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Eclipsing Binary System CU Sagittae

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Abstract

A complete lightcurve and six new times of minima (Tmin) of CU Sge are presented. This is a system displaying characteristics similar by physical properties to W Ursae Majoris type contact systems but is not in contact. The lightcurve and computed parameters are presented identifying this binary system as detached with both stars smaller than their limiting Roche lobes and the secondary minimum displaying a total eclipse. The system has been ignored since its discovery and only sixty-eight timings have been published and no spectroscopic values have been derived.

1. Introduction

CU Sge is listed in the General Catalogue of Variable Stars (1949) as an Eclipsing Binary, DW, which are systems with similar properties to W UMa type contact systems but not in contact. It has been ignored but in 1935 and again in 1949 two papers were published in Germany on the orbital times of the system. Since that time, 68 times-of-minimum have been recorded. The lightcurve acquired is symmetrical and out of eclipse indicates the stars have spherical shapes. Modeling of the system by Binary Maker 3, Bradstreet (2004), obtained a fillout = -22% which makes the system detached. The derived temperatures indicate both stars are of spectral type F or G. No spectroscopic velocity curves have been obtained or found in the literature. The orbital period of the system appears to be stable with a slight indication of an increase in the 71 years of observed data.

2. Observations

CU Sge was observed at two observatories during the 2006 session. The Paradise View Observatory utilizes a Meade 14” LX200GPS with an STL-1301 SBIG camera maintaining 2007mm (79”) focal length and field of view of 1.49 arcsec/pixel. The Kings Canyon Observatory uses a Meade 12” LX200 Classic with an SBIG ST=9XE yielding a 1920mm (75.6”) focal length and FOV of 2.18 arcsec/pixel. All data were obtained in the V and R color system approximating the standard Johnson UBVRI photometric system. Since the comparison stars are on the same CCD images as the variable, extinction corrections for the data were not made.

Data were obtained at the telescope using the MPO Connections Software and reduced using the MPO Canopus software.

3. Photometric Solutions

The lightcurves obtained of CU Sge, Figure 3 in the V and R bands were modeled assuming both stars to be spectral type of F or G and main sequence type. The primary star was set at T = 6600 K and the secondary T was adjusted for modeling. Since the lightcurves indicated this to be a detached system, the radii inputs were used. Since no spectroscopic data is available different mass ratios were attempted until the eclipses were properly fitted. The secondary eclipse, see Figure 5, displays a total eclipse which made determining the mass ratio through trial and error modeling much easier. The best photometric mass ratio, q = 0.30, was determined by measuring the lightcurve residuals until a mass ratio produced the smallest sum of the squares. A fillout for the primary = -0.225 and for the secondary = -0.095 was obtained. Figure 4 displays the geometrical relationships of the surfaces of CU Sge at phase 0.24.

4. Orbital Period Variations

The O-C diagram in Figure 1 includes all the available CCD, photoelectric and visual eclipse times of minimum and were calculated with the linear ephemeris,

Min.I= 2,442,633.473 +0.7916749 E days **(1)**

These times of minimum display a large scatter of up to ± 0.06 days. A polynomial fit indicates a small periodic cyclic sinusoidal change, Figure 2. A least-squares solution yields the following quadratic ephemeris:

$$\text{Min. I} = 2{,}442{,}633.472855 \pm 0.0078 + (0.70167216 \pm 2.735 \times 10^{-6})\,E + (1.2059 \pm 9.169 \times 10^{-11}) \times 10^{-10} E^2 \text{ days} \quad \textbf{(2)}$$

This quadratic term in this equation reveals a continuous period decrease at a rate of dP/dt = +0.0096 sec yr^{-1} which corresponds to a period increase of 0.96 sec $century^{-1}$.

5. Conclusion and Discussion

From the photometric solutions and the lightcurves it would be more appropriate to classify the binary system as semi-detached like Algol. I is also possible that the less massive secondary star is more evolved than the primary and mass is being transferred within the system. More data over time will determine is this is an Algol or W UMa type of system.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

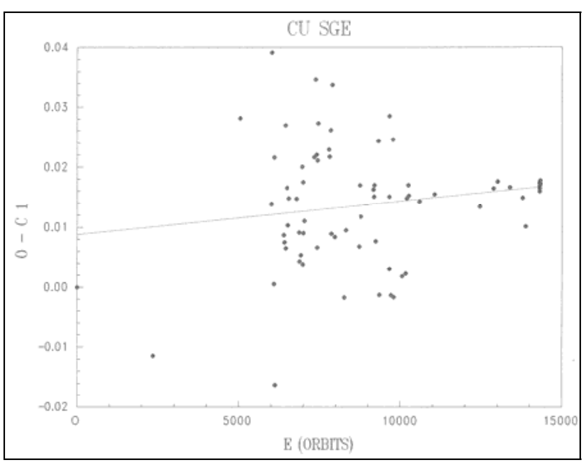

Figure 1. CU SGE O-C1 linear fit.

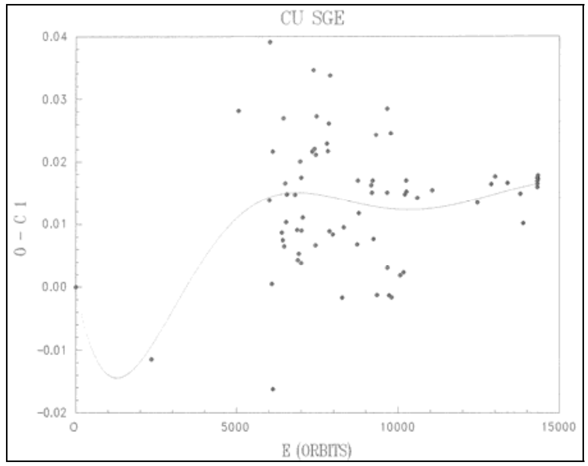

Figure 2. CU SGE O-C1 polynomial fit.

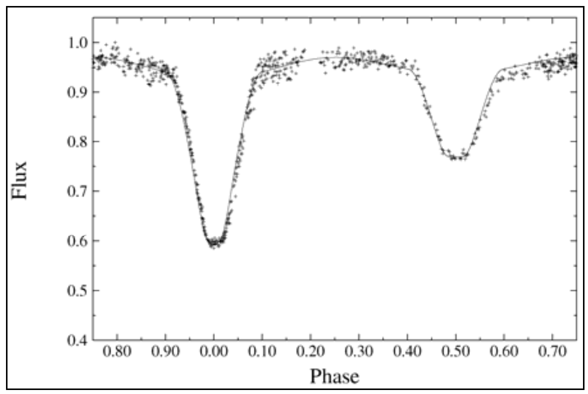

Figure 3. CU SGE modeled with lightcurve data.

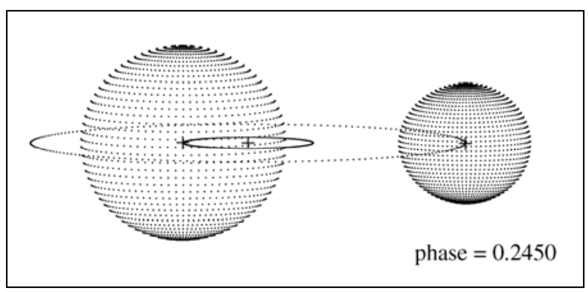

Figure 4. CU SGE 3-D modeling.

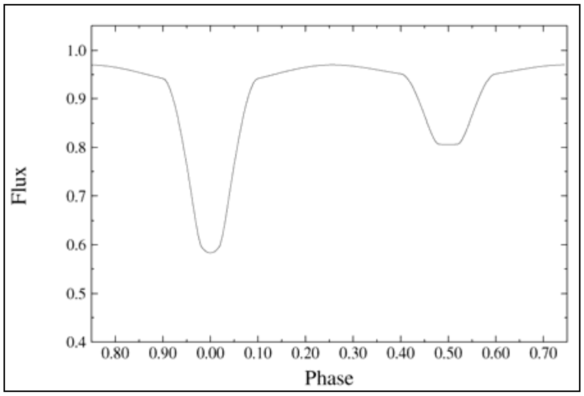

Figure 5. CU SGE modeled without lightcurve data.