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Photometric analysis of the contact binary system EL Aqr

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Abstract: Our recent ground-based BVRI CCD observations of the eclipsing binary system EL Aqr provide the most accurate photometric light variation obtained so far for this system. In addition to the photometric observations, a revision of all existing spectroscopic data is carried out and a new mass ratio is derived. The combined photometric and spectroscopic data are analyzed using the W-D light curve synthesis code and new geometric and photometric elements are calculated. EL Aqr is found to be in contact configuration, showing partial eclipses, and one of the smallest mass ratios ever found on contact binaries.

1 Introduction

EL Aqr ($BD-8^o6189, HIP117317, GSC05830:00377$) was first discovered by [7] and was not again studied until 1968, when [11] accidentally rediscovered it. EL Aqr is an active eclipsing variable with a short orbital period. The first photoelectric measurements were obtained by [11], who concluded that EL Aqr is a contact binary star with period P = 0.48141 d, which is very close to our own findings, and that its spectral type is F3V, based on its color index B-V = 0.41. The spectroscopic mass ratio was calculated by [9] and found to be equal to 0.203 ± 0.007, while a later study [10] provided a new value for the mass ratio, $q = 0.197 \pm 0.014$. The first combined photometric and spectroscopic study of EL Aqr was carried out by [12]. They found the orbital inclination of the system equal to $i = 70.84 \pm 1.04$ deg, which does not agree with our value. Their data (collected by the HIPPARCOS satellites and the ASAS survey) suffered from great scattering; therefore we can fairly assume that their results were not very accurate. Another value for the orbital inclination was found by [5], based again on low quality ASAS photometric data. They gave a value of $i = 70.36 \pm 0.32$ deg, which again does not agree very well with our value. Our results are further discussed in the forthcoming paragraphs.

2 Observations

The observations of EL Aqr were obtained on October 5, 7, 13, 14, 15, 16, 18, 19, 20, 21 and November 1, 8, 9, 2012. The instruments used were the 0.40 m Cassegrain reflector at the University of Athens Observatory, Greece, and a SBIG ST10 XME CCD camera, equipped with U, B, V, R, I (Bessell) filters. The CCD chip has 2184×1472 useful pixels of 6.8×6.8 μm, covering an area of approximately $16 \times 11 arcmin$ on the sky. An attached focal reducer f/6.3 increased the field of view up to 25×17 arcmin. Finally, the scale on the chip is 1.40 arcsec/pixel in 2×2 binning mode, using the focal reducer. A total number of 4172 frames was obtained in all filters (B, V, R, I), covering a total of 9 (primary and secondary) eclipses. The images were processed using the AIP4WIN software ([3]). All exposures and time recordings were converted to Heliocentric Julian Day (HJD). GSC 5830:0927 and GSC 5830:0121 were selected as comparison and check stars respectively, due to their similarity in magnitude and color to the target under study.

3 Combined spectroscopic and photometric analysis

The two values of spectroscopic mass ratio provided by [9] and [10] were combined by revising all available spectroscopic data for EL Aqr. We therefore derived a more accurate solution for the spectroscopic mass ratio. The value we found is $q = 0.203 \pm 0.007$, which is exactly equal to the first value obtained by [9]. ($K_1 = 52.58 \pm 1.67$, $K_2 = 258.93 \pm 1.70$). Combining our new times of minima with all the available data from literature, we calculated the linear ephemeris of the system: $MinI(HJD) = 2456208.4402(4) + 0.4814106(2) \times E$.

The new light curves were analyzed using the W-D code ([13], [14]), where the following parameters were adjusted during iterations: inclination angle i, temperature of the secondary component (T_2) and potential(s) $\Omega_{1,2}$. The spectroscopic mass ratio we used for the analysis of the light curve was fixed at q = 0.203 (from our combined solution explained above). The effective temperature of the primary component according to its spectral type (F3V) and the table from [6] was $T_1 = 6622K$. Limb darkening coefficients were taken from tables of [4] according to the wavelength of the observation for each case. The third light l_3 was assumed to be equal to zero, as there was no relevant evidence on the spectroscopic observations by [9], [10]. Based on the geometrical elements found in our model, the derived absolute parameters of EL Aqr are (in solar units): $M_1 = 1.555$, $M_2 = 0.316$, $R_1 = 1.733$, $R_2 = 0.888$ and $L_1 = 5.191$, $L_2 = 1.310$.

4 Conclusion

EL Aqr is a W UMa type contact binary with a short orbital period and a small mass ratio. In this project we gathered significantly more data than in other studies, which also were of much higher quality. It can be seen from the light curves that there was minimum scattering. We used the W-D code under LC mode, in order to find the best solution (model) of the system. We also re-adjusted the mass ratio of EL Aqr, around which certain confusion existed in previous papers. We did this by combining all spectroscopic data available up to date and the mass ratio was eventually found equal to $q = 0.203 \pm 0.007$. Referring back to literature values we found that our solution of the light curve (adjusted parameters) was slightly different from earlier findings. We can fairly conclude that the values cited above are the most accurate so far, since they fit best the accurate observational data.

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