A possible third body in the contact binaries AH Aur & AH Tau

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Abstract

New times of minima of the contact binaries AH Aurigae and AH Tauri, obtained at the Observatory of the University of Athens, have been used together with all reliable timings found in the literature in order to study the period variation and search for the presence of third body in each system. Their O-C diagrams are presented and apparent period changes are discussed with respect to possible Light-Time Effect (LITE) in the systems. The least-squares method has been used to compute new light elements (updated ephemeris and rate of period change) as well as the mass function, the minimum mass and the period of possible third body in each case.

1. Introduction

AH Aur (BD+28 1116 = AN 220.1928 = HD 256902 = HIP 30618, α_{2000} = 06^h 26^m 05^s, δ_{2000} = +27° 59´ 56´´) is a W UMa system with a period of ~0.49 days, discovered by Guthnick & Prager (1929) as an eclipsing binary. The first photoelectric observations were published by Hinderer (1960) and the first spectroscopic study of the system was made by Rucinski & Lu (1999). BV photoelectric and BVR CCD observations were also obtained by Vanko et al. (2001) who derived the absolute parameters of the system and found fast period changes from an analysis of the O-C diagram. AH Tau (CSI 24 03442 = HV 6187, α_{2000} = 03^h 47^m 12^s, δ_{2000} = +25° 07´ 00´´) was discovered as a variable by Shapley et al. (1934). Binnendijk (1950) and Romano (1962) obtained photographic observations of the system and classified it as a W UMa type and as β Lyr type, respectively. Bookmyer (1971) performed further photometric observations and indicated a spectral type around G5. Liu et al. (1991) and Byboth et al. (2004) gave a complete solution using the Wilson-Devinney code. Yang and Liu (2002) performed a period study of the system and suggested various mechanisms in order to explain the period variations.

2. Observations

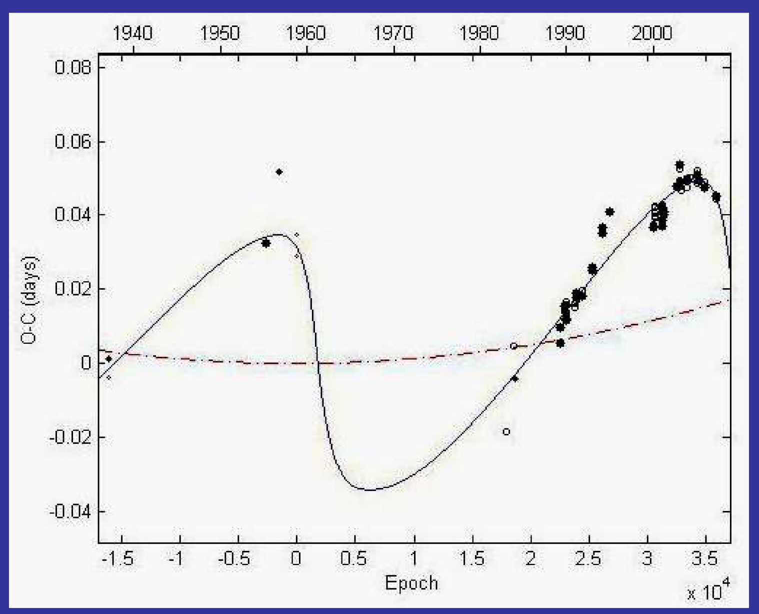
Both systems were observed with the 40-cm Cassegrain telescope of the Observatory of the University of Athens, equipped with the ST8XMEI CCD camera and with Bessell R-filter. For AH Aur the observations were carried out during one night in March 2007 and one night in April 2007; and for AH Tau during one night in December 2006 and one night in January 2007. Differential magnitudes were obtained for both systems. For AH Aur the stars GSC 1887:1240 and GSC 1887:1259, and for AH Tau the stars GSC 1804:2485 and GSC 1804:2332 were used as comparison and check stars, respectively. One primary and one secondary minimum for AH Aur, and two primary minima for AH Tau were obtained and they are given in the Table 1.

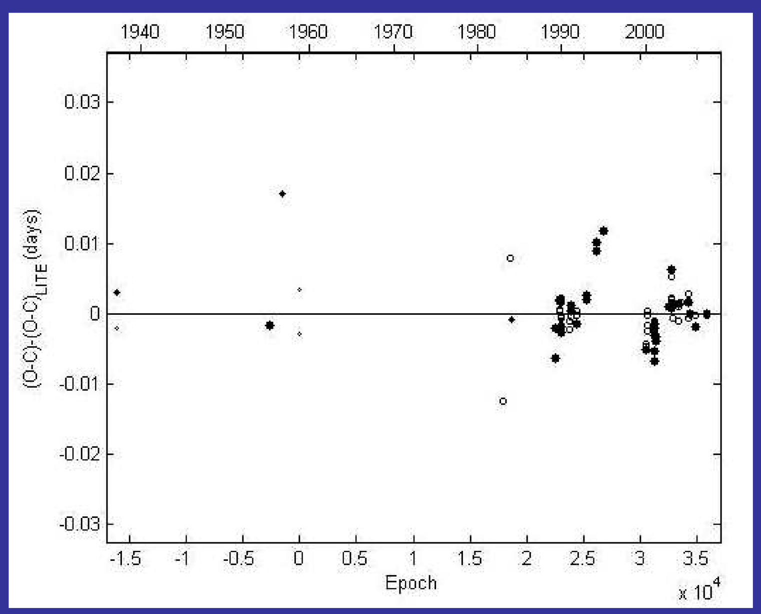
Table 1. The times of minima from our observations

AH Aur			AH Tau		
HJD (2400000+)	Error	Type	HJD (2400000+)	Error	Type
54178.36275	0.00007	I	54099.32718	0.00006	I
54203.31439	0.00009	II	54115.29518	0.00004	I

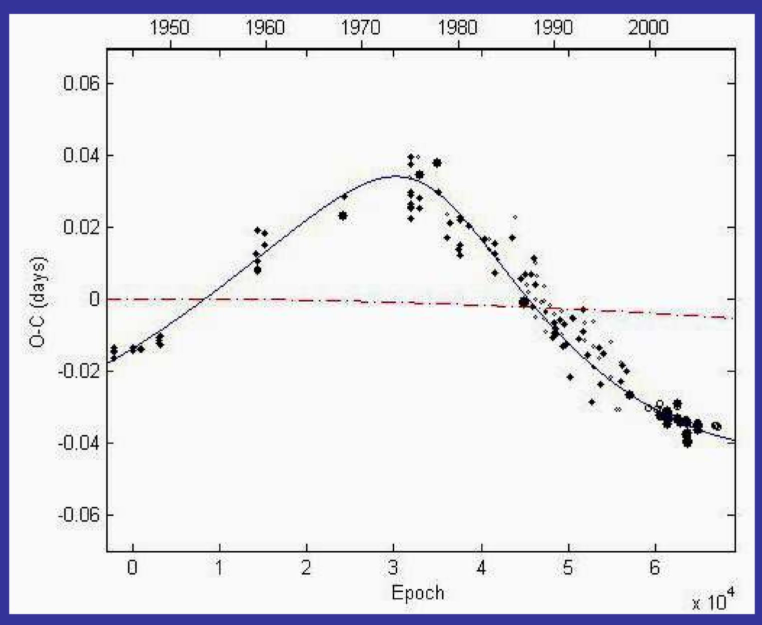
3. Analysis of the O-C diagrams

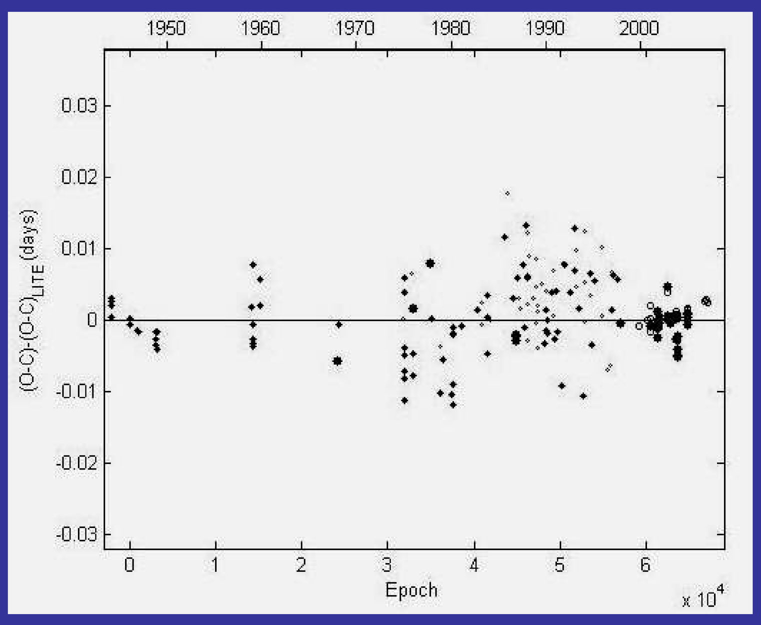
We used all the existing reliable times of minima for the O-C analysis. Particularly, 81 for AH Aur and 176 for AH Tau, kindly sent to us by J. M. Kreiner (private communication), taken from his database http://www.as.ap.krakow.pl/ephem/, and the new minimum times from our observations listed in Table 1. The O-C residuals of all compiled times of minima have been initially computed according to the linear ephemeris **T = 2436499.2448 + 0.49410575 × E** (Kreiner et al. 2001) for AH Aur, and **T = 2431822.3653 + 0.33267368 × E** (Kreiner et al. 2001) for AH Tau. The O-C diagrams have been analyzed by the least-squares method and the results are presented in the Figures 1-4. Figures 1 and 3 show the O-C diagrams fitted by a parabolic and sinusoidal curve, thus suggesting a mass transfer between the components and the presence of a third body in the systems. In Figures 2 and 4 the residuals, obtained by subtracted LITE solutions, are presented for AH Aur and AH Tau, respectively. The new LITE elements of the binaries and the orbital parameters of possible third body are given in Table 2.





Figs. 1 & 2. The O-C diagram of AH Aur fitted by a parabolic and a sinusoidal curve (left), and the residuals obtained by subtracting LITE solutions (right).





Figs. 3 & 4. The O-C diagram of AH Tau fitted by a parabolic and a sinusoidal curve (left), and the residuals obtained by subtracting LITE solutions (right).

Table 2. The LITE parameters of AH Aur and AH Tau

Parameter	AH Aur	AH Tau
$M_1 + M_2$ ($M_\odot$)	1.68 + 0.28	0.93 + 0.71
Mass transfer ($M_\odot$ /yr)	(4.206 ± 0.001)×10^{-9}	(-2.53 ± 0.07)×10^{-9}
P_{third} (yrs)	48 ± 1	92 ± 1
A(semi-amplitude of O-C) (days)	0.035 ± 0.003	0.035 ± 0.001
e_{third}	0.8 ± 0.1	0.4 ± 0.1
ω_{third} (deg)	175 ± 2	119 ± 9
$f(m_{third})$ ($M_\odot$)	0.43 ± 0.03	0.028 ± 0.001
$M_{third\ (min)}$ ($M_\odot$) (i = 90°)	1.8 ± 0.1	0.508 ± 0.001
χ^2	0.00875240	0.00842676

4. Discussion and Conclusions

New LITE parameters for the eclipsing binaries AH Aur and AH Tau have been derived by means of an analysis of their O-C diagrams. A third body in an eccentric orbit with a period of ~48 years and a minimum mass of 1.8 $M_\odot$ was found for the case of AH Aur, while for the case of AH Tau, a third body in an eccentric orbit with a period of ~92 years and a minimum mass of 0.508 $M_\odot$ was also found.. Assigning a weight of 1 to visual data, 5 to photographic data, and 10 to photoelectric and CCD observations, we found: a quadratic ephemeris **T = 2436499.24190(1104) + 0.4941050(7) × E + 0.125500(20) × 10^{-10} × E^2** and a period increase rate of **dP/dt = 1.855(2) × 10^{-8} days/yr** for AH Aur which indicates a mass transfer from the less massive to the more massive component of the system; and for AH Tau we found the quadratic ephemeris **T = 2431822.35345(477) + 0.3326739(1) × E - 0.011500(3) × 10^{-10} × E^2** and a period decrease rate of **dP/dt = -2.52515× 10^{-9} days/yr**, which indicates a mass transfer from the more massive to the less massive component.

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