MASS TRANSFER AND STELLAR WIND EFFECTS IN THE ECLIPSING BINARY RT ANDROMEDAE

G.A. Bakos[1] and J. Tremko[2]
[1]Department of Physics, University of Waterloo, Waterloo, Ontario, Canada
[2]Astronomical Institute, Skalnaté Pleso Observatory, Czechoslovakia

Introduction

In recent years the short period eclipsing binary RT And has been studied extensively by a number of authors. From photoelectric observations the light curve and the photometric elements were derived by Dean (1974) and Mancuso et al. (1979). The geometric dimensions of the binary confirm that the system is detached consisting of two stars of spectral type F8 V and KO V. The mass ratio is 0.66. In spite of this classification, effects appearing among semidetached systems have been observed, namely, variations of the amplitude and the shape of the light curve and changes of the length of the orbital period.

The variations of the period have been studied by Williamon (1974). Based on all available observations since 1914 he constructed an O-C diagram and found two instances of a sudden change of the period, one in 1938 and another in 1964. In an effort to clarify the changes of the period and to elucidate the nature of the changes we collected and reexamined all photoelectric epochs of minima.

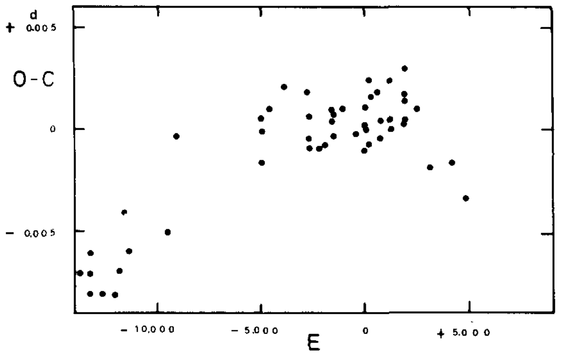
Observations and Results

Since 1968 the star RT And was observed near the times of minima at the Skalnaté Pleso Observatory. A total of five epochs of primary minima were obtained. These and all other available photoelectric epochs have been collected and listed in Table I. We also observed one secondary minimum whose epoch is J.D. 2440196.2900.

The data of Table I have been used to compute the residuals from a linear ephemeris. For the period of the system we adopted the value of Williamon (1974), P_3=0.6289298 days. A plot of the residuals, extending over 18650 cycles, is shown in Fig. 1.

The distribution of the residuals can be represented by an asymmetric curve. The slope of the curve at different cycles is variable. Its shape does not suggest that it represents

C. Chiosi and R. Stalio (eds.), Effects of Mass Loss on Stellar Evolution, 491–494.



a light-time orbit due to the presence of a third body. Thus we adopted the conclusion of Williamon that from time to time sudden changes of the period occur. From an analysis of the O-C curve we identified sections of the curve having the same slope. The slopes were converted to corrections to the adopted period and plotted in Fig. 2. It shows that between 1948 and 1979 at least four sudden changes of the period occurred.

The other feature of the O-C diagram is the large scatter of the points, especially between cycles -5000 and +2000. Since in photoelectrically observed light curves the time of mid-eclipse can be determined with high degree of accuracy it is obvious that the scatter is intrinsic to the system. The scatter would indicate an asymmetry of the primary minimum. Dean's (1974) study has shown that, indeed, a slight asymmetry in the primary minimum exists. The degree of asymmetry, expressed in days, is of the order of the scatter in the O-C diagram. At the same time we have also noticed a variability of the depth of the primary minimum. It amounts to 0.05 mag and it may oscillate periodically between deeper and shallower minima. Dean's and our observations indicate a period of about 20 days.

The O-C diagram between cycles -5000 and +2000 deserves a closer inspection. At cycle -1500 there are five points which are remarkably compact when compared with the regions to the left and to the right. We believe that this part represents a period of low activity of RT And while the neighbouring regions are signs of high activity within the system. Although the two stars represent a detached system (Cester et al., 1978) the inner contact surface is only a fraction of the radius from the surface of the F star. We disagree with Cester that the source of chromospheric activity is in the K component. Since there is a steady decrease of the orbital period, a mass transfer must take place from the F star

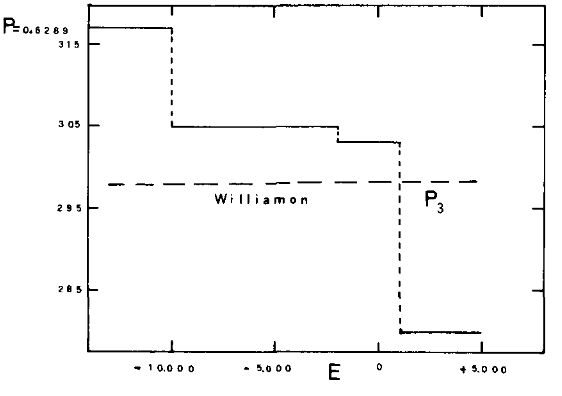


Table I.

Photoelectric Epochs of Minima of RT And

J.D. hel.	E	0-C	Source
243 2443.782	-13830	-0.007	Williamon (1974)
2758.876	13329	-0.007	"
2763.908	13321	-0.007	"
2775.858	13302	-0.006	"
2787.807	13283	-0.007	"
2804.787	13256	-0.008	"
2865.793	13159	-0.008	"
3175.856	12666	-0.008	"
3587.805	12011	-0.008	"
3627.4284	11948	-0.0069	"
3837.494	11614	-0.004	"
3918.624	11485	-0.006	"
3920.511	11482	-0.006	"
5066.422	9660	-0.005	"
5454.4731	9043	-0.0003	"
7958.8731	5061	-0.0017	Dean (1974)
7987.8061	5015	+0.0005	"
7992.7552	4996	-0.0001	"
8227.429	4634	+0.001	Williamon (1974)
8651.328	3960	+0.002	"
8728.6862	3837	+0.0013	Dean (1974)
9390.3209	2785	+0.0018	Williamon (1974)
9422.3936	2734	-0.0009	"
9429.3122	2723	-0.0005	"
9441.2630	2704	+0.0006	"
243 9739.374	2230	-0.001	"
244 0115.4755	1632	+0.0004	"
0161.3878	1559	+0.0009	Present paper
0190.3175	1513	-0.0003	"
0197.2368	1502	+0.0008	"
0200.3815	- 1497	+0.0009	"

Table I, continued

J.D. hel.	E	0-C	Source
244 0439.375	-1117	+0.001	Williamon (1974)
1141.8885	0	0.0000	"
1143.7753	+ 3	+0.0001	"
1167.673	+ 41	-0.001	"
1194.7197	+ 84	+0.0011	"
1197.865	+ 89	+0.002	"
1218.6181	+ 122	+0.0002	"
1227.4219	+ 136	-0.0010	"
1230.5675	+ 141	-0.0001	"
1232.4536	+ 144	-0.0007	"
1261.3875	+ 190	+0.0024	"
1300.3803	+ 252	+0.0015	"
1508.5563	+ 583	+0.0018	Mancuso et al. (1979)
1598.4911	+ 726	-0.0004	"
1619.2458	+ 759	-0.0004	Hall and Kreiner (1980)
1627.4227	+ 772	+0.0004	Mancuso et al. (1979)
1886.5418	+1184	+0.0005	"
1905.4092	+1214	0.0000	"
1924.2795	+1244	+0.0024	Hall and Kreiner (1980)
2317.3611	+1869	+0.0029	"
2329.3092	+1888	+0.0013	Mancuso et al. (1980)
2330.5675	+1890	+0.0017	"
2339.3710	+1904	+0.0002	"
2385.2832	+1977	+0.0005	"
2717.3586	+2505	+0.0010	Hall and Kreiner (1980)
3044.3992	+3025	-0.0019	Patkós (1980)
3381.5065	+3561	-0.0010	Ebersberger et al. (1978)
3725.5304	+4108	-0.0017	Mancuso et al. (1979)
3732.4486	+4119	-0.0017	"
244 4173.3267	+4820	-0.0034	Present paper

to the K star. Assuming a solar type activity in the former star flares and prominences would be adequate to eject a considerable amount of gas during an outburst. We estimate that the amount of mass transferred is of the order of 3×10^{-7} $M_\odot$/year. The high degree of activity may last two to three years and, if our interpretation of the 0-C diagram is correct, the "solar" cycle for the F star is about 8.5 years. A secondary effect, namely that of a stellar wind with a preferential direction toward the K star should also be considered. A spectroscopic study of the intensities of the H and K emission could be the way to attack the problem.

Conclusion

It is difficult to understand how a detached system can have all the characteristics of a semidetached system. As the geometry indicates the inner contact surface is only 0.2 of the radius from the surface of the F star. In our sun prominences can reach such a distance and, consequently, should be more frequent and more powerful in a hotter star. The spectroscopic evidence for the presence of the H and K emission requires a region of a low density gas in which it is produced. The presence of gas streams can explain the night-to-night fluctuation in brightness along the whole light curve. The already mentioned periodic oscillations of the depths of

https://doi.org/10.1017/S025292110009518X Published online by Cambridge University Press

the primary minima may indicate the gaseous streams to be in an orbital motion about the centre of the mass with a period of about 20 days.

We wish to express our thanks to Dr. Kreiner for making a list of epochs of minima available to us in advance of publication (Hall and Kreiner, 1980). One of us (G.A.B.) would like to thank the National Research Council of Canada for a partial financial support.

References

Cester, B., Fedel, B., Giuricin, G., Mardirossian, F. and Mezzetti, M.: 1978, Astron. Astrophys. Suppl. 32,351
Dean, C.A.: 1974, Publ. Astron. Soc. Pac. 86, 912
Ebersberger, J., Pohl, E., Kizilirmak, A.: 1978, I.A.U. Comm. 27, Info. Bull. Var. Stars N° 1449
Hall, D.S. and Kreiner, J.M.: 1980, Acta Astron. 30, No. 3
Mancuso, S., Milano, L., Russo, G. and Sollazzo, C.: 1979, Astron. Astrophys. Suppl. 38, 187
Patkós, L.: 1980, I.A.U. Comm. 27, Info. Bull. Var. Stars No. 1751
Williamon, R.M.: 1974, Publ. Astron. Soc. Pac. 86, 924