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Semiregular variable RX Bootis: Double-period optical variation of a cosmical maser?

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Periodogram analysis of 349 photovisual observations showed the peaks corresponding to periods 352 ± 5^d, 179.1 ± 0.3^d and 162.4 ± 0.8^d. The first value is very close to 1 year, so it might not be justified by the present observations. The other two values obtained by 'two-parameter' search seem to be independent periods, but not the effect of 'observational windows'. No other significant peaks were detected in the interval from 65^d to 100^d.

Die Periodogrammanalyse von 349 photovisuellen Beobachtungen zeigte Maxima bei den Perioden 352 ± 5^d, 179.1 ± 0.3^d und 162.4 ± 0.8^d. Der erste Wert entspricht fast einem Jahr, so konnte er auf Grund der zeitlichen Beschränkung der vorliegenden Beobachtungen nicht verifiziert werden. Die beiden anderen Werte, durch eine „Zwei-Parameter"-Analyse gefunden, scheinen unabhängige Perioden zu sein und kein „Beobachtungsfenster"-Effekt. In dem Zeitraum von 65^d bis 100^d konnten keine weiteren signifikanten Maxima nachgewiesen werden.

Key words: intrinsic variables — RX Bootis — maser

AAA subject category: 122

The star RX Bootis is a source of H_2O maser emission (Schwartz et al. 1974), and what is more surprising, no other maser emission (eg. OH) similarly to other objects was detected (Berulis et al. 1983, Rudnitskij 1983). Vardanjan (1967, 1978) discovered the polarisation of the optical emission, decreasing with the increasing wavelength (2 per cent at $\lambda = 0.45$ µm and 0 per cent at 0.63 µm). He also detected the brightness change of 0.8^m during 51^d. However, the photometric behaviour of the star was studied very poorly, so the mean cycle length is believed to be in a wide interval from 78^d (Keping et al. 1984) to 340^d (very uncertain) in General Catalogue of Variable Stars (Kholopov et al. 1985).

The star was investigated on 349 photovisual plates taken in JD 2431396—2445826 on the seven-camera astrograph of Astronomical Observatory of Odessa State University. The finding chart is shown at Fig. 1. The observations were fitted by the sinus-like curve:

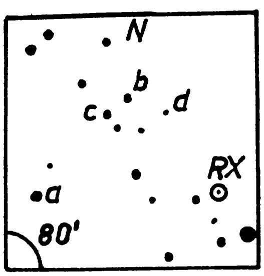

Fig. 1. Comparison stars for RX Bootis. The values of photovisual brightness are: $a = 6.77$, $b = 7.37$, $c = 8.14$, $d = 8.97$.

$$m_0 + R \cos 2\pi(wt_i + \varphi) = m_i\,, \tag{1}$$

where m_i, $i = 1 \ldots N$, is the brightness of the star at the moment of time t_i, $w = 1/P$ is the frequency, P the trial period and m_0, R and φ are the coefficients determined by the method of least squares. As the test function, the correlation coefficient r between the observed and calculated values according to eq. (1) was used.

The corresponding periodogram is shown in Fig. 2. Three prominent peaks correspond to the periods 352, 179 and 164 days. The first value corresponds to the period published in GCVS (Kholopov et al. 1985), but it is very close to 1 year, so the corresponding phase interval is covered by the present observations not completely. Thus the reality of the existence of this periodicity remains very questionable, and possibly it is an effect of "observational window". The part of the periodogram near the two other peaks is shown in Fig. 3.

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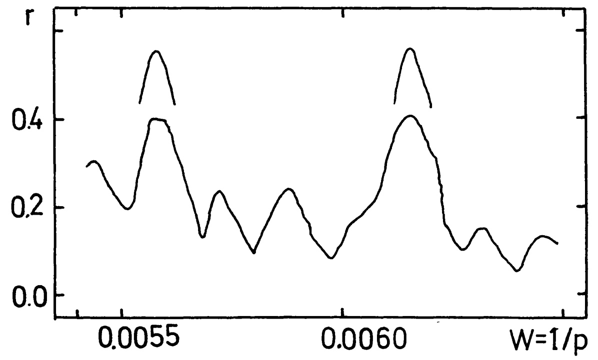

Fig. 2. The periodogram corresponding to 'one-frequency' model (Eq. (1)). The periods corresponding to the most prominent peaks are written.

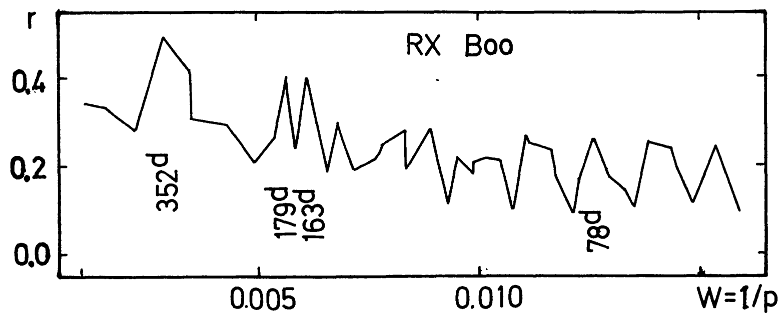

Fig. 3. The part of the periodogram near the two neighbour peaks for 'one-frequency' (solid line) and 'two-frequency' (dashed line) models. For the 'two-frequency' model, the 'best fit' value of w_3 is used. Right peak corresponds to the left one, but shifted at this value w_3.

Assuming two-frequency model, one may write

$$m_0 + R_1 \cos 2\pi(w_1 t_i + \varphi_1) + R_2 \cos 2\pi(w_2 t_i + \varphi_2) = m_i\,. \tag{2}$$

As two independent parameters which must be determined, we preferred w_1 and $w_3 = w_2 - w_1$. The "best fit" values are the following: $P_1 = 179.13 \pm 0.35^d$, $P_2 = 162.42 \pm 0.77^d$, $P_3 = 1741 \pm 82^d$ (beat period). The corresponding parts of the periodogram obtained by using the "best fit" value of w_3 are also shown in Fig. 3.

The amplitudes of both harmonic contributions are equal within 1 per cent: $R_1 = R_2 = 0.12^m \pm 0.014^m$, the initial phases corresponding to the arbitrary epoch JD 2400000 are 0.78 ± 0.02 and 0.08 ± 0.02 for periods 179^d and 162^d, respectively.

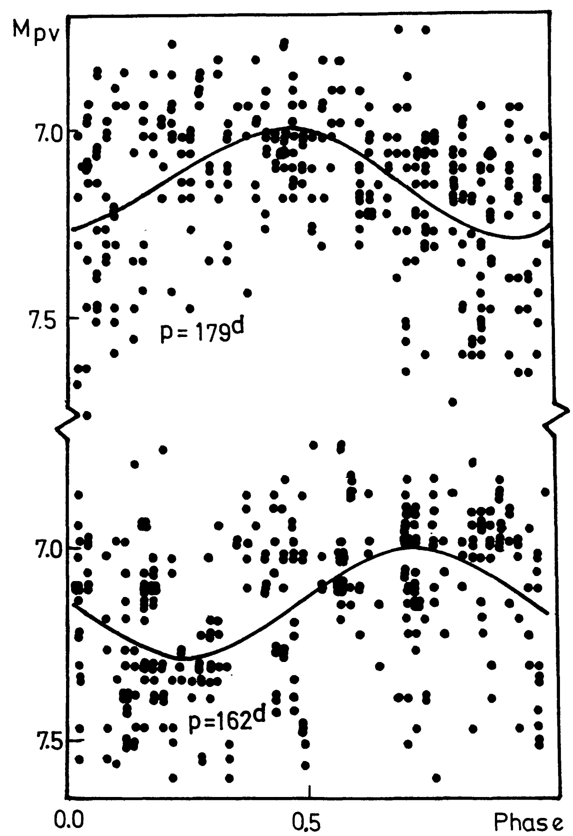

Fig. 4. The phase curves corresponding to both periods. The line is the 'best-fit' sinus-like curve, and the points are the observations with the 'correction' made by removing the harmonic contribution of the other period.

According to BRONSTEIN and SEMENDJAJEW (1979) the value r/σ_r has the Student t-distribution with $m = (N - L)$ degrees of freedom, where N is the number of observations, L — the number of "free parameters" being determined, and the error of correlation coefficient

$$\sigma_r = ((1 - r^2)/(N - L))^{1/2} . \tag{3}$$

In our case, $r = 0.558$, $\sigma_r = 0.0447$, $L = 5$, so $r/\sigma_r = 12.5$. For comparison, the value of Student's coefficient $t_{\alpha,m} = 3.3$ for the significance level $\alpha = 0.001$. Thus the "two-frequency model" is statistically significant despite the large scatter (0.18 mag) at corresponding light curves (Fig. 4). This scatter might be explained by the observational errors and (possibly) changes of period(s). The possibility of the presence of some other cyclic variations cannot be ruled out, so the intensive study of this very interesting objects is needed.

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