

WAVE MINIMUM OF AR LACERTAE

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Abstract. *U*, *B*, and *V* observations of AR Lacertae, obtained in 1981, have been presented alongwith the colour indices. A distortion wave minimum is found to lie at $0^{\circ}21$. The amplitude of the wave minimum in *V* filter is too weak, while it is stronger in *U* and *V* filters, the strongest being in *V* filter. The period of the migration wave turns out to be 2.53 yr.

1. Introduction

Hall *et al.* (1976) found a wave-like distortion – an important photometric feature which makes the RS CVn-type binaries unique – caused by the differential rotation of dark spots. In case of AR Lac (= BD + 45° 3813), it migrates towards the decreasing orbital phase at a rate which varies between 10 or 15 yr cycle⁻¹ and 50 or 60 yr cycle⁻¹. Recently, Kurutaç *et al.* (1981) found a wave migration period of 2.5 yr based on 1978 and 1979 photoelectric *B* and *V* observations. Besides photometric wave migration, the RS CVn binaries are the active systems, and are possessed with UV and IR excesses, which are relevant here.

Various investigations of AR Lac have been reported by me earlier (cf. Srivastava, 1981, 1983, 1984, 1985a, b, 1986; Goraya and Srivastava, 1984).

AR Lac has proved to be a puzzling object and its peculiarities are not fully understood because its light curve is changing its features year to year, hence, it has become necessary to continuously monitor this system. We feel even a small part of observations of AR Lac will be important in analysing this system.

2. Observations

There was a need to observe AR Lac from 2 to 4 October, 1981, and thus, we observed this system on 2 October, 1981 with the same instrument and other things as reported earlier (cf. Srivastava, 1981). The comparison star, BD + 44° 4044, has been used for deriving the differential magnitudes and colour indices. The standard differential *U*, *B*, and *V* magnitudes and colour indices have been listed in Tables I and II, respectively, and are plotted in Figure 1 (except one point around $0^{\circ}182$, which is too off), in which the solid lines represent free-hand smoothed curves. The error of the individual observations in *U*, *B*, and *V* filters are $\pm 0^{\prime\prime}.031$, $\pm 0^{\prime\prime}.009$ and $\pm 0^{\prime\prime}.024$, respectively.

TABLE I
Standard U , B , and V observations of AR Lacertae

J.D. (Hel.)	Phase	ΔU	J.D. (Hel.)	Phase	ΔB	J.D. (Hel.)	Phase	ΔV
2444880.1995	0.1647	0 ^m .659	2444880.1989	0.1644	0 ^m .152	2444880.1986	0.1643	0 ^m .778
.2144	0.1722	0.639	.2143	0.1720	0.158	.2138	0.1719	0.829
.2258	0.1780	0.571	.2252	0.1777	0.198	.2248	0.1775	0.831
.2349	0.1826	-0.196	.2339	0.1821	-0.013	.2330	0.1816	-0.096
.2470	0.1887	0.625	.2464	0.1884	0.133	.2459	0.1881	0.777
.2581	0.1943	0.799	.2574	0.1939	0.177	.2570	0.1937	0.807
.2697	0.2001	0.745	.2691	0.1998	0.160	.2686	0.1996	0.895
.2808	0.2057	0.817	.2805	0.2056	0.150	.2798	0.2052	0.964
.2913	0.2110	0.752	.2906	0.2107	0.168	.2901	0.2104	0.970
.3021	0.2165	0.738	.3016	0.2162	0.164	.3012	0.2160	0.959
.3129	0.2219	0.675	.3123	0.2216	0.147	.3116	0.2213	0.873
.3237	0.2274	0.757	.3232	0.2271	0.134	.3226	0.2268	0.861
.3335	0.2328	0.737	.3339	0.2325	0.153	.3334	0.2323	0.840
.3446	0.2379	0.700	.3441	0.2376	0.183	.3434	0.2373	0.757
.3546	0.2429	0.693	.3541	0.2427	0.160	.3535	0.2424	0.802
.3634	0.2474	0.586	.3630	0.2472	0.151	.3625	0.2469	0.774

TABLE II
Standard colour indices of AR Lacertae

Phase	$\Delta(U - B)$	$\Delta(B - V)$
0.164	0 ^m .507	-0 ^m .626
0.172	0.481	-0.671
0.178	0.373	-0.633
0.182	-0.183	0.083
0.188	0.492	-0.644
0.194	0.622	-0.630
0.200	0.585	-0.735
0.206	0.667	-0.814
0.211	0.584	-0.802
0.216	0.574	-0.795
0.222	0.528	-0.726
0.227	0.623	-0.727
0.233	0.584	-0.687
0.238	0.517	-0.574
0.243	0.533	-0.642
0.247	0.435	-0.622

3. Wave Minimum

A definite minimum is visible in Figure 1, which lies nearly at 0^p.21. This phase is well beyond the expected phases of the primary and the secondary minima, and the phases of the first and the fourth contacts of both eclipses. Thus it is nothing but a distortion wave minimum of AR Lac. The amplitudes of the migration wave in U , B , and V filters are 0^m.16, 0^m.03, and 0^m.20, respectively. It is evident from these amplitudes that the amplitude of the migration wave is very weak in B filter, although it exceeds 3σ level, while it is sufficiently strong in U and V filters, the strongest being in V filter. The wave is not strictly sinusoidal, but slightly asymmetric.

4. Comparison of Results

Ertan *et al.* (1982) also observed the eclipsing binary system AR Lac in B and V filters in 1981. He could not give the phase of the migration wave minimum, however, he suggested that there were two maxima of distortion wave at 0^p.7 and 0^p.25. If we consider that the wave is symmetrical to some extent, and maxima and minima are separated half period apart, then the wave minima, according to two maxima, should lie at 0^p.3 and 0^p.75. But in Ertan *et al.*'s (1982) observations, the wave minimum does not appear to lie near this phase 0^p.3 which is far removed from our wave minimum phase 0^p.21. If we consider Ertan *et al.*'s (1982) deeper wave minimum, then from visual inspection, the amplitudes of the wave minimum in B and V filters are found to be 0^m.11 and 0^m.07, respectively, based on 1981 observations. It is evident that these amplitudes are quite different from those of ours. This may be due to the fact that Ertan *et al.* (1982) may

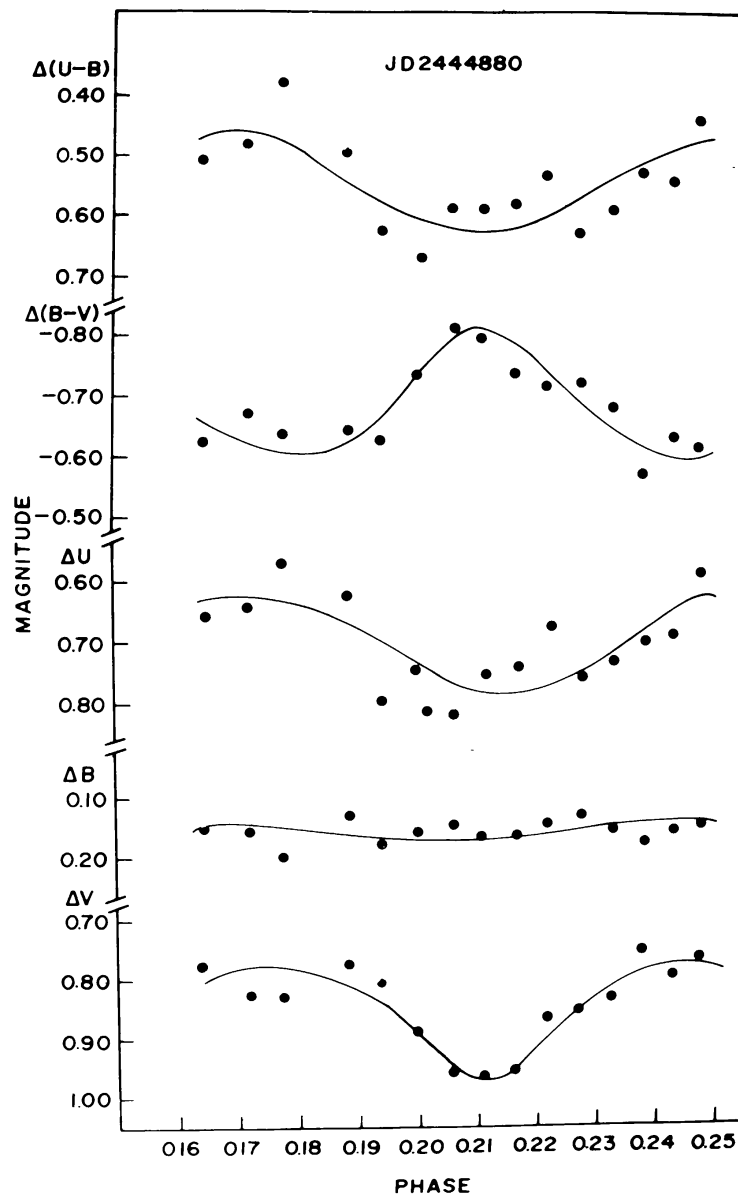


Fig. 1. Wave minimum of AR Lacertae.

not have observed the wave minimum fully, as their observations on two nights, J.D. 2444844 and J.D. 2444914 lie, respectively, 36 days before and 34 days after our observations. Thus our observations are important as these lie in between their observations, and act as supplementary observations for the better coverage of the wave minimum falling in the vicinity of $0^m.25$.

5. Colour Indices of the Wave

Figure 1 shows a minimum in the $U - B$ colour curve, while a maximum in the $B - V$ colour curve. Both are more than $0^m.2$ in the amplitudes. It is well known that the

RS CVn-type eclipsing binaries show both UV and IR excesses, and the present colour curves show more contribution in U and V light, thus, it may be possible that colour curves may tell something about the physical nature of the maximum spotted region.

6. Period of Wave Migration

As already stated, Hall *et al.* (1976) have given two different sets of period of the wave migration and Kurutaç *et al.* (1981) have presented entirely different period; thus it is important to investigate what is the present period of wave migration.

Kurutaç *et al.* (1981) found that the wave minimum lay at $0^{\circ}0$ in 1979. In the present observations, the wave minimum appears to lie at phase $0^{\circ}21$. Thus, it is apparent that the wave minimum has migrated $0^{\circ}79$ in two years. This result indicates that the period of the wave is nearly 2.53 yr. This conclusion of ours is in fair agreement with the period of the wave, 2.5 yr, given by Kurutaç *et al.* (1981) based on 1978 and 1979 observations.

7. Conclusions

Our results are important as they supplement the observations of AR Lac, given by Ertan *et al.* (1982), which lie both sides of our observations around the phase of the wave minimum. The effect of the minimum is very strong in U and V filters. The period of the wave migration is 2.53 yr.

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