PECULIAR PHOTOMETRIC BEHAVIOUR OF THE β CEPHEI SUSPECT 53 PISCIUM

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ABSTRACT We show that in its photometric behaviour 53 Psc differs from ordinary β Cephei stars. Taking into account that it is also much cooler than the coolest stars of this type, we conclude that 53 Psc is probably not a β Cephei star.

INTRODUCTION

The variability of 53 Psc = AG Psc = HR 155 (B2.5 IV, V = $5^{m}.9$) was first reported by Williams (1954). From observations on one night he derived a yellow light amplitude of about $0^{m}.01$ and a period of $0^{d}.097$. Williams (1954) believed that 53 Psc represents a low temperature extension of the β Cephei instability strip.

Sareyan et al. (1979) confirmed the variation, but not the amplitude: on two nights in September 1971 they found the amplitude to be $0^{m}.005$ in *u* and less than $0^{m}.002$ in *b*. However, the star was shown by Percy (1971), Balona and Marang (1988), Le Contel et al. (1988), and Jerzykiewicz and Sterken (1990) to have been constant in 1967, 1973, 1979, 1982, 1986, 1987, and 1988. In most cases the observations were limited to a few closely spaced nights, but Balona and Marang (1988) monitored 53 Psc on 17 nights during an observing run in September 1986 spanning 27 days. They concluded that the star was constant to better than $0^{m}.004$ in blue light during this time.

THE LARGE AMPLITUDE

A strikingly different result was recently published by Wolf (1987): on one night in 1985 he recorded a V-light curve with a range of $0^{m}.035$ and a period of about $0^{d}.096$, the latter being almost the same as that found originally by Williams (1954). Taking into account earlier observations, this implies an amplitude variation from zero to at least half the above-mentioned value. As an explanation, Wolf (1987) suggested an interference of two oscillations of different periods, a phenomenon common among β Cephei stars.

DISCUSSION

Wolf's (1987) idea of an interference of two oscillations, although feasible in principle, becomes very unlikely if the negative results of Percy (1971), Balona and Marang (1988), Le Contel et al. (1988), and Jerzykiewicz and Sterken (1990) are taken into account. In order to prove this, we shall first estimate the minimum length of the beat-period from the duration of the longest interval over which the star was found nonvariable.

Interference of two oscillations, represented in the following by two sinusoids of the same amplitude, A, and periods equal to P_1 and P_2, leads to amplitude modulation of the form:

$$A_{beat} = A\sqrt{2[1 + \cos(2\pi t/P_{beat})]}\,, \qquad (2)$$

where $P_{beat} = 1/(1/P_1 - 1/P_2)$ is the beat-period. From this equation it follows that the time required for the amplitude to reach a certain value A_{obs}, counted from the epoch of $A_{beat} = 0$, is equal to

$$\Delta t_{min} \approx \frac{P_{beat}A_{obs}}{2\pi A}\,. \qquad (3)$$

Assuming $A = 0^m.010$, that is, about half the amplitude (one-fourth the range) found by Wolf (1987), and taking into account Balona and Marang's (1988) results, that is, $A_{obs} = 0^m.004$ (twice their upper limit of the observed amplitude to compensate for the amplitude increase from $A_{beat} = 0$) and $\Delta t_{min} = 13^d.5$, we get $P_{beat} > 210^d$.

From equation (1) it also follows that the interval over which the amplitude in the beat cycle stays within Δm of its maximum value amounts to

$$2\Delta t_{max} \approx \frac{2P_{beat}}{\pi}\sqrt{\Delta m/A}\,. \qquad (4)$$

CONCLUSIONS

Two conclusions can be drawn from the last equation. First, in each beat cycle the amplitude of the light variation will stay within 0.1 of its maximum value for about $P_{beat}/3.5$. Second, the probability of observing the amplitude within 0.1 of its maximum value is about 3.5 times the probability of finding that it does not exceed 0.1 of the maximum value. These conclusions, together with $P_{beat} > 210^d$, derived above, make it indeed difficult to understand why 53 Psc showed its (presumably) maximum amplitude only in 1985, while remaining apparently constant, or very nearly so, in 1967, 1973, 1979, 1982, 1986, 1987, and 1988.

Thus, in order to account for the available observations of 53 Psc in terms of amplitude modulation, one may have to postulate that the amplitude stays below the detection threshold most of the modulation cycle. Another possibility is that the star shows transient short-period variations, an alternative suggested by Balona and Marang (1988).

53 Psc is much cooler than the coolest β Cephei stars (see, e.g., Sterken and Jerzykiewicz 1990). Counting it among the members of the group would therefore imply that the β Cephei type pulsations can occur at much lower effective temperature thanis now thought to be the case. On the other hand, the star's peculiar photometric behaviour indicates that it may not be a β Cephei star. We believe that the latter conclusion should be preferred.

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