COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS
Number 1800

Konkoly Observatory
Budapest
1980 June 9

# UBV - OBSERVATIONS OF THE ECLIPSING BINARIES Z Her, AR Lac, AW Peg AND RS Vul

During 36 nights in the summer of 1973 photoelectric observations were made of the eclipsing binary stars Z Her, AR Lac, AW Peg and RS Vul. These systems were selected for observation since, according to the catalogue of Koch et al. (1970), their light curves are rather incomplete.

The observations were made with a 40 cm telescope located near Stefanion, Greece ($\lambda=-1^h31^m$, $\varphi=+37^o45'08"$) at an altitude of 800 m. A shielded uncooled EMI 6256A photomultiplier was used in combination with the following filters: Schott UG 1, 2 mm (U); Corning 5030 + Schott GG 13, 2 mm (B); and Baltzers DT Grün (V). The red leak of the U filter is of no consequence since the photomultiplier has zero response in the red. Diaphragms of 44 and 96 seconds of arc were employed. The use of these rather large diaphragms did not cause difficulties as our program stars are rather bright ($V \leq 9$) and are not located in crowded fields.

Although there were a fair number of clear nights, we often encountered variations of the atmospheric extinction on timescales of the order of ten minutes. We have, therefore, observed the variable stars and the comparison stars in one of the following sequences: 1-v-v-1-v-v-1 and 1-v-2-v-1-v-2, where v denotes the variable star and 1 and 2 the comparison stars (see Table II for information about the comparison stars). The mean duration of these sequences is about ten minutes.

On the nights that absolute photometry was done on standard stars and comparison stars possible changes in the sensitivity of the photometer were monitored by means of a standard Čerenkov source.

The data were recorded on a strip-chart recorder with integration times for one star measurement ranging from 5 to 15 seconds.

Table I

Transformation and Extinction Coefficients

| | V | B-V | U-B |
|---|---|---|---|
| Transf. coeff.'s ($\varepsilon,\mu,\psi$) | -0.190(±0.007) | 1.077(±0.007) | 1.110(±0.021) |
| Principal ext.coefficient | 0.538(±0.006) | 0.107(±0.003) | 0.262(±0.005) |
| Second order ext.coefficient | 0.00 (±0.03) | -0.06 (±0.03) | 0.03 (±0.05) |

Table II

Data on Comparison Stars

| Star | | BD | N | V | B-V | U-B |
|---|---|---|---|---|---|---|
| Z Her | 1 | +14°3378 | 3 | 7.16(7.20)[a,b] | 0.53(0.53)[a,b] | -0.08 |
| | 2 | +15°3290 | 3 | 7.47 | 0.35 | 0.11 |
| AR Lac | 1 | +44°4043 | 3 | 5.04 | 1.54(1.57)[c] | 1.94(1.98)[c] |
| | 2 | +44°4073 | 3 | 5.45 | 0.04 | 0.00 |
| AW Peg | 1 | +23°4392 | 10 | 7.42 | 1.00 | 0.47 |
| | 3 | +23°4416 | 22 | 8.50 | 0.96 | 0.41 |
| RS Vul | 1 | +22°3644 | 4 | 7.86 | 0.12 | -0.26 |
| | 2 | +21°3719 | 2 | 6.83(6.89)[b] | 0.19(0.17)[b] | 0.14 |

a) Popper 1956

b) Popper 1957

c) Eggen 1966

Table III

Data on Variables

| Variable | BD | Period | Epoch | Eclips* | Remarks | N** |
|---|---|---|---|---|---|---|
| Z Her | +15°3311 | 3.993 | 2441870.447 (±0.001) | o | Emission lines RS CVn system | 8 |
| AR Lac | +45°3813 | 1.9832 | 2439376.4955 | O | Emission lines RS CVn system | 4 |
| AW Peg | +23°4415 | 10.662 | 2441903.690 (±0.015) | t | | 12 |
| RS Vul | +22°3647 | 4.478 | 2441884.482 (±0.001) | o | Probably mass-exchange | 12 |

* O = total occultation
o = partial occultation
t = partial transit

**N = number of observed nights

For the reduction of the observations we employed a method outlined in detail by Hardie (1962). The principal extinction coefficients and the coefficients for the transformation from the instrumental to the UBV system were determined from standard star observations during four nights of good photometric quality

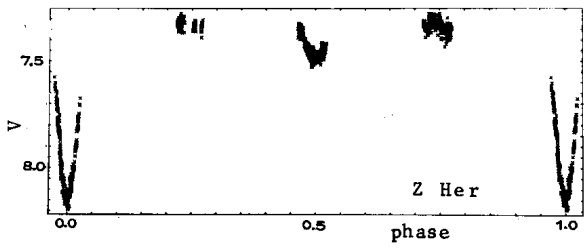
well distributed over the whole observing run. The standard stars were chosen from the list of Johnson and Harris (1954) and the cluster IC 4665 (Johnson 1954). Because the coefficients showed little variation during these nights, the mean values (see Table I) have been used in the reduction of all observations. For our differential observations the effect of the extinction variations on the magnitude and colour differences is less than 0.01 magnitude.

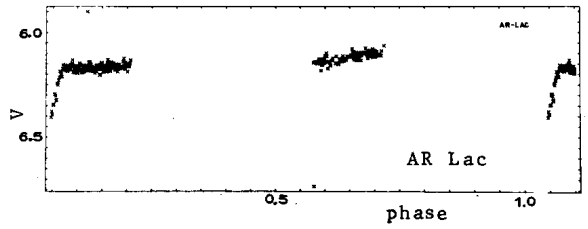
The magnitude and colour indices of the comparison stars were determined during two of the nights that standard stars were measured, from a direct fitting of these stars into the UBV system. The results are given in Table II. Data of these stars from the literature are given between parentheses.

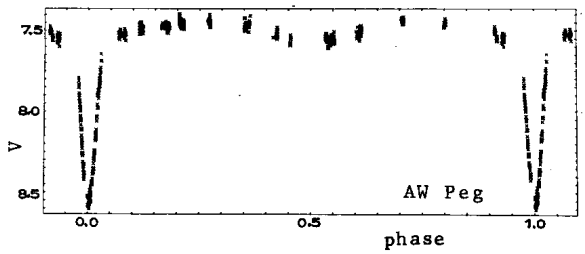
The standard deviation of the distribution of individual magnitudes and colour indices has been determined from the dispersion in the magnitude and colour index differences between the two comparison stars of AW Peg (which have been most frequently observed). We find $\sigma(V) = 0.03$ mag., $\sigma(B-V) = 0.03$ magn. and $\sigma(U-B) = 0.05$ magn. Apart from these standard deviations the magnitudes have a systematic uncertainty due to errors in the zero-points. These errors in V, B-V and U-B are 0.02 mag., 0.01 mag. and 0.01 mag., respectively.

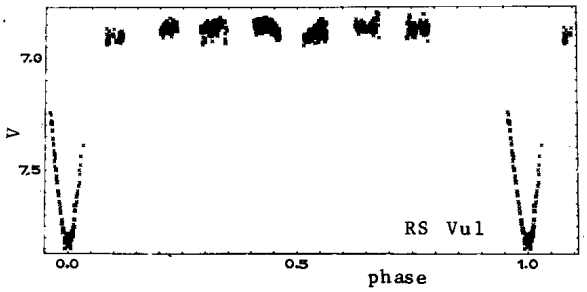
The data have been sent in tabular form to the depositary of photoelectric observations of variable stars at the Royal Astronomical Society, Library, Burlington House, London W1V ONL, Great Britain (file number 64).

The V magnitudes of the four variable stars are represented as a function of phase in Figures 1 through 4. Some basic data of the variable stars are listed in Table III. The epochs of primary minimum of Z Her and RS Vul have been determined from our observations using the method of Kwee and Van Woerden (1956). In this method the observations of one single primary minimum must be used. The epoch of AR Lac, for which no primary minimum was observed, has been taken from Chambliss (1976). The epoch of AW Peg, for which no complete primary minimum was observed on one night, has been determined by folding all available data with Fresa's (1966) period. The other data in Table III have been taken from the catalogue of Koch et al. (1970), except for the period of AR Lac which has been taken from Chambliss (1976).


7.5
V
8.0
Z Her
0.0
0.5
1.0
phase


6.0
V
6.5
AR-LAC
AR Lac
0.5
1.0
phase


7.5
8.0
V
8.5
AW Peg
0.0
0.5
1.0
phase


7.0
V
7.5
RS Vul
0.0
0.5
1.0
phase

The epochs of Z Her and RS Vul, determined from the present data, agree, within the quoted uncertainties, with the times calculated from the ephemeris given by Plavec et al. (1961) and Marmykov (1954). The epoch of AW Peg differs from the time calculated from Fresa's (1966) ephemeris by 0.08 days. This epoch-difference is however not significant because the uncertainty in the period determination of Fresa is 0.01 days.

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