PHOTOMETRIC AND SPECTROGRAPHIC OBSERVATIONS OF SPICA

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Abstract

A multisite observing program of brightness and radial velocity is proposed to look for the possible recurrence of pulsation in Spica.

1. Introduction

Spica (α Vir, B1 IV) is a double-line spectroscopic binary with a 4.01454-day orbital period. Shobbrook *et al.* (1969) discovered light variations with a range of 0.03 magnitude which he interpreted as caused by a tidally distorted, ellipsoidal primary. In addition, a sinusoidal variation with a period of 0.1738 day and a light amplitude of 0.016 magnitude (in yellow light) was seen. They attributed this light variation to a Cepheid-type pulsation of the primary.

Four years after this discovery, the pulsations of Spica's primary became undetectable (Lomb 1978), and there is no firm evidence that the pulsations have reappeared (for discussion, see Sterken *et al.* 1986). So far, Spica is the only known "ex"-Cepheid star. Still, the decline of the short-period variations is not necessarily intrinsic, as was suggested by Balona (1985). He pointed out that in the case of nonradial pulsations inside a binary system, the amplitudes of the observed radial velocity and light variations may vary due to the precession of the rotational axis (assumed to be identical with the pulsation axis), which causes a change in the angle with the line of sight. In the case of Spica, the period of precession is on the order of 200 years, and this time scale offers the possibility of verifying Balona's hypothesis observationally: if it is correct, the amplitude of the pulsational variations should increase during the next decades. The verification of this hypothesis calls for a regular effort in monitoring Spica to see whether the pulsational variations revive. Meanwhile, a thorough investigation of the orbital radial-velocity variation and of the ellipsoidal light variation should be carried out. We propose such a coordinated project.

2. The Observations

2.1. Photoelectric Photometry

The extremely small amplitude of variation to be detected calls for very careful and precise photoelectric photometry. First in importance is a good photometric site. Because of its southern declination (-10°), Spica cannot be observed with high photometric precision from most sites in the northern hemisphere. A large telescope is not needed: because Spica is one of the brightest stars in the southern hemisphere (V=0.96), there exists hardly any professional telescope that can observe it without the use of a neutral density filter. Still, one needs a good-quality photometer and, since photon arrival-rate is no problem, one should use an intermediate bandpass filter, so that color effects do not interfere. Since the amplitude of light variations of Cepheid variables increases with decreasing wavelength, one should preferably use a blue filter, e.g. Strömgren *b*. Because of problems with atmospheric extinction, observing with an ultraviolet filter may yield lower photometric precision. A particular problem when observing Spica photometrically is the fact that for this bright star virtually no suitable comparison stars exist. The closest bright, constant stars which match Spica's color are i Vir and HR 5059, which are several degrees from Spica. This situation, especially when using slow, manually-pointed telescopes, leads to relatively large differential-airmass values and consequently to large extinction corrections. For these reasons, Spica is an outstanding case where spurious variations may be introduced during nights of variable sky transparency.

A very strong disadvantage of observing Spica from a single site comes from the fact that its orbital period (and the period of the associated ellipsoidal variation) is almost exactly equal to 4.0 days. In fact, a single observer would need more than a decade to cover a complete ellipsoidal light curve. This situation calls for a multisite approach with observations from South America, South Africa, Australia, and New Zealand.

Although successful photometry of Spica has been carried out from good sites in the southern hemisphere, we are of opinion that long-term monitoring of this star should be done using medium-sized automatic photometric telescopes. Such robotic telescopes offer the advantage of combining very fast observations (high time-resolution in order to increase precision, yielding at the same time high temporal density of data points) with minimum investment of manpower. The need for coordinated observations from several southern sites suggests the establishment of a dedicated network for such measurements.

2.2. Spectrographic Work

Spectroscopic monitoring of Spica is not undertaken frequently, since it is not easy to obtain large blocks of observing time for such a bright star. In addition, the multisite requirement makes coordinated observations extremely difficult.

We carried out a preliminary investigation using the 1-m telescope and Coudé spectrograph of the Yunnan Observatory (China). The detector was a CCD. With exposure times between 15 and 30 minutes we obtained a signal-to-noise (S/N) ratio of about 300:1 at a spectral resolution of 0.13 Angstroms. We obtained sequences of line profiles of the Si III triplet around 456 nm during four consecutive nights (distributed over one single orbital cycle) in April 1989. Displacement of the absorption-line profile and movement of an absorption "spike" from night to night was obvious. Smith (1985) observed a similar feature in the Si III lines of Spica. According to Smith, the traveling spike appears near the red edge of a line and moves to the blue edge and back to the red with a period of 8.03 hours. The period seems stable over several observing runs separated by over one year, and a cycle-to-cycle variation of the amplitude of the spikes has been seen. Our data, however, are not sufficiently extensive to confirm this, or to reveal other pulsational variations in this star.

3. Conclusions

A thorough effort to monitor Spica on a time scale of several decades is needed to find out whether the pulsational variability of this star is reviving, and to test Balona's hypothesis. Such observations should be carried out both photometrically and spectrographically from at least three suitable locations in the southern hemisphere. Photometric observations can best be made using robotic telescopes located at good photometric sites. Spectrographic work should be done with high-resolution spectrographs and telescopes of one-meter or larger aperture. The combination of both photometry and spectrography (simultaneous observations) is crucial for the determination of the pulsation mode in case the pulsational variability reappears.

References

Balona, L. A. 1985, *Mon. Not. Roy. Astron. Soc.*, **217**, 17P.
Lomb, N. R. 1978, *Mon. Not. Roy. Astron. Soc.*, **185**, 325.
Shobbrook, R. R., Lomb, N. R., and Herbison-Evans, D., 1969, *Mon. Not. Roy. Astron. Soc.*, **145**, 131.
Smith, M. A. 1985, *Astrophys. J.*, **297**, 224.
Sterken, C., Jerzykiewicz, M., Manfroid, J. 1986, *Astron. Astrophys.*, **169**, 166.