. This ongoing observation and analysis of the listed carbon stars does indicate a variation of a carbon star's brightness on a short term scale, but more continued observation and analysis is needed to make a more concrete assessment.

Acknowledgements

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0.9 m telescope at Kitt Peak, 0.6 m telescope at Cerro Tololo, and 1.0 m telescope at La Palma provided by Southeastern Association for Research in Astronomy SARA