FG SGE: THE R CORONAE BOREALIS – TYPE ACTIVITY AND PULSATIONS

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ABSTRACT. Using the known connection between pulsations and the deep light decline in stars of the R Coronae Borealis – type variability, the pulsation period of FG Sge is determined, which is now equal to 103 days.

Key words: Stars: variable; stars: individual: FG Sge.

Two types of variability are observed in stars with the R Coronae Borealis (RCB) type variability: deep light declines by several magnitudes with a duration up to hundreds of days and pulsations with periods of 30–50 and more days and an amplitude up to 0.4^m. In RY Sgr, the most stable pulsating star with such variability, the declines are found to be triggered by a pulsation after its light maximum (Pugach 1977). The most deeper part of a light minimum falls at a pulsation minimum, i.e., the RCB minimum resembles a giant pulsation (Feast 1996). Similar properties were found to a different extent in other stars with the variability of this type: V854 Cen (Lawson et al. 1992) and FG Sge (Arkhipova 1996). In FG Sge Gonzalez et al. (1998) found a deviation from the ephemeris of Arkhipova (1996) and ascribed this to a possible change of pulsation period of the star.

The 6th RCB minimum of FG Sge which started recently manifested both these properties, and this allows us the possibility to follow the change of the pulsation period of this unique star. In addition this minimum also displays quasi-periodicity in the succession of the RCB minima.

The present research is based on visual estimations from the VSOLJ and the AFOEV databases and from the VSNET.

The definition of a light minimum and light maximum is important for our study. We propose and use such ones. A maximum is a state with the brightness close to the maximal one documented for the full history of observations of a star. It is typical for the maximum when a star is weakenned up to 0.5^m but without a stable trend to the increasing of brightness. A minimum is a state of weakenning star between two succesive maxima with a typical shape of light curve and a duration more than one pulsation period. The typical light curve is with a sharp light decline and a slower recovering to normal brightness.

For FG Sge this means that the state of brightness during JD 2449870-...2450100 was the giant pulsation according the definition of Feast (1996) and Menzies and Feast (1997). A relatively short-term duration of maximum state becomes typical in the behavior of FG Sge. It is so short that the star shows no more than 1–3 pulsations. The pulsation period P, according to Arkhipova (1996), is nearly 114 days, and it decreases.

From the full light curve since 1992 it is obvious that the typical RCB minima follow at 530–780–day intervals (Table 1). For a more unambiguous determination of the initial moment of the RCB minimum we took into consideration that observed light curves in a minimum are described sufficiently well by the simple analytic expression as the sum of several shallower declines (Rosenbush 1996)

$$m(t) = m_{max} + \sum_{i=1}^{n} \Delta m_i \cdot (\tau_i + 1)^{2.7} \cdot \exp(-2.7\tau_i), \quad (1)$$

where $m(t)$ is the star brightness at the current time t, m_{max} is the star brightness in the quiet state, Σ is the sum over i from 1 to n "elementary" minima shaping the observed light curve, Δm_i is the depth of the i-th light decline, $\tau_i = (t - T_i')/T_{oi}$ is a time parameter, T_i' is the moment of minimal brightness in the i-th decline, T_{oi} is the duration of light drop in the i-th decline. Therefore the beginning of light decline was obtained by us with an accuracy of ten days and correspondingly the accuracy of determination of pulsation period was higher then two days. Here we assumed that a light

Table 1: Parameters of the RCB minima of FG Sge

Minimum number	Moment of minimum beginning, JD–2400000	Time interval between minima, day	Number of pulsations	Pulsation period, day
1	48860			
2	49430	570	5	114
3	50110	680	6	113
4	50890	780	7	111
5	51420	530	5	106
6	52030	610	6	102

Table 2: Parameters of the RCB minima of FG Sge.

Minimum number	Moment of minimum beginning, JD–2400000	Time interval between minima, day	Number of pulsations	Pulsation period, day
1	48860			
2	49430	570	5	114
3	50110	680	6	113
4	50890	780	7	111
5	51420	530	5	106
6	52030	610	6	102

minimum always begins since the same pulsation phase (at least within $0.1P$), and we oriented on the known pulsation period P=114 days.

As a result we derive the equation for the FG Sge pulsation period in 1992-2001:

$$P = 113.95 + 0.000361 \cdot (JD - 2448800) - 1.5285 \cdot 10^{-6} \cdot (JD - 2448800)^2. \quad (2)$$

A comparison with Arkhipova's ephemeris shows a distinction. According to our ephemeris, the pulsation period decreases faster and now the distinction reaches ten days. We cannot answer, at which pulsation phase a RCB minimum begins, as the pulsation period is very unstable and the star has two pulsation periods (see below). Thus we confirm the well–known property (Pugach 1977) that the RCB minimum begins after the light maximum in a pulsation.

As a result we can say that the RCB minima in FG Sge follow after 5-7 pulsations and, correspondingly, we can expect the 7th minimum.

The light curve of FG Sge has only two intervals of maximal light with the duration more than $2P$. In the last of these intervals, before the 6th RCB minimum, the pulastion, which was more or less well observed, had the period P_1, which is nearly $1.4P$. Two periods with the similar ratio were noted by Arkhipova (1996), but she suggested that the second period was false. As it seems to us in this connection, it should be noted that the time intervals between the 3th and 4th, and the 5th and the 6th RCB minima are multiples of P_1, and P_1=155 days. But the data are deficient for certain conclusions. It is necessary to expect the following RCB minima. It is not improbable that the RCB type variability is operated by the interplay of pulsations with these two periods.

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