SOME IMPORTANT RESULTS FROM TWO PHOTOMETRIC CAMPAIGNS ON SHORT TERM VARIABILITY IN Be STARS

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In 1983 and 1984 a programme of UBV observations was carried out to set up a network of standard stars, identify short term variables, and analyse the variability of the 86 bright ($V \gtrsim 6.5$) southern ($\delta < -20°$) Be stars.

The timing of the observations was designed specifically to reveal short term variability. Each group of Be and comparison stars was observed at least four times. Where possible, the first two sets of observations were made on one night and the next two sets on the next night (and sometimes a fifth set of observations was also made). Eleven Be stars were identified as possible short or intermediate term variables (Stagg, in preparation). These included the Be star 28 ω CMa, whose V and B-V (but not U-B) variations were consistent with the spectroscopic period of 1.37 days found by Baade (1982).

A statistical analysis was also carried out. A mean standard deviation, $\bar{\sigma}$, was obtained for each Be star. First, the differential magnitudes of each Be star relative to the comparison and check stars in its group were obtained. The standard deviations for all sets of these magnitudes were then averaged to give $\bar{\sigma}$. In a similar way, mean standard deviations were obtained for each comparison and check star with respect to the other comparison and check stars in its group.

For very few of the comparison and check stars was the mean standard deviation greater then 0.01 mag. But about half the Be stars had $\bar{\sigma}$ greater than 0.01 mag, indicating that <u>about half of all Be stars may exhibit short or intermediate term photometric variability at a low level.</u>

The average value of $\bar{\sigma}$ for spectral types B0 to B5 is significantly greater than the average value for spectral types B6 to B9 (at the 98% level for V and B and at the 99% level for U). This is an important result because B stars in which nonradial pulsation is known to occur (the β Cephei and 53 Per stars) are of early B spectral type, whilst stars in which rotational modulation of brightness occurs (the Bp stars) are of late B spectral type. Nonetheless, rotational modulation of brightness is also postulated to occur in stars such as the helium strong stars, which tend to be of earlier spectral type. The greater variability at earlier spectral type is therefore consistent with both rotational and pulsational models.

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In 1983 an international UBV 'minicampaign' was carried out to study the short term variability of five northern Be stars (Stagg et al., in preparation). Four of the Be stars (o And, KY And, LQ And, and EW Lac) are 'classical' Be stars, whilst one (KX And) is an interacting binary. The periods of these objects (from about half a day to a day) made it impossible to observe a complete cycle of variation from a single station.

Five stations (Hvar, McDonald, Kitt Peak, Toronto, and Peking) were involved during the first two weeks of October 1983, and more extensive measurements before and after this period were made from the McDonald and Hvar (Yugoslavia) Observatories. Periods were obtained or confirmed for all the minicampaign stars, and the observations were pooled to construct light and colour curves. The light curves of both o And and EW Lac were nonsinusoidal.

As part of his Ph.D. research, the author has carried out an analysis of these minicampaign observations.

With the possible exception of KX And, whose physical properties are quite uncertain, the periods of all the objects observed are too long to be explained by radial pulsation.

In 1984, Percy found that the V amplitude of o And was near zero. The decrease from 0.1 mag in 1983 is difficult to explain in terms of an ellipsoidal variable model, even if one assumes rapid precession. Cycle to cycle changes in the light curve of KY And are also an argument against the model. And LQ And would have to be a contact binary for the model to apply.

Two other models were considered, the magnetic oblique rotator model, and the nonradial pulsator model. Both models appear to be consistent with the observations of o And, KX And, KY And, and LQ And.

Of particular interest, however, were the observations of EW Lac. The earlier data could best be fitted with a period of 0.7228 days, and a light curve with two unequal minima per period. There appeared to be cycle to cycle variations in this light curve. There was then an abrupt change over a timescale of a day or less, with the primary minimum disappearing, and the secondary minimum deepening. The V amplitude increased from 0.04 to 0.2 mag.

The abrupt change in the light curve is difficult to explain in terms of the magnetic oblique rotator model, and probably impossible in terms of the ellipsoidal variable model. It is explainable in terms of the nonradial pulsator model, if one assumes that the pulsation is confined to the star's surface layers. One then requires special assumptions to explain the nonsinusoidal light curve.

Reference
Baade, D. (1982). Astr. Astrophys., 105, 65-75.

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DISCUSSION FOLLOWING STAGG

Baade:

Did, during the dramatic change you reported for the light curve of EW Lac, the star's color change, too?

Stagg:

The color and mean brightness did not change, just the form of the light curve.

Sareyan:

With such a star, it seems that *simultaneous* photometry and spectrography are even more necessary to understand what is going on in the star. Did you observe line profile variations?

Stagg:

I obtained simultaneous spectra, but they were not of high enough resolution to show line profile variations. No significant changes in radial velocity were detected.

Alvarez:

I would like to comment that our 13-Color photometry shows a clear separation between early type Be stars (09.5 - B5) and late type Be stars (B6 - B9 - A0) as you have found also from your program. We should start looking for physical parameters to classify stars.

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