A PHOTOMETRIC STUDY OF THE ACTIVE EW/RS BINARY STAR SYSTEM: GSC 05586-00371

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Abstract

GSC 05586-00371 is a fast-rotating (P.rot ≈ 0.44 days) eclipsing binary. Our study showed that this star system is an overcontact eclipsing binary star that belongs to the W UMa class with characteristics of RS CVn type stars. We studied this binary system through photometric means to obtain a more precise orbital period. We also monitored the binary system to detect possible flares from the system, where two consecutive events were monitored from one of our observing stations. We have derived a model for this binary system based on the empirical data we acquired that revealed the presence of star spots on both components that evolve over a seasonal periods.

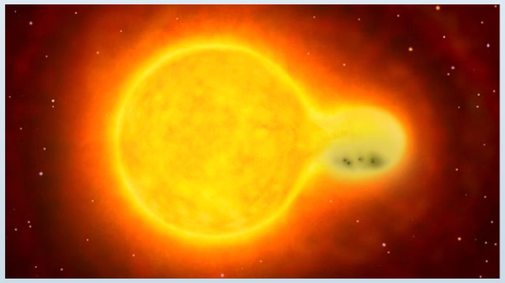

Figure 1: 3D rendition of GSC05586-00371 showing the sunspot/s group on the secondary star.

Introduction

GSC 05586-00371 is a variable star that was recently discovered to be a variable source on 30th October 2016 from Malta. It has been classified as an EW/RS binary star system. EW components usually comprise of two cool, main-sequence stars with spectral types ranging from F to K. These star systems orbit each in close proximity to exchange material from one another. W UMa stars have short orbital periods of less than a day with continuous light variation during their cycle. RS Canum Venaticorum (RS CVn) traits were also identified in its light curve. Stars within RS systems exhibit star spot activity that is due to strong magnetic activity.

The study of binary star systems is important for the study of stellar astrophysics as these star systems give an insight on the absolute sizes of the stars that are crucial for the calibration of the basic framework of astrophysical relations.

Materials

GSC 05586-00371 was observed by the observatories listed in Table. 1. The system was also observed through a Clear-filter, based on the V-magnitude standard. All our brightness measurements were derived through differential aperture photometry with zero-points calibrated to the APASS Catalog.

Table 1 – Observatories and equipment details

Observatory / (Location)	Observer	Telescope	Filters	CCD Sensor
Tacande Observatory (La Palma, Spain)	Hills K.	0.500-m Optimised Dall Kirkham	B, V	FLI ML3200/ KAF3200ME
Antares Observatory (Fgura, Malta)	Grech W.	0.279-m SCT	C	SBIG STL-11000/ KAI-11000M
Flarestar Observatory (San Gwann, Malta)	Brincat S.M.	0.254-m SCT	V, Ic	Moravian G2-1600 / KAF 1603ME
Znith Observatory (Naxxar, Malta)	Galdies C.	0.203-m SCT	V, Ic	Moravian G2-1600 / KAF 1603ME

Methodology

We have observed this star system in order to:

- Enhance the known rotation period of the star system by observing it at predicted time of minimum over a period of time and to derive whether the period is changing over time.
- Determine whether we could detect flaring events through a 73 hour monitoring campaign.
- Establish the physical parameters of the system by extracting light curve morphology data through different bandpass.
- Derive a synthetic model of the binary star system based on empirical data.
- Establish the location of any star-spots on the system based on the light curve differences as observed on different time periods.
- Attempt to establish long-time variability due to star spot/group evolution by extracting survey data over a 6-year time period.

Results

Using 6 methods to derive the Time of Minimum through a weighted mean, our Observed minus Calculated (O-C) measurements allowed us to enhance the derived rotation period of the binary star system to be:

HJD 24559280.51663288±0.0001+ 0.441453554±0.012 d × E

Our O-C also shows a downtrend that could possibly indicate that the rotation period is slowly decreasing.

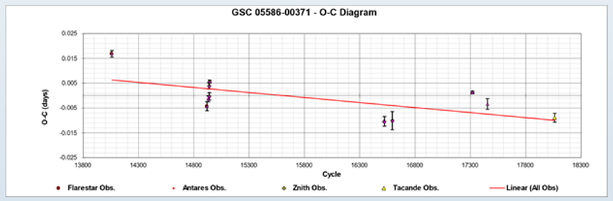

Figure 1: Observed minus Calculated (O-C) curve for GSC 05586-00371 as fitted through a polynomial based on the 2nd Order.

The derived light curve of GSC 05586-00371 allowed us to monitor for star spot evolution as shown in Fig 3.

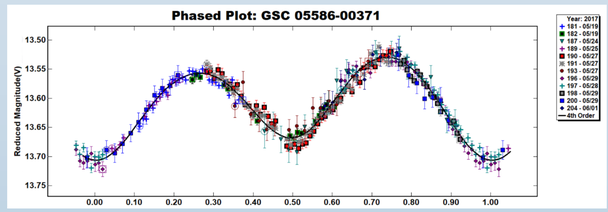

Figure 2: Lightcurve of GSC 05586-00371 as obtained through a Clear filter (CV). These observations were obtained to obtain the time of minimum and for the detection of any possible flares.

For our flare monitoring campaign, we took images every 1 minute to yield a total effective monitoring time of 73 hours based on 4387 images. Antares Observatory captured two flaring events that happened in short succession.

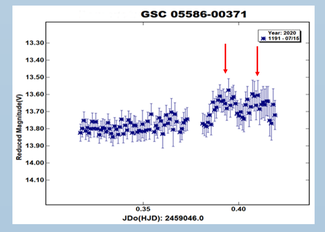

Figure 3: Lightcurve of the flaring events as observed on 2020 July 15 by Antares Observatory.

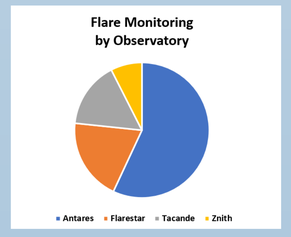

Figure 4: Pie chart showing the total monitoring coverage by the observatories shown in Table 1

V and Ic light curves were modeled through Binary Maker 3.0. Our modeling results showed consistent fitting to that of a shallow contact eclipsing binary with the following parameters: q=0.16 ± 0.01, fill-out=0.70 ± 0.05, i=46.0 ± 0.5, T1=5000 ± 50, T2=6300 ± 50, with one cool spot at each star at the respective location on the primary star Lat. 100.0 ± 5; Long. 70 ± 5; and secondary star at Lat. 110.0 ± 5 and Long. 110.0 ± 5.

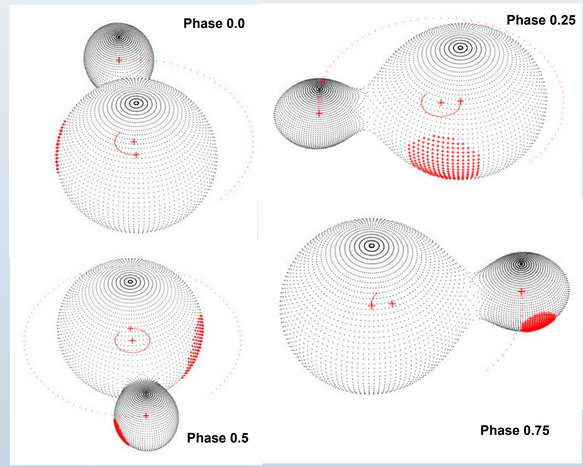

Figure 5: Geometrical representation at various phases of the binary model of GSC 05586-00371 derived by Binary Maker.

Conclusion

From the evidence collected, we infer that GSC 05586-00371 is an overcontact eclipsing binary star where both stars are in close proximity with each other and share their gaseous envelopes. The solar-like component stars revolve around each every 0.441453554 ± 0.0120 days. In consideration of the temperature difference between the 2 components, we postulate the system as being a young poor thermal overcontact binary where the stars have not been in contact for long enough time to reach thermal equilibrium. The flaring events recorded makes the star system more dynamic than originally envisaged and makes it intriguing from the point of view of exoplanet habitability, where a growing number of exoplanets are being discovered around binary stars.