Light Curves and Analyses of the Eclipsing Binaries IK Per and WY Tau

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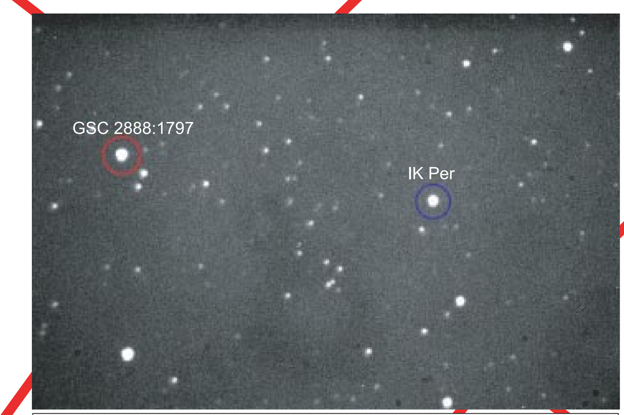
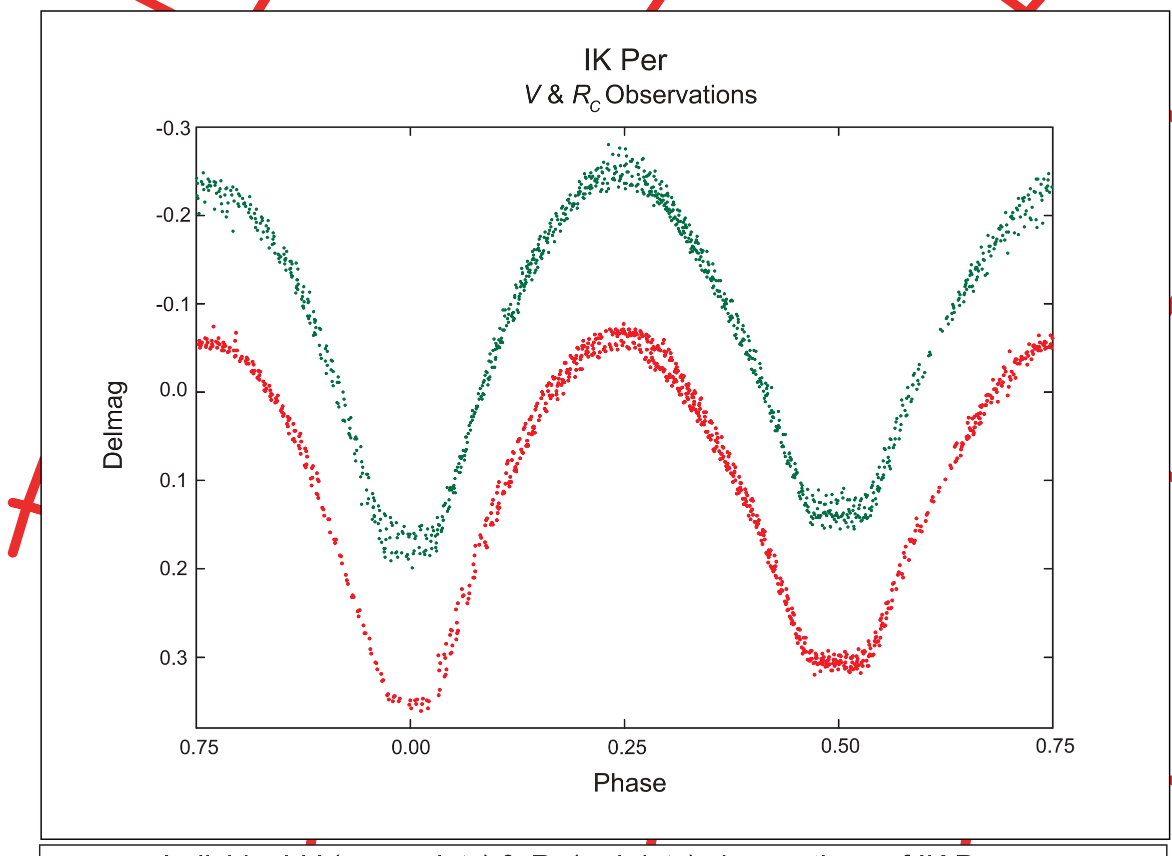


13 x 9 arcminute CCD field of IK Per (blue circle) and the comparison star GSC 2888:1797 (red circle).

New precision V & R_C light curves of the eclipsing binaries IK Per and WY Tau have been obtained using the 41-cm telescope at Eastern University equipped with an SBIG ST-10XME CCD. IK Per (P = 0.6760 days) has only one other published light curve, with no light curve analysis (Zhu *et al.* 2003). The system was observed on 13 nights from 30 Sep - 20 Nov 2003, accumulating 1132 observations in V and 998 in R_C. IK Per is an A-type overcontact binary that exhibits total eclipses and slightly asymmetric maxima, and the light curve was seen to vary somewhat over the 7-week observing session. IK Per has a fairly small mass ratio (q = 0.152) and large fillout (f = 0.75). Analysis of the O-C diagram indicates that the period is steadily decreasing at a rate of -2.05×10^{-3} sec/yr. Large starspots, slightly cooler than the surrounding photosphere, were required in order to fit the light curves. The presence of large, cool starspots is consistent with the observed variability of the light curves. A radial velocity curve is needed in order to establish the absolute parameters of the system.

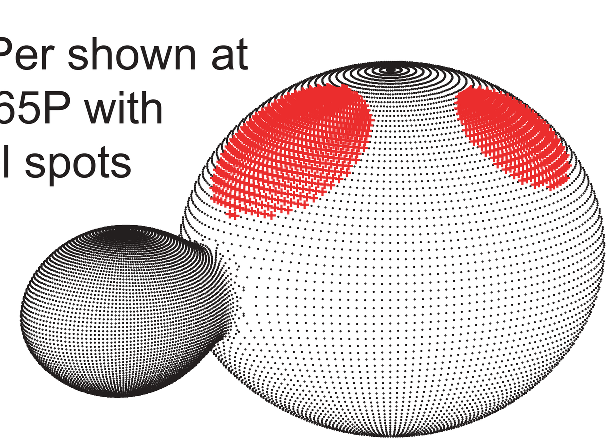
WY Tau (P = 0.6928 days) has no photoelectric light curves published, although it has several decades of visual timings of minimum light. It was observed on 15 nights from 15 Jan - 19 Feb 2004, accumulating 1574 observations in V and 1533 in R_C. The O-C diagram indicates that the period of the system has probably been constantly varying over the past 70+ years, steadily increasing at a rate of $+5.36 \times 10^{-3}$ sec/yr. Although the light curves of WY Tau indicate identical eclipse depths, the system, previously classified as on overcontact binary, is definitely ***not*** in contact as evidenced by the morphology of the out of eclipse light variations. Both components of WY Tau appear to be nearly in contact with their inner Lagrangian surfaces. Many models of WY Tau were tried, at many different mass ratios, but the eclipses depths could not be fit as well as the shoulders of the eclipses. There is virtually no difference in the fits between mass ratio equal to unity and the solution mass ratio = 0.894 to which the Wilson-Devinney differential corrections program meandered. The mass ratio was assumed to be unity in the models presented here. A radial velocity curve will be the only way to extract meaningful mass ratio information from this system, and the acquisition of such data is planned. Along with the solutions using ***Binary Maker 3.0*** and Wilson-Devinney, we employed the genetic algorithm of ***ELC*** (Orosz & Hauschildt 2000) to ensure robust and sufficient coverage of parameter space. A population of 100 models was evolved for 100 generations (breeding the best-fit models), resulting in over 10,000 trial light curve solutions. Of the myriads of models attempted, no better solutions were found than the one presented here with a mass ratio of unity. We found the most trying issue in the modeling was fitting the depths of the eclipses accurately; the inability to satisfactorily represent the eclipse depths remains a mystery. One possibility is that the system may harbor interstellar gas stream between the components. These gas streams would be eclipsed thus explaining the loss of extra light. The close proximity of the stars lends some credence to this idea, as well as the fact that there is more scatter in the data at quadratures than in the eclipses. However, investigation of the presence of such gas may have to wait until spectra are obtained.

13 x 9 arcminute CCD field of WY Tau (blue circle) and the comparison star GSC 1871:184 (red circle).

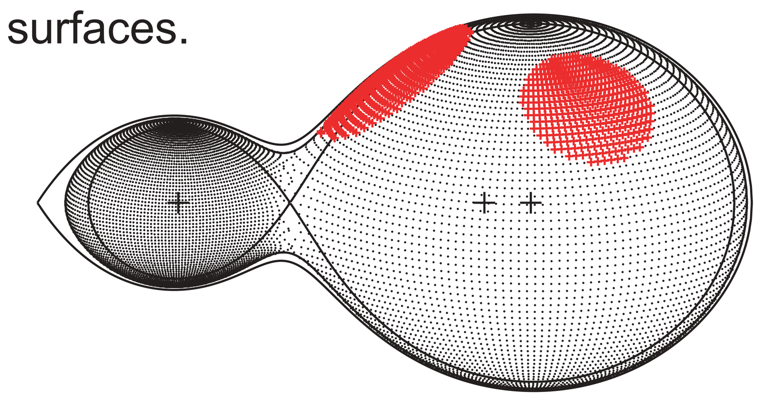


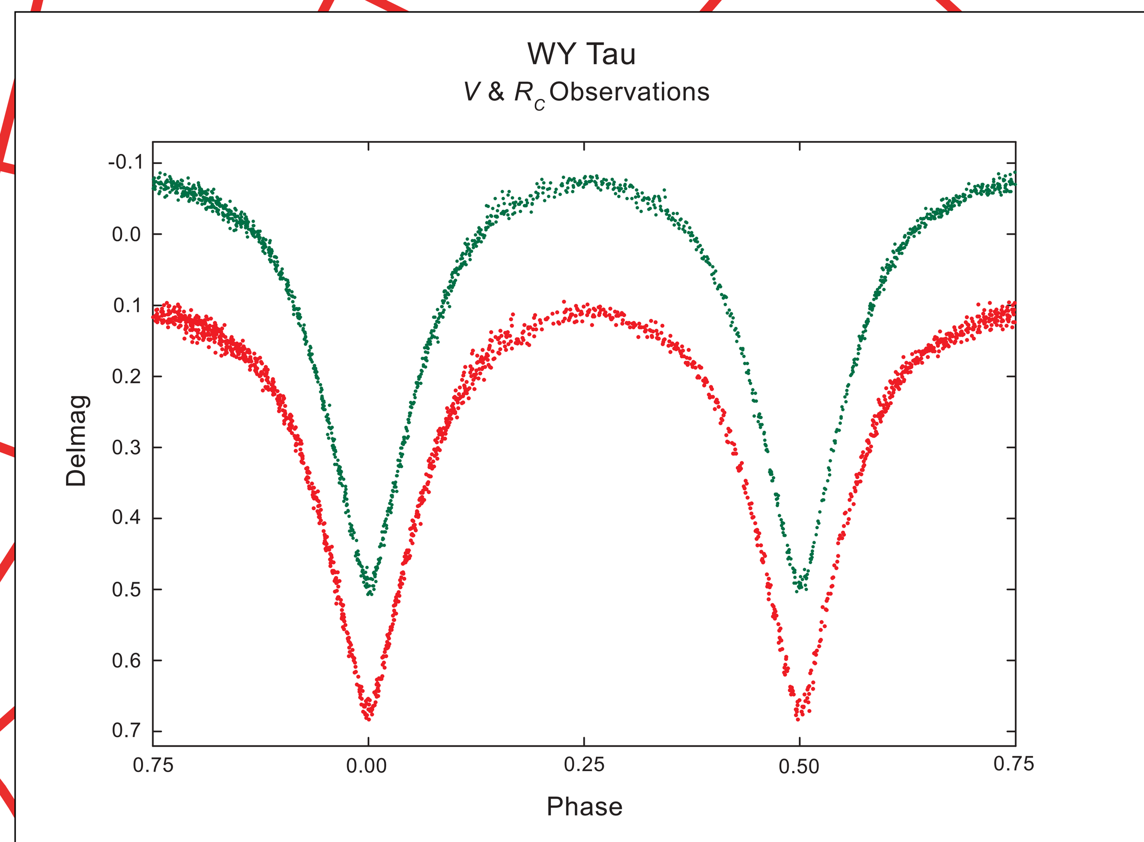
Individual *V (green dots)* & R_C *(red dots)* observations of IK Per

IK Per shown at 0.865P with cool spots

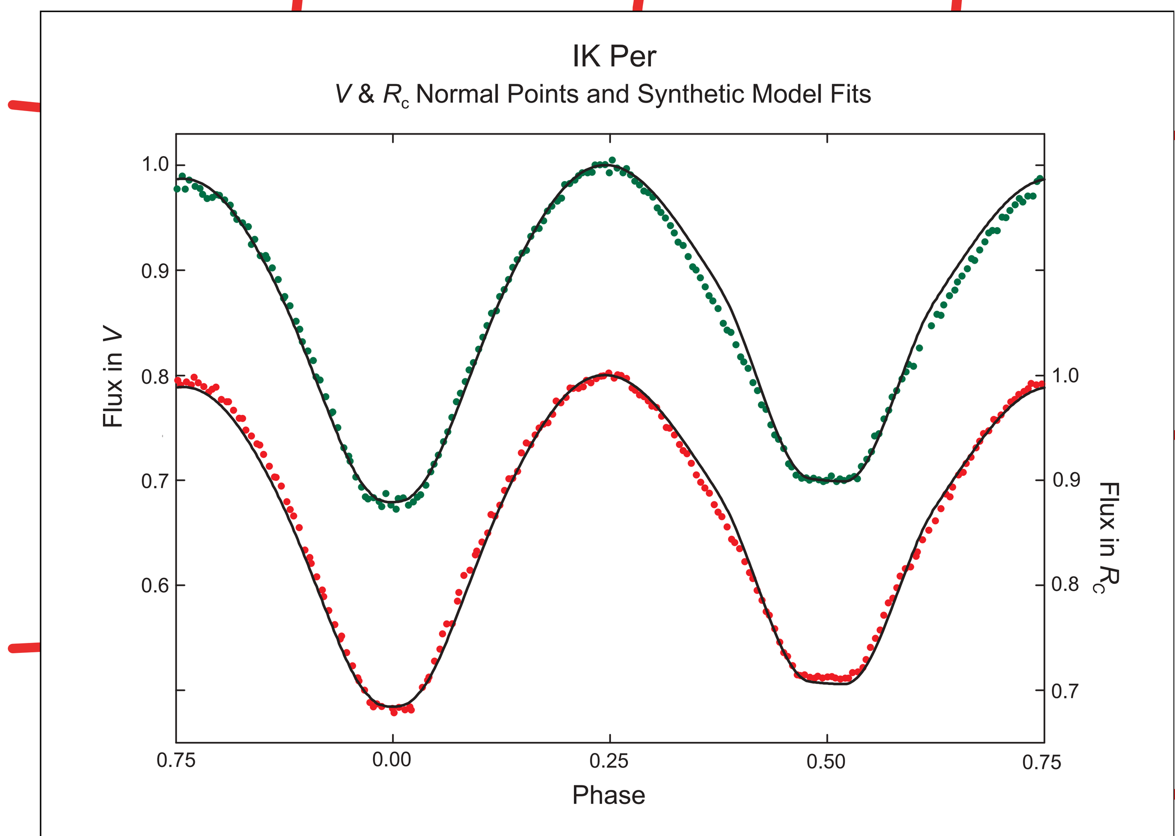


IK Per with inner and outer Lagrangian surfaces.





Individual *V (green dots)* & R_C *(red dots)* observations of WY Tau



V & R_C synthetic Wilson-Devinney fits (solid curves) to normal points of IK Per

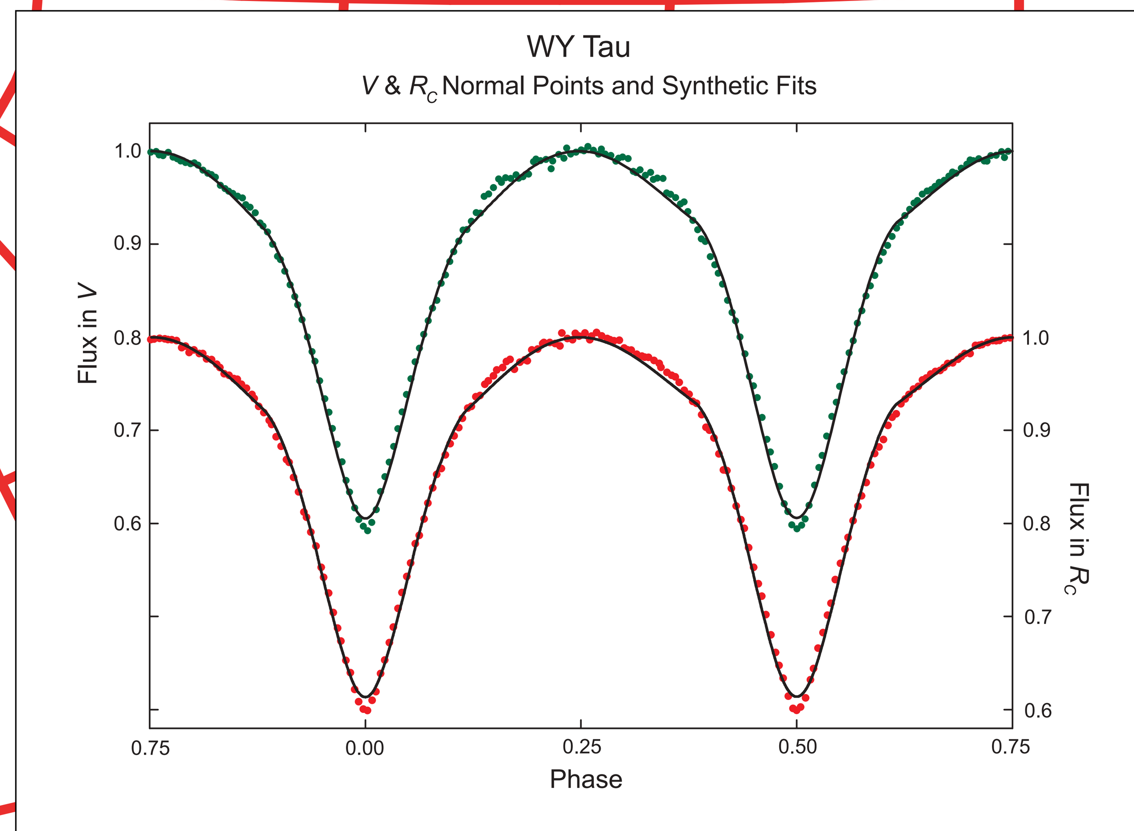
Light Curve Parameters for IK Per
(Probable errors given in parentheses)

mass ratio	=	0.1516 (4)
Ω_1	=	2.0341 (38)
Ω_2	=	0.7497
inclination	=	74.83° (30)
mean density$_1$	=	0.193 g/cm^3
mean density$_2$	=	0.314 g/cm^3
T_1	=	5500 °K (assumed)
T_2	=	5666 °K (6)
Albedo$_1$ = Albedo$_2$	=	0.50 (assumed)
Luminosity$_1$ L_1(6400 Å)	=	0.8123 (13)
Luminosity$_2$ L_2(6400 Å)	=	0.1877
Limb darkening $x_1 = x_2$ = (6400 Å)	=	0.597 (21)
Luminosity$_1$ = L_1 (5500 Å)	=	0.8094 (14)
Luminosity$_2$ = L_2 (5500 Å)	=	0.1829
Limb darkening $x_1 = x_2$ = (5500Å)	=	0.604 (19)
Gravity brightening $g_1 = g_2$	=	0.32 (assumed)

r_1 back	= 0.61327 (181)	r_2 back	= 0.32057 (486)
r_1 side	= 0.58640 (152)	r_2 side	= 0.25112 (125)
r_1 pole	= 0.52633 (96)	r_2 pole	= 0.23797 (98)

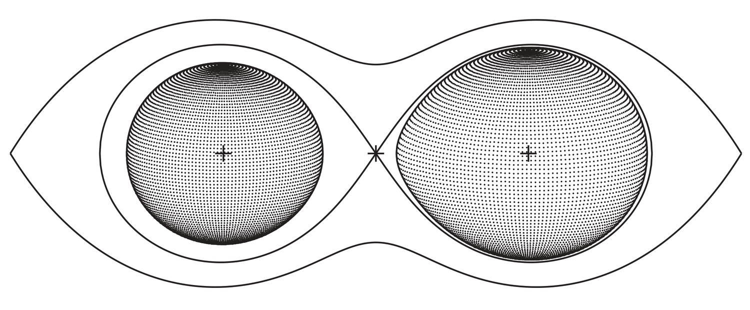
Spot Parameters

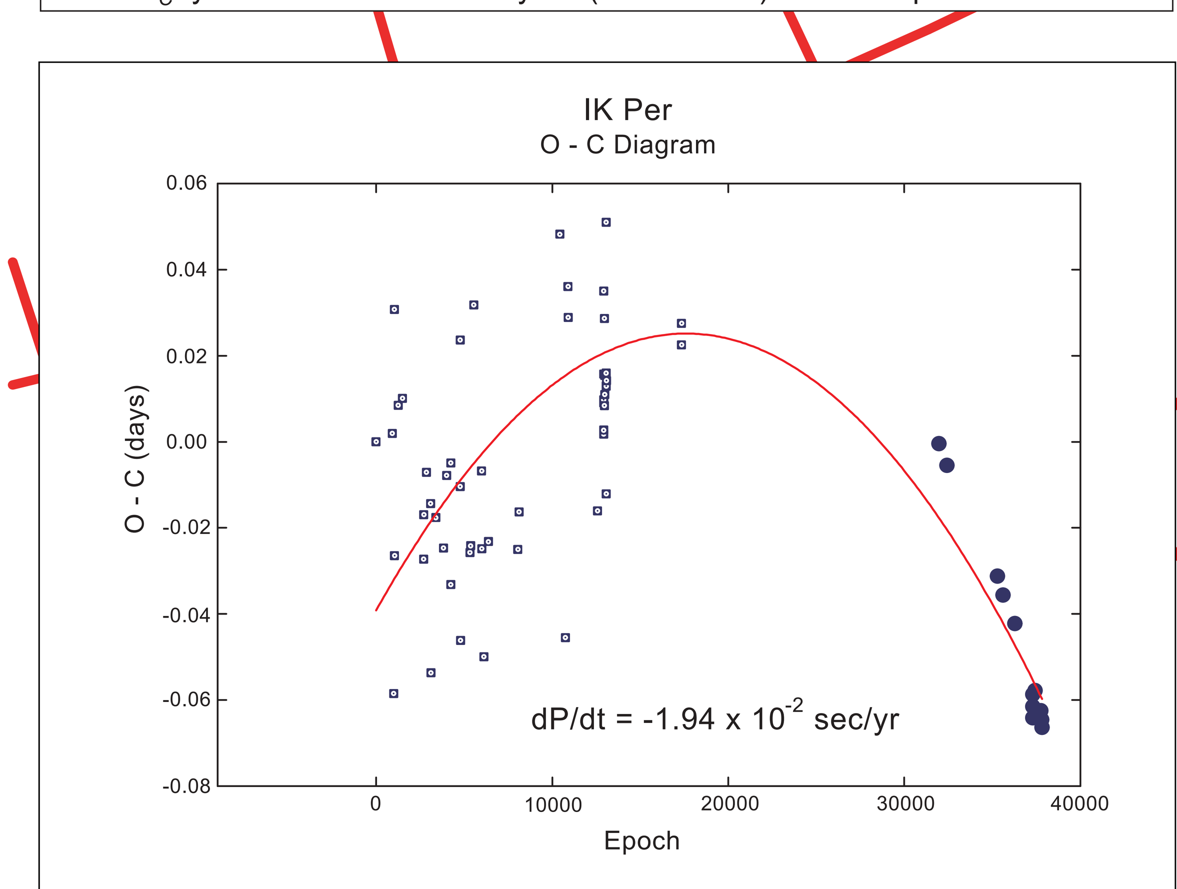
Latitude	Longitude	Radius	Temperature Factor
45°	245°	20°	0.96
45°	0°	26°	0.96



V & R_C synthetic Wilson-Devinney fits (solid curves) to normal points of WY Tau

WY Tau inner and outer Lagrangian surfaces



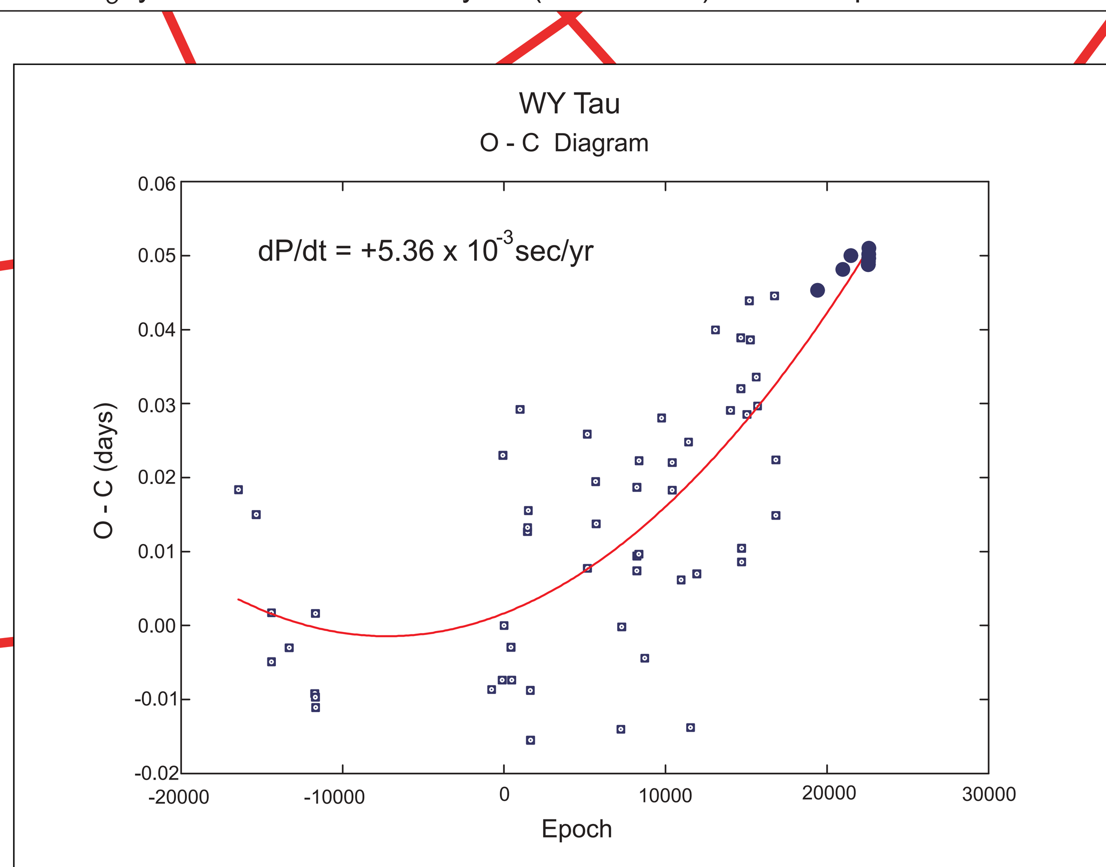


Parabolic fit to the O - C residuals of IK Per; open squares represent visual and photographic timings, filled circles represent photoelectric or CCD timings.

Light Curve Parameters for WY Tau
(Probable errors given in parentheses)

mass ratio	=	1.00 (assumed)
Ω_1	=	3.8279 (34)
Ω_2	=	4.3294 (151)
inclination	=	78.38° (8)
T_1	=	8000 °K (assumed)
T_2	=	7783 °K (9)
Albedo$_1$ = Albedo$_2$	=	1.00 (assumed)
Luminosity$_1$ L_1 (6400 Å)	=	0.6093 (46)
Luminosity$_2$ L_2 (6400 Å)	=	0.3907
Limb darkening $x_1 = x_2$ = (6400 Å)	=	0.438 (assumed)
Luminosity$_1$ = L_1 (5500 Å)	=	0.6121 (47)
Luminosity$_2$ = L_2 (5500 Å)	=	0.3879
Limb darkening $x_1 = x_2$ = (5500Å)	=	0.517 (assumed)
Gravity brightening $g_1 = g_2$	=	1.00 (assumed)

r_1 back	= 0.38957 (65)	r_2 back	= 0.31722 (170)
r_1 point	= 0.43288 (146)	r_2 point	= 0.32627 (200)
r_1 side	= 0.36282 (48)	r_2 pole	= 0.30489 (145)
r_1 pole	= 0.34685 (40)	r_2 side	= 0.29667 (130)



Parabolic fit to the O - C residuals of WY Tau; open squares represent visual and photographic timings, filled circles represent photoelectric or CCD timings.