THE RADIUS AND THE PULSATION CONSTANT OF THE PRIMARY OF SPICA*

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1. INTRODUCTION

In the late sixties, Spica (α Virginis, a 4.01454-day SB2 and interferometric binary, with a B1 IV primary component) was showing a light variation that consisted of two periodic terms. One term had the form of a double wave with the above-mentioned orbital period, the other was sinusoidal in shape and had a period equal to 0.1738 days. The double-wave term was clearly an ellipsoidal variation, caused by aspect changes of the tidally distorted primary, whereas the short-period term could only be explained as due to the primary's β Cephei-type pulsations. However, in 1972 these pulsations became undetectable.

2. OBSERVATIONS

We undertook photoelectric observations of Spica in order to study the star's ellipsoidal light variation. The observations were carried out on thirteen nights in February 1985 with the *uvby* spectrograph-photometer, attached to the Danish 50-cm reflecting telescope at ESO, La Silla. Not expecting any interference from the apparently extinct pulsations, we usually took just one or two observations per night. However, on each of the last two nights of the run we monitored the star for about four hours, so that we would not miss the short-period variation, had it re-appeared. We used three comparison stars, θ Vir, 73 Vir, and HR 5059.

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Unfortunately, 73 Vir showed δ Scuti-type light variations, and therefore was discarded (Sterken and Jerzykiewicz 1986). All observations were carefully corrected for the differential atmospheric extinction effects, but were not transformed to a standard system.

The main results of our observations are shown in Fig. 1. The magnitudes and colour indices in this figure are mean values of the data obtained on a given night. The observations taken four, eight or twelve days apart fall at nearly the same phases. This resulted, of course, from the fact that the orbital period is so close to four days. The $b-y$ and m_1 indices are not shown in the figure, because we found them constant (see Section 4).

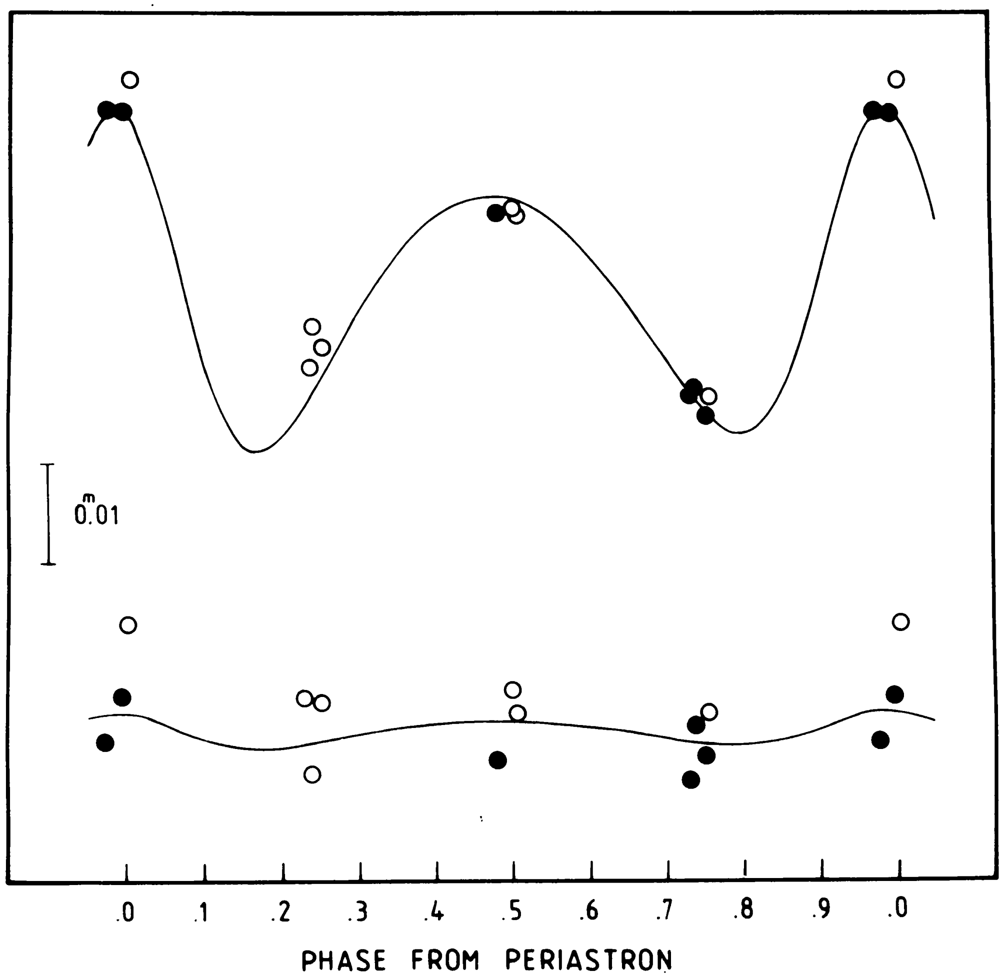

Figure 1. The nightly differential y magnitudes (top) and c_1 indices (bottom), Spica *minus* θ Vir, plotted as a function of the orbital phase. Open circles denote single observations or means of not more than three observations, whereas filled circles denote means of eight or more observations. The solid lines represent the computed ellipsoidal light and colour index variations, referred to in Section 3.

3. THE RADIUS OF THE PRIMARY COMPONENT

The tidal distortion of a binary component, and therefore its contribution to the ellipsoidal light variation, is a function of the orbital elements, the mass ratio of the components, and the mean radius. In the case of Spica, the orbital elements, including the inclination of the orbit, and the mass ratio are known from the spectrographic and interferometric observations (Shobbrook et al. 1972 and Herbison-Evans et al. 1971). In addition, the contribution of the secondary to the light variation is negligible. The mean radius of the primary can therefore be derived from a comparison of the observed and computed ellipsoidal light variations.

In the present case such a comparison leads to a value of 7.75 $R_\odot$, which yields the fit shown in Fig. 1 (top). This value is in very good agreement with the interferometrically determined radius of the primary (equal to 7.8 $\pm$ 0.6 $R_\odot$ according to Code et al. 1976). However, the mean error of our value we estimate to amount to $\pm$0.2 $R_\odot$, much less than the uncertainty given by Code et al. (1976).

In Fig. 1 (bottom) is shown a comparison of the observed and computed c_1 index variations. As can be seen from the figure, the range of the computed variation amounts to a few thousandths of a magnitude. Unfortunately, the observational scatter in c_1 has a much larger range. This excessive scatter probably has been caused by the atmospheric extinction problems in the u band, related to the fact that the comparison stars, both being A stars, have very differerent flux distributions than Spica.

4. THE SHORT-PERIOD VARIATIONS

The individual observations (used already to derive the mean values shown in Fig. 1) were carefully examined for the presence of short periods by means of a frequency analysis of the residuals from the computed ellipsoidal variations. The results of the analysis were negative: in the amplitude spectra spanning the frequency interval from 4 to 11 cycles/day there were no peaks higher than the noise level, which was generally below 0.002 mag for y and c_1, and below 0.0005 mag for $b-y$ and m_1. In other words, no coherent short-period variation with an amplitude exceeding 0.002 mag was present in our observations of the y magnitude or c_1 index of Spica. For $b-y$ and m_1 the maximum amplitudes did not exceed 0.0005 mag.

5. THE PULSATION CONSTANT

With its mass and radius known (the mass can be derived because the inclination of the orbit is known from the interferometric observations), the primary of Spica is among the few stars for which the pulsation constant

$$Q = P\langle\rho\rangle^{1/2},$$

where P is the pulsation period and $\langle\rho\rangle$ the mean density of the star in solar units, can be obtained directly, without recourse to photometric calibrations of the luminosity and effective temperature criteria. Using P = 0.1738 days, the mass equal to 10.9 ± 0.9 $M_{\odot}$ (Herbison-Evans et al. 1971), and the mean radius derived in Section 3, one gets Q = 0.0266 ± 0.0015 days. Note that the mean error of Q is only moderately sensitive to the mean error of the radius: if our estimate of the latter were doubled, that is, if it were increased to 0.4 $R_{\odot}$, the mean error of Q would become 0.0023 days.

Theoretical models of the primary of Spica, in addition to reproducing the period of 0.1738 days, must comply with the above-mentioned value of the pulsation constant. Unfortunately, the few recent attempts of this kind (Cox 1983, Cox et al. 1981) fail to meet this condition.

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