DETERMINING PROPERTIES OF THE ECLIPSING BINARY CV BOO USING DIFFERENTIAL PHOTOMETRY. S.L. Walters[1,2] and C.H.S. Lacy[1,3]. [1]Arkansas-Oklahoma Center for Space and Planetary Sciences. [2]Dept. of Physics and Astronomy, Benedictine College, Atchison, KS 66002. [3]Dept. of Physics and Astronomy, University of Arkansas, Fayetteville, AR 72701.

Introduction: It is commonly believed that the majority of stars in the universe are a single-star system (like our own sun). On the contrary, researchers have found that over half of the stars in our galaxy [1], and presumably the rest of the universe, belong to systems containing multiple stars. Of these multiple-star systems, the majority are binary systems that contain two stars. There is a shortage of accurate data regarding binary systems, due to the use of photographic techniques when the study of eclipsing binaries first began in the late 1800s. Stellar evolution models for binary systems were created using this inaccurate data.

Now, new photometric techniques are available and have proven to be much more accurate. Studying data that results from observing eclipsing binaries yields the desired information about these systems relatively quickly and accurately. With enough data, stellar evolution models can be tested and rejected or refined.

Objective: The long-term goal is to narrow down which models of stellar evolution for stars in a binary system are accurate in order to gain a better understanding of how the majority of stars in the universe spend their lifetimes. The goal of this particular research is to study the eclipsing binary CV Boo in order to contribute data that can be used to produce a more complete stellar evolution theory.

Data Collection: Images of CV Boo were taken over the course of a year by Dr. Lacy using the Undergraduate Research Studies in Astronomy (URSA) telescope at the University of Arkansas. The URSA telescope is a Meade LX200 10-inch f/6.3 telescope that records images with a SBIG ST8EN camera using UBVRI filters. This telescope is capable of taking images of 10th magnitude objects accurate to .005 magnitudes.

For each night of observations, the magnitude of CV Boo was plotted as a function of time. If an eclipse had occurred, there would be a steady drop followed by a steady increase in brightness. Each night an eclipse occurred, the exact Heliocentric Julian Date (HJD) of the eclipse was found and recorded. These times of eclipse, totaling 14, were then used to find the period.

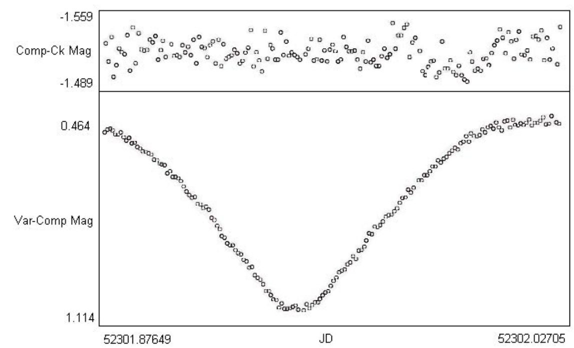

Figure 2: Typical data from a night of eclipse, viewed with the program *Measure*. There is a drop in brightness as one star passes in front of the other, and an increase as it continues to pass over and is no longer blocking light from the other star.

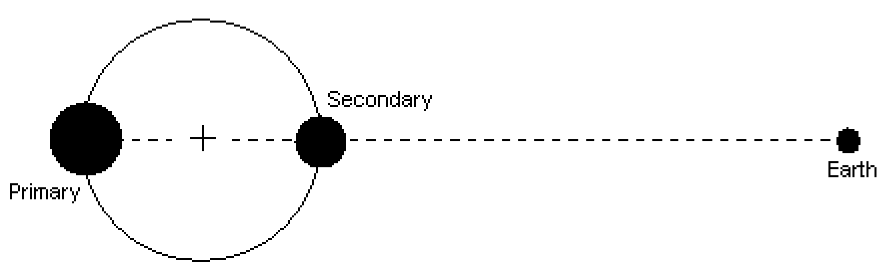

Figure 1: An eclipsing binary system undergoing a primary eclipse as seen from Earth

Light Curve Analysis: A light curve is a plot of magnitude as a function of orbital phase. The shape of the light curve is determined by the properties of the binary system as seen from Earth, such as mass, luminosity, radius, and temperature of each star, inclination, eccentricity, etc. If the light curve of a theoretical system is identical to a given light curve, then the properties of the two systems are the same. The program EBOP does precisely this.

Given the photometric data of CV Boo, EBOP plotted its light curve. Based on some known data, a theoretical model was then generated whose light curve was plotted and compared to that of CV Boo. If the plots did not match, EBOP changed the theoretical parameters slightly, plotted a new curve, and compared the two again. This process continued until the two curves matched, thus determining the properties of CV Boo. Properties of the system that were found using the program EBOP were then input to the program MRLcalc. This program calculated the properties of each individual star in CV Boo.

Several papers have been published with theoretical models of how properties (element abundances, luminosity, mass, etc.) change with age in stars that belong to binary systems. The properties of the stars in CV Boo were compared to these models in order to determine the element abundances and age of each. Because the masses and other properties were not directly listed in these models, they were found by the process of interpolation.

Results and Conclusion: Both stars in the binary systems CV Boo are similar to our sun, having comparable masses, luminosities, surface temperatures, etc. However, based on theoretical models of stellar abundances, CV Boo is much older than our solar system, at roughly 10.3 billion years old. Yet, the galaxy to which CV Boo belongs must be younger than ours, based on the small abundance of heavy elements – only 0.1% in each star versus approximately 1% in our sun [2].

Future Work: More binary systems need to be studied in order to determine what they are like at different stages with a wide variety of possible physical properties. A stellar evolution model encompassing any combination of stars in a binary system could then be developed to give scientists a better understanding of the way the majority of stars in the universe spend their lifetimes.

References: [1] J.C. Evans (1995), George Mason University, "Binaries and Star Clusters," *http://www.physics.gmu.edu/classinfo/astr103/CourseNotes/ECText/ch14_txt.htm#14.2.* [2] D. Morrison and T. Owen (2003), *The Planetary System*, Pearson Education Inc.

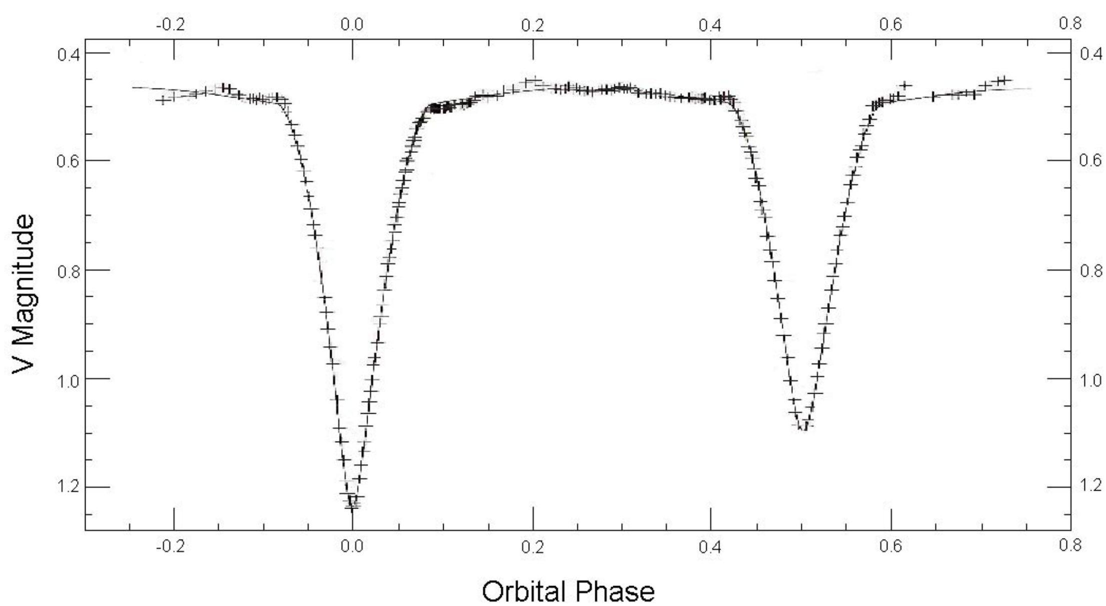

Figure 3: The light curve of CV Boo produced by the program EBOP. The + signs indicate normalized data points, combining to make up the actual observed light curve. The theoretical curve found by EBOP is the solid line tracing over these points.