

# PHOTOMETRIC AND SPECTROSCOPIC ANALYSIS OF ECLIPSING BINARY TY TAU

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## Background

An eclipsing binary system is a system in which two stars are orbiting a common center of mass, with the plane of their orbit along our line of sight. In this type of system, the stars appear to pass in front of each other at regular intervals, which is known as the period of the system. By analyzing observational photometric and spectroscopic data, certain properties and information about the system can be determined. Binary star systems such as these can provide critical comparisons with models of stellar evolution, as they are relatively easy to measure and analyze.

## Methods

### Light curve.

To construct a light curve for TY Tau, photometric observations collected from November 2000 to December 2010 were used. These observations were taken using the URSA telescope, a 10" Meade Schmidt-Cassegrain telescope located on top of Kimpel Hall at the University of Arkansas, and recorded using an SBIG ST-8 CCD camera with a field of approximately 20' by 30'. Thousands of collected photos were then processed using *Multi-Measure* 2.11 [1].

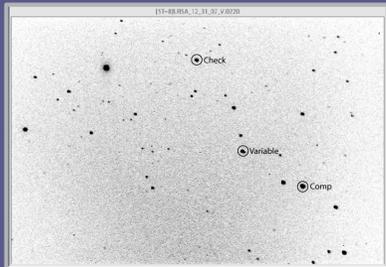


Fig. 1: An example of a user-defined pattern used by *Multi-Measure*. This method of using nearby comparison and check stars to accurately measure the magnitude of the variable star is called differential photometry.

These measurements are then compiled in *Multi-Minima* 2.2 [1]. By combining the observations of the variable star over a long period of time, a light curve is constructed. A light curve (Fig. 2) shows the change in magnitude of the variable star versus the orbital phase.

For each full eclipse that was measured, the date at the minimum was measured and collected in a separate file, then analyzed in the program *Dates of Minima* [1]. This program gives an estimate for the period of the eclipsing binary system. The average was used as the final adopted period. To complete the ephemeris, an accurately measured date of primary eclipse was used.

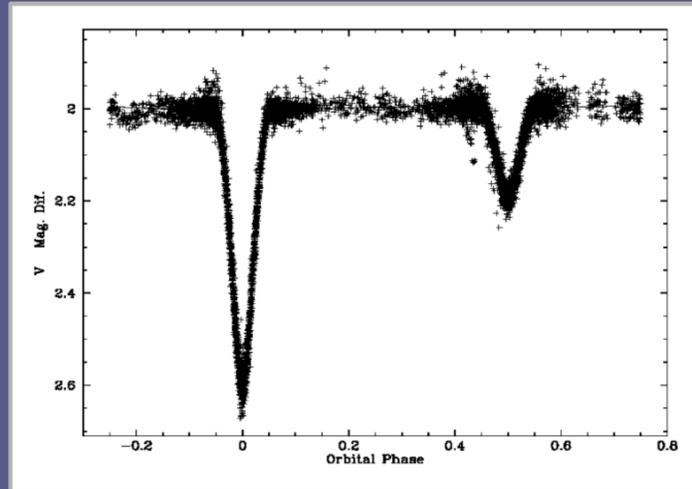


Fig. 2: Light curve for TY Tau. The period was determined to be 1.0773629, with a full ephemeris of  $HJD \text{ Min I} = 1.0773629n + 54307.3175$ .

### Radial Velocity Curve.

In addition to a light curve, a radial velocity curve was also constructed, using data provided by G. Torres [2]. Using the program *GLSPL*[3], these data were used to fit a radial velocity curve using a general least squares method. A radial velocity curve provides certain information about the system such as the velocity of each star, eccentricity of the orbit, and the combined radial velocity of the system.

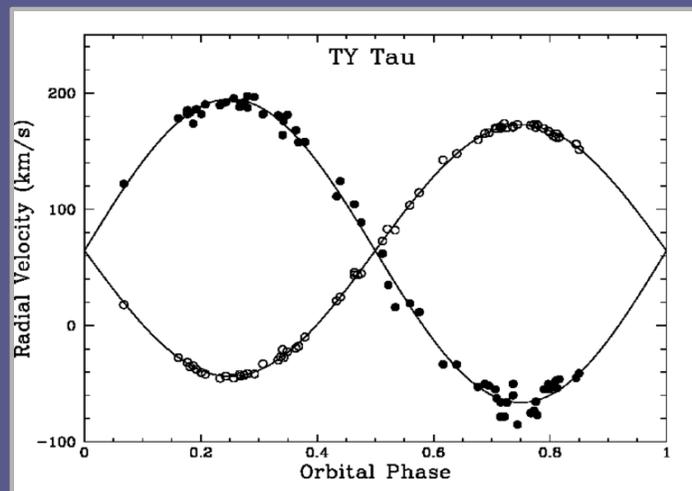


Fig. 3: Radial velocity curve for TY Tau. From the shape of the curve, the orbits of the stars are very circular.

## Modeling

The program *JKTEBOP* [4] was used to fit a theoretical curve to the light curve constructed from observational data. *JKTEBOP* can be used to gain valuable insight into the binary system. From the light curve fit, the relative radii, mass, and luminosities of the stars in the system can be found.

*MRLCALC* (Mass, Radius, Luminosity Calculator)[1] was used to model the system in a different way, by producing physical values relative to our sun.

Finally, modeling the system using a YY-model [5] was attempted. However, due to the fact that the stars in TY Tau are low-mass (below 1 solar mass) from *JKTEBOP* and *MRLCALC* results, they do not fit well with the YY-model. Without a fit, it is difficult to determine the age for this system.

## Results and Discussion

Properties	Primary	Secondary
Mass ( $M_{\odot}$ )	$0.846 \pm 0.016$	$0.701 \pm 0.008$
Radius ( $R_{\odot}$ )	$0.802 \pm 0.008$	$0.864 \pm 0.007$
Log G	$4.557 \pm 0.008$	$4.411 \pm 0.008$
Log L	$-0.132 \pm 0.075$	$-0.391 \pm 0.050$
Visual Magnitude	$5.07 \pm 0.020$	$5.94 \pm 0.20$
Temperature (K)	$5971 \pm 281$	$4958 \pm 150$

There are a few points of interest in regards to the results and data. First, from the light curve of TY Tau (Fig. 2) it is clear that there is some magnitude variance outside of eclipse which may be due to star spots, much like those our Sun has. Second, from *JKTEBOP* results it is unclear whether or not a third star is present in the system, as a third light of approximately 16% produced by the model. In addition, *JKTEBOP* produces unexpected results in regards to the relative radii of the stars. For future research, additional spectroscopic data may be used to produce more thorough and accurate results.

## References and Acknowledgments

[1] Lacy, C. H. S. (2011) [2] Torres, G. (2011) Private communication [3] Daniels, W. E. (1966) University of Maryland, Physics and Astronomy Technology, Report No. 579 [4] Southworth et al. (2004) *MNRAS*, 351, 1277S [5] Yi, Demarque, Kim, Lee, Ree, Lejeune, & Barnes (2001) *ApJS*, 136, 417

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