MULTIFILTER LIGHT CURVES AND ANALYSIS OF THE SEMI-DETACHED BINARY RV TRIANGULI

The Bradstreet Observatory at Eastern University

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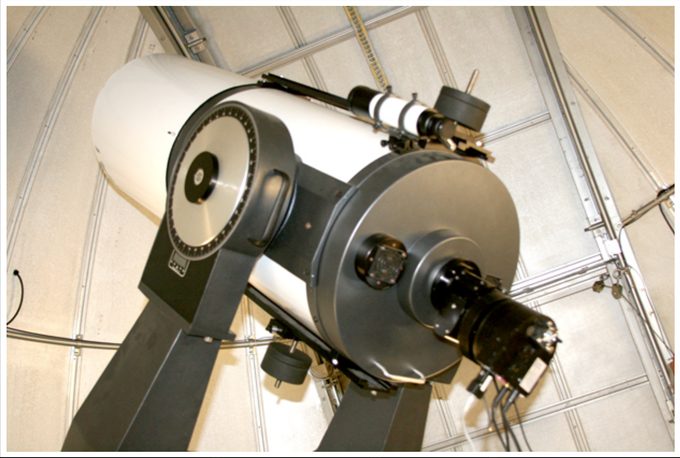


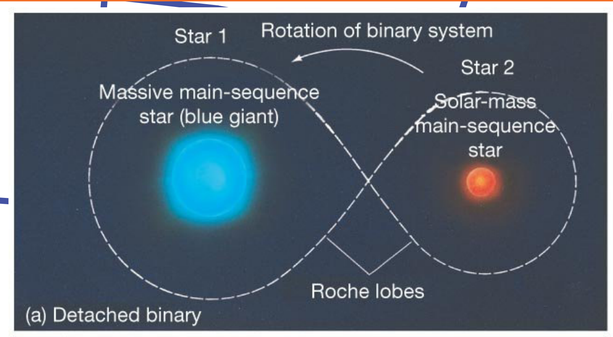
16-inch Schmidt-Cassegrain telescope with SBIG-10XME CCD camera and filter wheel

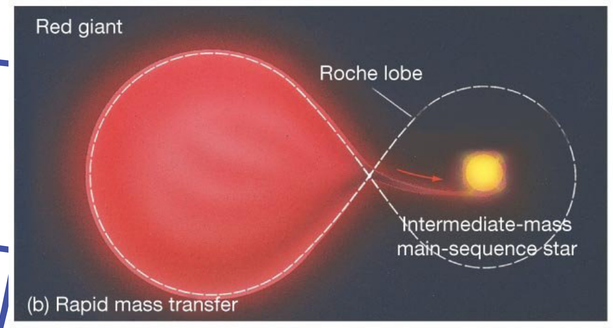
Bradstreet Observatory at night as seen with X-ray eyes

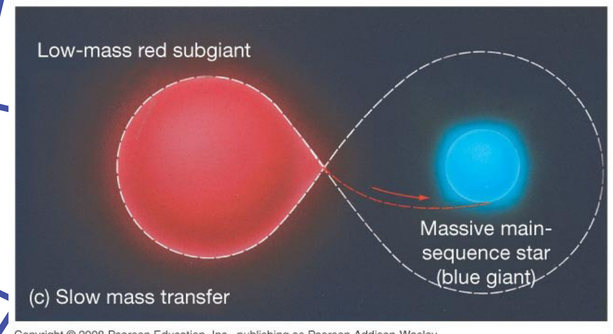
The careful analysis of eclipsing binary light curves is the only means by which astronomers can determine crucial stellar parameters such as size, mass and temperature. Semi-detached binaries consist of two stars where the formerly more massive component has evolved first and in its evolutionary expansion has transferred much of its mass onto its formerly less massive companion. The current state of these binaries finds the formerly more massive star in an advanced evolutionary condition but deficient in mass and completely filling its so-called Roche surface. This evolved, tidally-distorted star thus takes a peculiar tear-drop shape! RV Tri is a faint (11.5-12.7 magnitude) short period (18.09 hours) semi-detached binary which at the time of our observations had no modern precision published light curve and no published analysis. From October – December 2008 RV Tri was observed for eight nights at the Bradstreet Observatory of Eastern University. 996 digital images in the *V* filter and 974 in R_c were obtained using the Observatory's 41-cm telescope coupled with an SBIG ST-10XME charge coupled device (CCD) digital camera. These images were then reduced using the MIRA software suite resulting in the *V* and R_c light curves shown below.

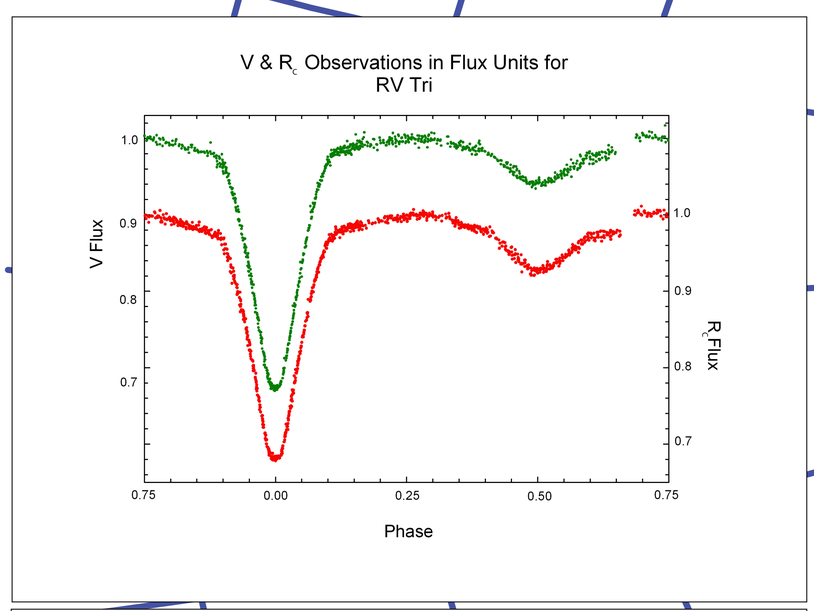
These *V* and R_c light curves were initially analyzed using the Binary Maker 3.0 light curve analysis software in order to derive preliminary parameters for the binary system. These preliminary results were then fine tuned using the differential corrections mode (DC) of the benchmark Wilson-Devinney code. The model was very well behaved and iterated to a robust final solution where the suggested parameter corrections were all much smaller than their formal probable errors. The results of this analysis are given in tabular form below as well as the synthetic light curves drawn through their respective normal points. The system was found to be totally eclipsing, *i.e.*, the smaller, cooler and more evolved tear-dropped star is completely hidden from view when eclipsed by its larger companion. Derivation of masses and absolute dimensions for this system will require spectroscopically derived radial velocity curves from future workers.

Three new timings of minimum light were measured in order to analyze whether or not the system's period had changed since its discovery. These three timings were combined with 256 others from the literature (mostly from amateur astronomers' observations) to confirm that the system's period is definitely decreasing at a rate of -6.29 x 10^{-8} days/year. This is most likely due to loss of orbital angular momentum in the system as the stars slowly spiral in towards each other and their orbital period decreases. In addition to this relatively large parabolic trend, there can be seen superimposed on the parabola an oscillating component. This is the telltale signature of a third star in the system. This third star along with the eclipsing semi-detached binary are orbiting a common barycenter which alternately puts RV Tri closer to Earth in one part of its orbit and then further away later in its orbit. The effect of this changing distance to Earth is that the eclipsing binary is sometimes closer and hence its light arrives sooner than predicted because the light has a smaller distance to traverse. Likewise when the binary is more distant the eclipses are later than predicted because the light from the stars takes longer to reach Earth. Preliminary analysis indicates that the orbital period of the third star with RV Tri is 26.8 years with a semimajor axis of ~11 AU. A more detailed analysis of this "light time effect" will be undertaken later.

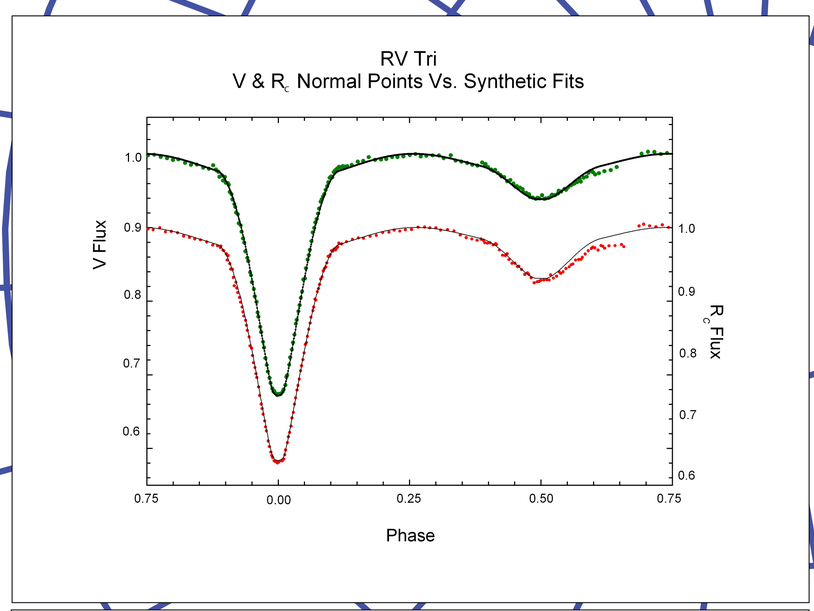




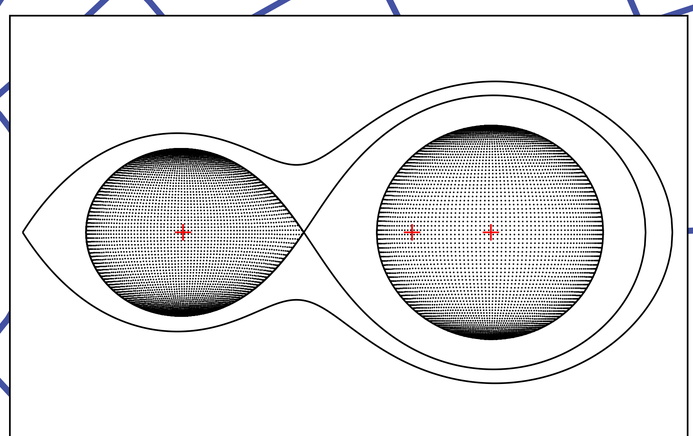




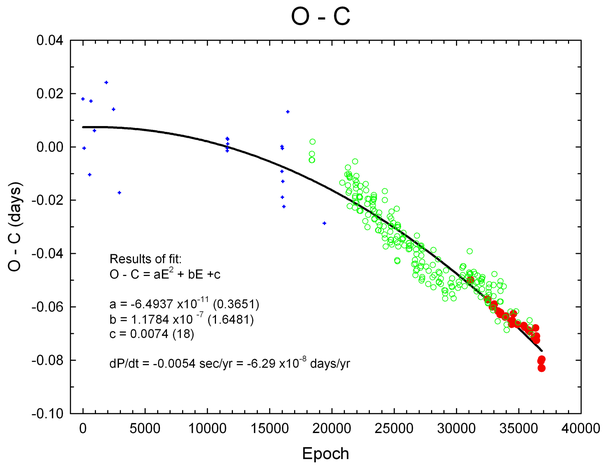
Individual V (green dots) and R_c (red dots) observations of RV Tri



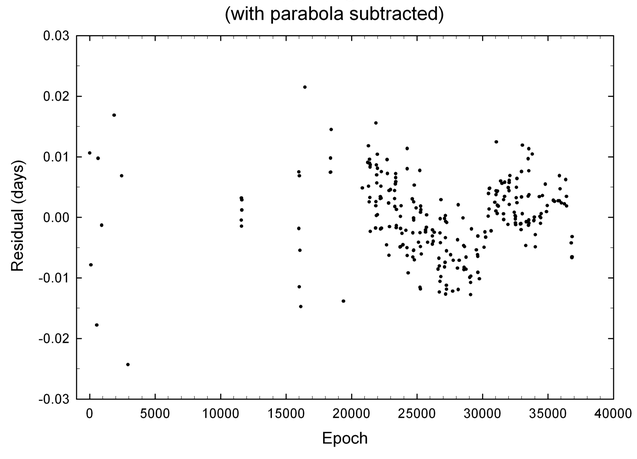
V and R_c synthetic Wilson-Devinney fits (solid curves) to normal points of RV Tri



RV Tri with inner and outer Lagrangian surfaces



Parabolic fit to the O-C residuals of RV Tri. The red circles represent CCD image timings. The open green circles represent the photographic timings, and the blue crosshairs represent the visual timings. The systematic undulation of the data about the parabolic fit is the telltale signature of a third star in the system. This undulation is due to the "light time effect."



Residuals after the parabolic fit was subtracted from the O-C values in the previous figure. The sinusoidal fluctuation reveals the presence of a much fainter third star in the system. Preliminary analysis indicates a period of 26.8 years and a semimajor axis of 11 AU. Further detailed analysis of this oscillation should reveal the orbital properties of this third star more accurately.

Light Curve Parameters for RV Tri

(Formal probable errors given in parentheses)

Mass ratio	= 0.3442 (12)
Inclination	= 87.20°(13)
Ω_1	= 3.2093 (22)
Ω_2	= 2.5620 (assumed)
T_1	= 7300 K (assumed)
T_2	= 4390 K (11)
$Albedo_1$	= 1.00 (assumed)
$Albedo_2$	= 0.50 (assumed)
Third Light	= 0.00 (assumed)
$Luminosity_1 = L_1$ (5500 Å)	= 0.9425 (10)
$Luminosity_2 = L_2$ (5500 Å)	= 0.0575
$Luminosity_1 = L_1$ (6400 Å)	= 0.9226 (11)
$Luminosity_2 = L_2$ (6400 Å)	= 0.0774
$Gravity\ Brightening_1$	= 1.00 (assumed)
$Gravity\ Brightening_2$	= 0.32 (assumed)
Period	= 0.75366648 days

Stellar Radii (units in terms of separation of the stars)

r_1 back	= 0.36467 (52)	r_2 back	= 0.31529 (36)
r_1 side	= 0.25722 (45)	r_2 side	= 0.28257 (36)
r_1 pole	= 0.34673 (39)	r_2 pole	= 0.27125 (34)
r_1 point	= 0.37070 (59)	r_2 point	= 0.39236 (45)