NEW PERIOD AND PERIOD VARIATIONS OF DX AQUARII

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Abstract. The new period ($P = 0^{d}.461700$) of the eclipsing binary system DX Aqr has been presented, which is based on available times of minima. O–C diagram of DX Aqr has been presented for the first time, and the period variations present in the system have been analysed. In all five period increases and five period decreases are nothed, and four period increases and five period decreases have been discussed. The strongest period increase occurs between 1975 and 1976. The total period change in different portions of the O – C diagram ranges from 1.40×10^{-4} d to 3.61×10^{-6} d. Appreciable period fluctuations have been noted to have occurred in the time intervals, 1964–1965 and 1974–1975.

1. Introduction

The eclipsing binary DX Aquarii (BD – 17°6422) was discovered to be a variable by Strohmeier *et al.* (1965) and Strohmeier (1966). Popper (1966), Cowley *et al.* (1969), and Paffhausen and Seggewiss (1976) gave the spectral types of the system. Due to the presence of contamination of the light from the visual companion, the system DX Aqr remained neglected photometrically. Olsen (1976) tried to attempt its photometry but failed to complete it. The author was the first to obtain its *UBV* light curves and to publish results (cf. Srivastava and Sinha, 1985). The second set of *UBV* observations have also been secured and published by the author (cf. Srivastava, 1985).

2. Epoch and Period

The epoch and/or the period of DX Aqr have been given by various authors (cf. Strohmeier *et al.*, 1965; Strohmeier, 1966; Locher, 1974a, b, c, 1975; Olsen, 1976; Paffhausen and Seggewiss, 1976; Srivastava and Sinha, 1985; Srivastava, 1985). Some epochs along with the periods have been listed in Table I. Locher (1974a, b, c, 1975) gave the epochs of minima but not the periods of the system. Recently, Srivastava and Sinha (1985) and Srivastava (1985) presented photoelectric epochs and periods of DX Aqr.

3. New Period

It is evident from Table I that there has been a controversy about the period of DX Aqr. Strohmeier (1966), Olsen (1976), and Paffhausen and Seggewiss (1976) gave similar periods of nearly $0^{d}.945$. Srivastava and Sinha (1985) from their first photoelectric observations announced that the period of the system DX Aqr was nearly half the periods given by Strohmeier (1966), Olsen (1976), and Paffhausen and Seggewiss (1976). This fact was further confirmed by Srivastava (1985) from his second set of *UBV* observations. The first period of DX Aqr given by Strohmeier *et al.* (1965) was

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TABLE I

Epochs and periods of DX Aqr

No.	Author	Epoch and period
1	Strohmeier *et al.* (1965)	J.D. 2438618.250 + $18^{\mathrm{d}}.25$
2	Strohmeier (1966)	J.D. 2436814.440 + 0.945006
3	Olsen (1976)	J.D. 2442687.697 + 0.9450132
4	Paffhausen and Seggewiss (1976)	J.D. 2436814.4184 + 0.94501435
5	Srivastava and Sinha (1985)	J.D. 2436814.440 + 0.472502
6	Srivastava (1985)	J.D. 2436814.440 + 0.4605944
7	Srivastava (present work)	J.D. 2436814.440 + 0.4617

completely different either from Strohmeier (1966), Olsen (1976), and Paffhausen and Seggewiss (1976) or from Srivastava and Sinha (1985) and Srivastava (1985).

This controversy (or uncertainty) about the period of DX Aqr necessiated us to search for a new period of DX Aqr. The author collected 27 minima of DX Aqr, which are available in the literature. Out of these eight minima are photoelectric, of which seven belongs to the author and one to Olsen (1976), four are visual and the remaining minima are photographic. In deriving the new period of the system DX Aqr, 24 minima have been used, leaving the first three as they are centered at zero cycles, hence they are not useful for deriving the period of the system. In the beginning, the O–C values of different minima and corresponding periods have been derived using the ephemeris: namely,

$$\text{Primary Minimum} = \text{J.D. } 2436814.418 + 0^{\mathrm{d}}.4605944E.$$

(Strohmeier, 1966) (Srivastava, 1985)

Several periods of the system DX Aqr have been tried to fit these minima using the method of least squares as mentioned in author's earlier papers (Srivastava and Sinha, 1985; Srivastava, 1985). A new period of $0^{\mathrm{d}}.4617$ ($\pm$ $0^{\mathrm{d}}.0001$) has been arrived at after trials, which satisfies these minima fairly well.

4. O–C Diagram and Period Variations

All available primary and secondary minima of DX Aqr have been collected, which have been observed between 1959 and 1981, and an O–C diagram has been constructed from the O–C values calculated from

$$\text{Primary Minimum} = \text{J.D. } 2436814.418 + 0^{\mathrm{d}}.461700E.$$

(Strohmeier, 1966) (present work)

The times of minima along with the O–C values and the cycles have been listed in Table II. The O–C values versus cycles have been plotted in Figure 1. An inspection of the O–C diagram reveals that the time interval (1959 to 1981) gets split up into ten portions between points *A* to *K*. The solid lines in the Figure 1 represent the smoothed lines drawn through the points, while the dashed lines are the lines which join the individual minima (or O–C values).

TABLE II

Minima of DX Aqr

Minima (J.D.$_{\odot}$)	Type of minima	Cycle	O–C (days)	Reference
2436814.418	I	0	0.000	Strohmeier (1966)
.4184	I	0	+0.0004	Paffhausen and Seggewiss (1976)
.440	I	0	+0.022	Strohmeier (1966)
50.330	I	78	−0.101	Strohmeier (1966)
68.306	I	117	−0.131	Strohmeier (1966)
7174.435	I	780	−0.109	Strohmeier (1966)
203.355	II	842.5	−0.044	Strohmeier (1966)
8618.250	I	3907	−0.030	Strohmeier *et al.* (1965)
.444	I	3907	+0.164	Strohmeier (1966)
36.400	I	3946	+0.114	Strohmeier (1966)
72.286	I	4024	−0.013	Strohmeier (1966)
91.244	I	4065	+0.015	Strohmeier (1966)
92.250	I	4067	+0.098	Strohmeier (1966)
9023.337	II	4784.5	−0.084	Strohmeier (1966)
51.246	I	4845	−0.109	Strohmeier (1966)
42242.595	I	11757	−0.030	Locher (1974a)
351.268	I	11992	+0.144	Locher (1974b)
385.251	I	12066	−0.039	Locher (1974c)
621.527	I	12578	−0.154	Locher (1975)
87.697	I	12721	−0.007	Olsen (1976)
3073.149	I	13556	−0.074	Srivastava and Sinha (1985)
4139.159	I	15865	−0.130	Srivastava and Sinha (1985)
77.217	II	15947.5	−0.161	Srivastava and Sinha (1985)
531.159	II	16713.5	+0.119	Srivastava and Sinha (1985)
899.236	I	17511	−0.011	Srivastava (1985)
936.119	I	17591	−0.064	Srivastava (1985)
44.130	II	17608.5	−0.132	Srivastava (1985)

I = Primary minimum.
II = Secondary minimum.

TABLE III

Changes in period of DX Aqr

Portion	Interval of cycles		Total change in period (days)	Period trend
AB	$E = 0$	to $E = 0$	–	–
BC	$E = 0$	to $E = 117$	7.25×10^{-5}	D
CD	$E = 117$	to $E = 3907$	7.79×10^{-6}	I
DE	$E = 3907$	to $E = 4845$	2.94×10^{-5}	D
EF	$E = 4845$	to $E = 11992$	3.61×10^{-6}	I
FG	$E = 11992$	to $E = 12578$	4.40×10^{-5}	D
GH	$E = 12578$	to $E = 12721$	1.40×10^{-4}	I
HI	$E = 12721$	to $E = 15947.5$	4.67×10^{-6}	D
IJ	$E = 15947.5$	to $E = 16713.5$	3.63×10^{-5}	I
JK	$E = 16713.5$	to $E = 17608.5$	2.50×10^{-5}	D

I = increase, D = decrease.

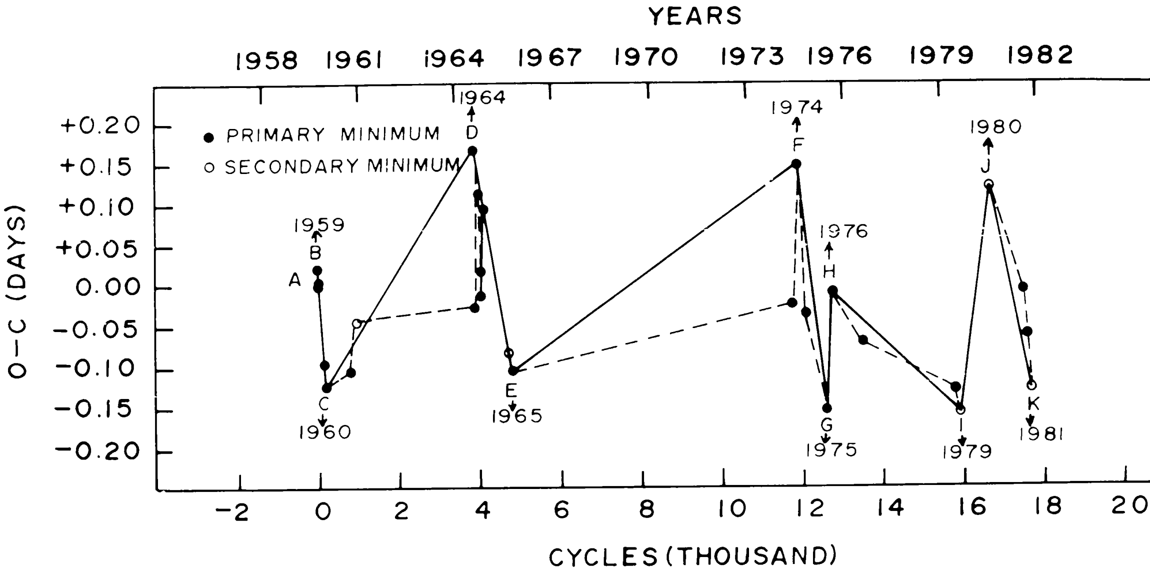

Fig. 1. O–C diagram of DX Aqr. Arrows represent the increasing and the decreasing trends of the period. Solid lines represent the period trends, while the dashed lines indicate period fluctuations.

Since some of the portions, such as *CD*, *EF*, *GH*, and *IJ*, are scantily covered, and thus our discussion of the period variation of DX Aqr is based on the assumption that the period of the system varies linearly between *C* and *D*, *E* and *F*, *G* and *H*, and *I* and *J*. While smoothing the solid lines some period fluctuations, coming in the way, have been ignored as they occur in a very short interval of time and are not explainable. Overall period trend (shown by solid lines) in different portions of the O–C diagram has been discussed. Appreciable period changes are noticed around the years 1959, 1960, 1964, 1965, 1974, 1975, 1976, 1979, 1980. The extent of the period decrease and increase has been estimated in different portions of the O–C diagram. The total change in the period in different portions of the O–C diagram are listed in Table III.

5. Discussion

It has been already described that the O–C diagram of DX Aqr gets split-up into ten portions. Three minima in the portion *AB* lie at zero cycle and, hence, this portion is not useful for period determination and discussion.

Some portions (*CD*, *EF*, *GH*, and *IJ*) of the O–C diagram are scantily covered. However, the portion *CD* does carry some points and, as such it is considerable. The portion *EF* is, of course, not properly covered and is open to question. The portions *GH* and *IJ* are based on the photoelectric observations and, hence, they can not be ignored in the discussion.

Some period fluctuations are seen around the years 1964, 1974, and 1981. Around 1964 and 1974, the minima have been determined from the photographic and the visual observations, respectively, hence, it may be possible that either some times of minima are not accurately determined or, alternatively, their type may require revision on the basis of half the period of the system. Since the period trend, as apparent from the visual inspection of Figure 1, is not going to alter, hence, we are safe in discussing the period variation in portions *CD* and *EF* also. The portion *JK* also shows some period fluctuations, but these fluctuations are not considerable; hence, these do not alter the decreasing trend of the period.

The strongest period change (increase) of 1.40×10^{-4} d appears to have occurred between 1975 and 1976. The slowest period change (increase) of 3.61×10^{-6} d appears to have occurred between 1965 and 1974, which is open to question as this interval of time is the longest and lacks observed minima. However, both solid and dashed lines show that the portion *CD* is also comparatively longer and is scantily covered. Hence, the period changes derived in the portions *CD* and *EF* can be regarded as tentative. The portions *GH* and *IJ* also lack minima observations but their time-interval is comparatively too short. Moreover, the period changes in these portions are based on the photoelectric minima. Thus, their period changes may be regarded as accountable. One important feature is evident from the O–C diagram: i.e., that, before 1975, the decreases of the period have steeper slopes than those of the increases, while after 1975, the period increases have steeper slopes than those of the decreases.

Srivastava and Sinha (1985) and Srivastava (1985) have shown that the light curve of DX Aqr is complicated. Srivastava (1985) has also shown that the features of DX Aqr are changing. From the present knowledge, it is difficult to say what phenomenon is responsible for these period variations. Normally, the mass transfer between the components of an eclipsing binary system is considered responsible for such strong period changes as are shown in Table III. But this fact is yet to be confirmed from future (light contamination-free) photometric and spectroscopic observations.

6. Conclusions

The period variation study of DX Aqr has been presented for the first time. The O–C diagram (Figure 1) does indicate the increasing and the decreasing trends of the period of DX Aqr. These period variations show no regularity either in the O–C amplitudes or in the cycle-intervals. However, the O–C diagram suggests that, before 1975, the decreases have steeper slopes than those of increases, while after 1975, the increases have steeper slopes than those of the decreases. During analysis, and also seeing short term fluctuations in the O–C diagram, it appeared that a few minima may require redefining of their types. However, we have left this point for future observers because some more photoelectric minima are desirable to determine an improved period of DX Aqr.

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