Light Curves and Analyses of the Eclipsing Binaries EG Cas and EP Cas

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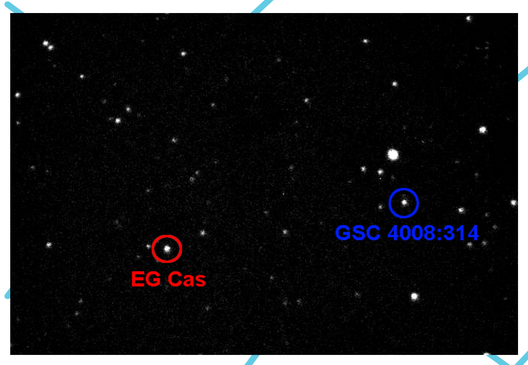
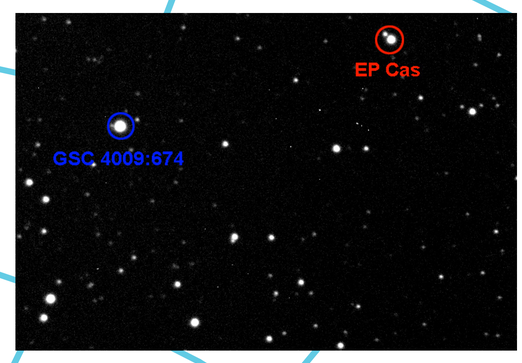
New precision V & Rc light curves of the eclipsing binaries EG Cas and EP Cas have been obtained using the 41-cm telescopes at the Bradstreet Observatory at Eastern University equipped with SBIG ST-10XME CCDs. Analysis was performed using ***Binary Maker 3.0*** to obtain initial models. These preliminary solutions were then more precisely fitted using the ***PHOEBE*** suite of light curve analysis tools based upon the ***Wilson-Devinney*** code.

EG Cas (P = 0.6115 days, Vmax = 12.9) has no published light curves and only a few dozen (mostly visual) timings of minimum light. The system was observed throughout the fall of 2009 and the light curves distinctly show that the system is a totally eclipsing, overcontact binary. All available times of minimum light were analyzed and the resulting O - C diagram is shown below. The resulting period study clearly indicates that the period of EG Cas has been decreasing at the significant rate of -0.019 sec/yr. This is almost exactly the period decrease observed for VW Cep, an overcontact binary that shows substantial changes in its light levels over short time periods.

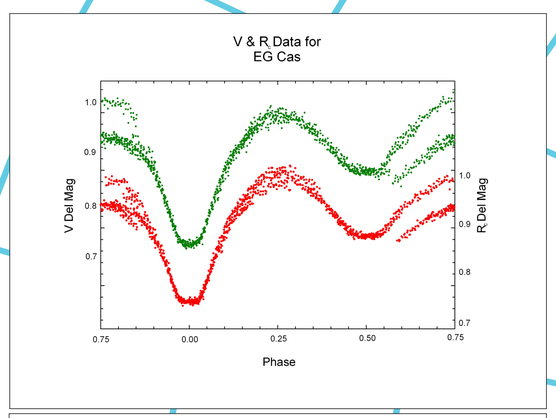
The light curves of EG Cas are also significantly asymmetric (strong O'Connell effect) probably indicating the presence of large, active starspot regions, most likely on both stars. Over the four months of monitoring the binary displayed extensive changes in the light curves from phases 0.42P - 0.82P. However the light curves were very stable around primary eclipse throughout the entire observing season. This would seem to indicate that the active regions reside on the facing hemispheres of the two stars. Because of poor weather we were unable to document whether the changes in the light curves were contiguous. A large number of cool starspot models were attempted in order to fit the asymmetrical part of the light curve, but no satisfactory solutions were obtained. Therefore only the symmetrical portions of the light curves were modeled. A robust solution was achieved and the parameters for it are listed below. Despite the anomalies in parts of the light curves, the mass ratio of this A-type (the larger, more massive star is the hotter component) binary is well determined due to the totality of the primary eclipse. It is also important to note the extremely poor thermal contact (3120 K) of this overcontact binary, one of the largest known, especially for a system with a fillout of 26%! We fully intend to carefully monitor this very active binary in the next observing season to confirm the rapid and extreme changes in its light output and hopefully better model its asymmetries.

EP Cas (P = 0.8134 days, Vmax = 11.2) is a partially eclipsing, detached system with a relatively deep primary eclipse of 1.0 mag in Rc. No published light curves exist for this system although many timings (mostly visual) of minimum light have been published. The O - C curve indicates that the period for the binary has remained relatively constant since observations were first published in 1936. This constant period for a binary with such close components is extremely rare. The light curve analysis indicates that the stars of EP Cas are almost in contact with each other. The light curves themselves are slightly asymmetrical and have been modeled with two cool starspots on the hotter, more massive star. Spots were initially placed upon the cooler secondary star but because its contribution to the light curves is minimal (~13% of the total light) it was nearly impossible to create the observed asymmetries in the light curves with cool spots on its surface.

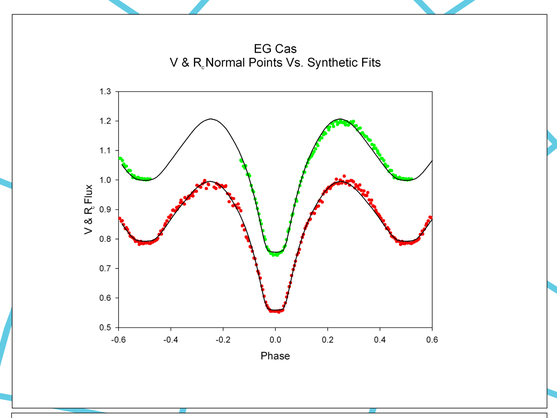




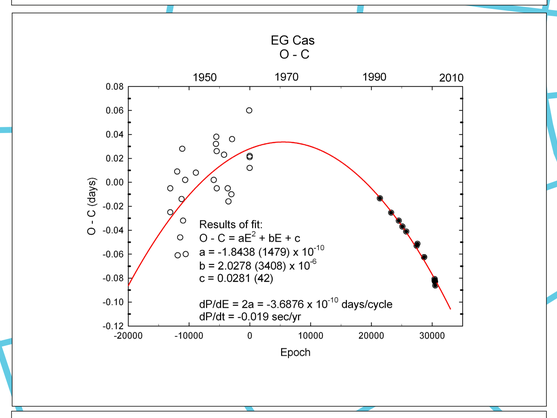
EG Cas



Individual V (green dots) and R_c (red dots) observations of EG Cas



V & R_c synthetic Wilson-Devinney fits (solid curves) to normal points of EG Cas



Parabolic fit to the O-C residuals of EG Cas. Open circles indicate visual timings, solid circles CCD timings.

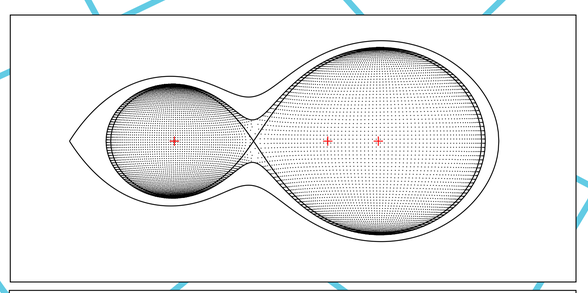
Light Curve Parameters for EG Cas

(Formal probable errors given in parentheses)

Mass ratio	= 0.3297 (14)
Inclination	= 90.0° (assumed)
Ω_1	= 2.47841 (602)
Ω_2	= 2.47841 (602)
T_1	= 7500 °K (assumed)
T_2	= 4380 °K (43)
Fillout	= 0.2574
$Albedo_1$	= 1.0 (assumed)
$Albedo_2$	= 0.32 (assumed)
Gravity brightening $_1$	= 1.0 (assumed)
Gravity brightening$_2$	= 0.32 (assumed)
$Luminosity_{1_{Rc}}$ = L_1 (6400 Å)	= 11.7460 (317) = 0.935 (3)
$Luminosity_{2_{Rc}}$ = L_2 (6400 Å)	= 0.8204 = 0.065
$Luminosity_{1_V}$ = L_1 (5500 Å)	= 12.2094 (284) = 0.972 (2)
$Luminosity_{2_V}$ = L_2 (5500 Å)	= 3.570 = 0.028
F_1 = F_2 (rotation parameter)	= 1.0 (assumed)
$X_{1_{Rc}}$ (limb darkening)	= 0.467 (assumed)
$X_{2_{Rc}}$ (limb darkening)	= 0.520 (assumed)
X_{1_V} (limb darkening)	= 0.548 (assumed)
X_{2_V} (limb darkening)	= 0.831 (assumed)

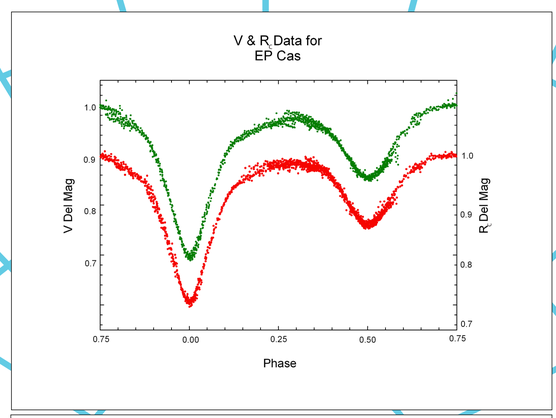
Stellar Radii

r_1 back = 0.5246	r_2 back = 0.3343
r_1 side = 0.4951	r_2 side = 0.2924
r_1 pole = 0.4590	r_2 pole = 0.2792

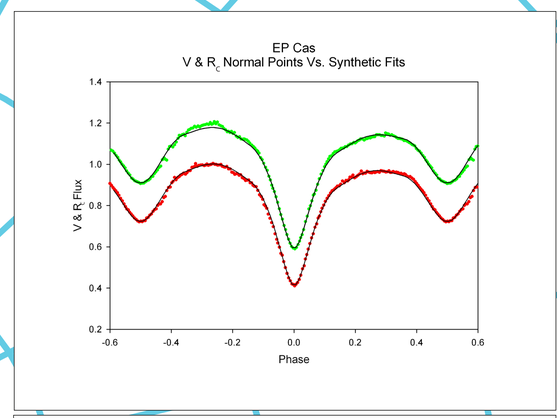


EG Cas with inner and outer Lagrangian surfaces

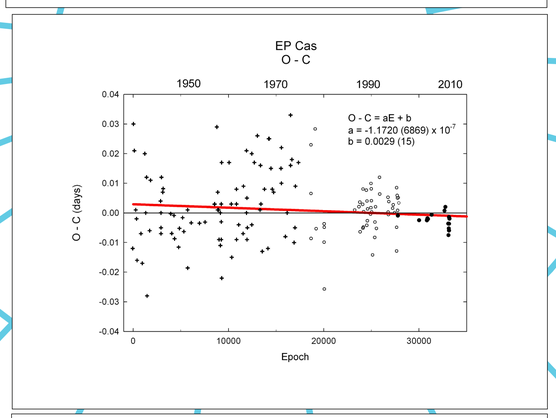
EP Cas



Individual V (green dots) and R_c (red dots) observations of EP Cas



V & R_c synthetic Wilson-Devinney fits (solid curves) to normal points of EP Cas



Linear fit to the O-C residuals of EP Cas, open circles represent visual timings, crosshairs represent photographic timings and solid circles represent CCD timings. The period appears to be fairly constant over the past 70 years.

Light Curve Parameters for EP Cas

(Formal probable errors given in parentheses)

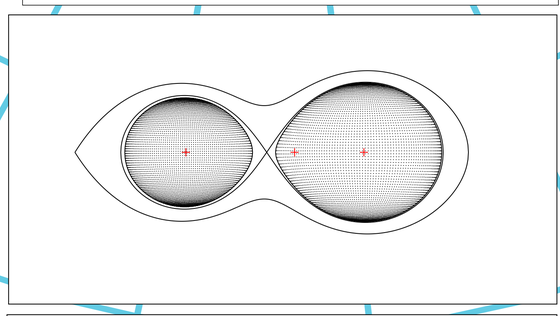
Mass ratio	= 0.0638 (3)
Inclination	= 85.°02 (5)
Ω_1	= 3.16688 (137)
Ω_2	= 3.22401 (137)
T_1	= 11000 °K (assumed)
T_2	= 6485 °K (52)
$Albedo_1$ = $Albedo_2$	= 1.0 (assumed)
$Luminosity_{1_{Rc}}$ = L_1 (6400 Å)	= 10.0988 (877) = 0.866 (8)
$Luminosity_{2_{Rc}}$ = L_2 (6400 Å)	= 1.5567 (288) = 0.134 (3)
$Luminosity_{1_V}$ = L_1 (5500 Å)	= 9.8508 (892) = 0.880 (8)
$Luminosity_{2_V}$ = L_2 (5500 Å)	= 1.3424 (281) = 0.120 (3)
Third $Light_{3_{Rc}}$	= 0.026 (6)
Third $Light_{3_V}$	= 0.041 (6)
Gravity brightening g_1 = g_2	= 1.0 (assumed)
F_1 = F_2 (rotation parameter)	= 1.0 (assumed)
$X_{1_{Rc}}$ (limb darkening)	= 0.295 (assumed)
$X_{2_{Rc}}$ (limb darkening)	= 0.301 (assumed)
X_{1_V} (limb darkening)	= 0.381 (assumed)
X_{2_V} (limb darkening)	= 0.497 (assumed)

Stellar Radii

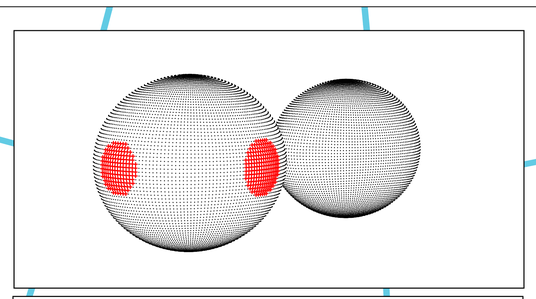
r_1 back = 0.4372	r_2 back = 0.3432
r_1 side = 0.4100	r_2 side = 0.3178
r_1 pole = 0.3888	r_2 pole = 0.3057
r_1 point = 0.4961	r_2 point = 0.3743

Both spots on are on the larger, hotter star:

Spot 1	Spot 2
Colatitute = 90.°0	Colatitude = 90.°0
Longitude = 175.°0	Longitude = 277.°0
Spot Radius = 16.°0	Spot Radius = 18.°0
Temperature Factor = 0.80	Temperature Factor = 0.75



EP Cas with inner and outer Lagrangian surfaces



EP Cas shown at 0.38P with cool spots