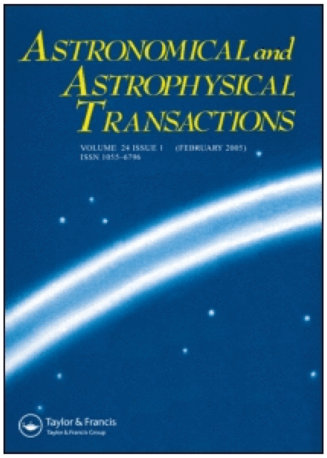

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ON THE SEARCH FOR THE ORBITAL PERIOD IN X PERSEI X-RAY/Be SYSTEM

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The polarimetric observations of *X* Per (Kemp and Barbour, 1983) are reanalysed. Neither the 290/580-day periodicity proposed by these authors, nor the 1-day period (Clarke and McGale, 1988) can be confirmed using these data. Only a 800-day characteristic timescale of variability was present in the period from 1977–1982; the variations were correlated with the changes in optical brightness. It is not clear whether these variations are connected with the orbital rotation or with the mass outflow from the primary.

KEY WORDS X-ray sources, orbital periods, polarimetry

1. INTRODUCTION

The bright Be-star *X* Per was identified as the optical counterpart of the *X*-ray pulsar 4U 0352 + 30 by Braes and Miley (1972), and van den Bergh (1972). All the data obtained since then do not contradict the model of a binary system with a O9e-B0e main star and a distant neutron star as a secondary. However, the problem of the rotation period seems to be far from being solved. Hutchings and coworkers (1974, 1977) have proposed an orbital period of 580 days based on radial velocity measurements. Kemp and Barbour (1983) (KB) confirmed this period using the analysis of their polarimetric data. Clarke and McGale (1988) (CMG) reanalysed the same set of data and obtained a strikingly different value of the period: 23.92 hr, which was interpreted as the axial rotation period of the single star with an active region which produces the polarization variations observed. Penrod and Vogt (1985) reexamined the nature of radial velocity variations in X Per Balmer lines and claimed that most of these variations are spurious and are caused by asymmetric and variable emission components which hide in the absorbtion profiles. This explanation, if correct, undermines the massive-black-hole model which seems almost inevitable if a 580-day periodicity is accepted, in favour of a "normal" neutron star model.

Trying to keep up the tradition of reanalysing already existing data, we return once more to Kemp and Barbour's polarimetry.

2. A VIEW AND ANALYSIS OF THE DATA

The data (Figure 1) are taken from Kemp and Barbour's Table 1, which lists 400 measurements of Q and U parameters in the V band, obtained in 1977–1982.

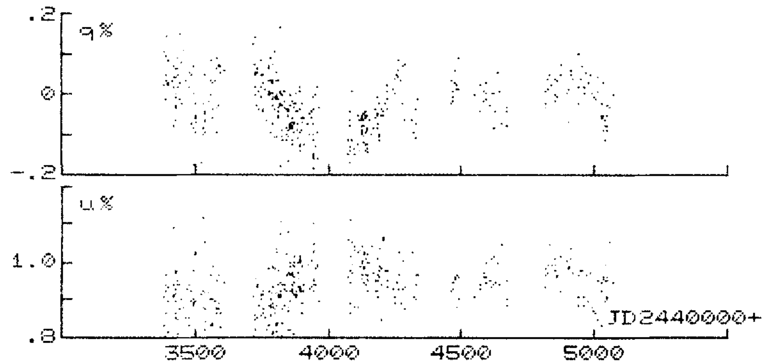

Figure 1 The time behavior of the Q and U polarization parameters in the period 1977–1982 (KB's Table 1).

The power spectrum analysis made by KB had revealed the low frequency peak in the spectrum corresponding to the 290-day period (Figure 2). KB interpret this peak in the framework of a binary system model, where the light from one component is scattered by the other component or by a gas-stream concentration between the components resulting in the polarized flux variations which have maxima near the two quadrature points. KB in their paper also mention that photometric variations had occurred in that period and state that they are not correlated with the photometric changes, although they note a long interval centered near JD 2444050 when the low brightness level corresponded to a strong dip in the Q polarization parameter. We return to the question of whether this correlation exists a bit later, after the discussion of the next attempt to analyse KB's data.

Clarke and McGale (1988) have noted that KB's data have a D-shaped distribution when placed on the U vs. Q plane. Since this kind of distribution is expected in their model of a single star with a zone of polarigenic activity (an oblique rotator with the magnetic poles collimating the scattered material), they

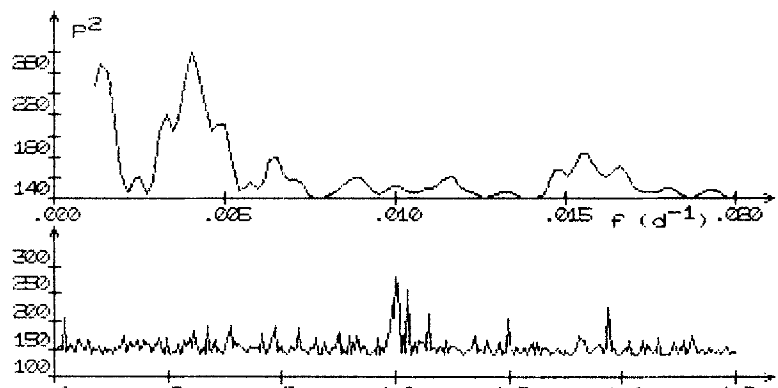

Figure 2 The low-frequency (upper panel) and high-frequency (lower panel) fragments of the power spectrum for the Q parameter variations.

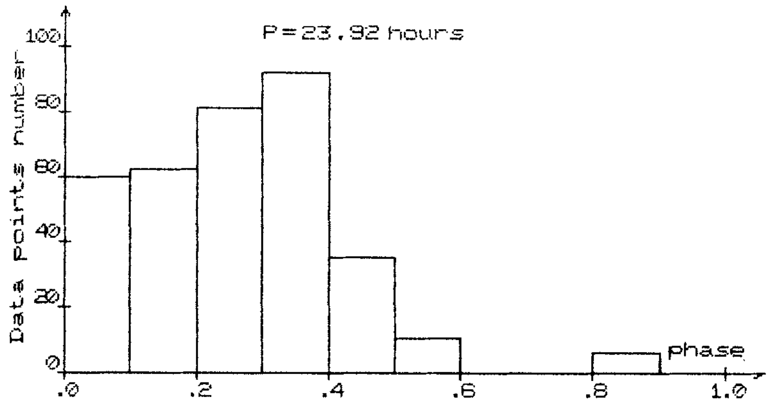

Figure 3 The histogram of the distribution of data points vs. phase of the 23.92 hr period.

made a search for a short-time variability corresponding to the axial rotation of the star.

Having noted the peak in KB's spectrum at the frequency corresponding to a 1 day period, CMG have undertaken a search of periodicity in the 23–25 hour range using the least-square method and claimed to have found it. The exact value of the period was found to be 23.92 hours, an amount practically identical to the data acquisition interval.

To test the significance of this period we made a histogram of the phase distribution of the data points with the period proposed. It is clearly seen that nearly 90% of the data points cover only 50% of full period (Figure 3), so independently of whether this period is real or not, we may say that the data sample used is insufficient for this search. It is well known that one can obtain spurious periods if not taking into account the spectral window.

Returning to the D-shaped appearance of the data points in the *U* vs. *Q* plot, one should note that it holds true only if all the data are used independently of time; but if we plot separately data referring to JD 2443393-4478 and JD 2444547-5054, we can see that in the former case there is an almost linear dependence and in the latter, more scattered and shifted. The superposition of these distributions gives the "D-shaped" appearance of the plot (Figure 4).

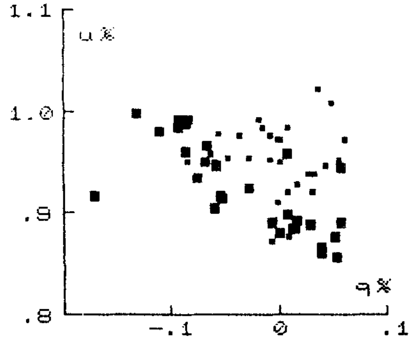

Figure 4 The plot of *U* vs. *Q* (data points smoothed within 20-days intervals). Large squares refer to JD 2443393-4478 and small ones, to JD 2444547-5054.

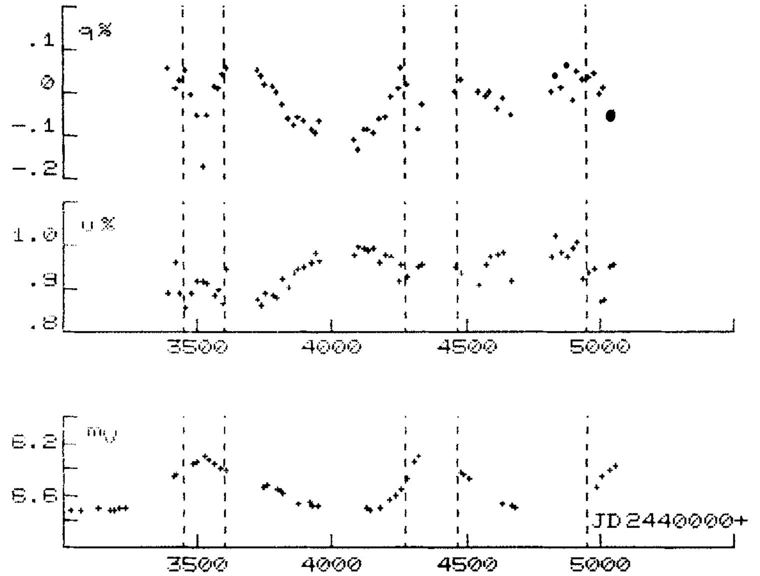

Figure 5 The smoothed Q and U time dependencies taken together with the V light curve (Kalv, 1992).

It should be noted that every time when polarimetry is analysed, photometry is very much needed also. In this case it was extremely unfavourable that we could not find in the literature the photometric data covering the entire interval of KB's observations. For this reason we are greatly indebted to Dr. P. Kalv from Tallinn Observatory for his kind permission to use his unpublished photometric data and Dr. P. Persi from Frascati (Italy) who called our attention to these data.

Having these data at hand, we have plotted the time dependences of the Q and U parameters from KB's Table 1, but smoothed with a 20-day interval (Fig. 5). When comparing this with the photometric data, one can see that these curves are closely correlated, in the sense that when X Per grows brighter, the Q parameter increases and U decreases. The only exceptions are the moments near the maximum of light (the areas marked with dashed lines on Fig. 5) when sharp dips in Q and smooth raises in U occurred.

The fact that the smoothed Q and U time dependencies are correlated with the photometry could help us to achieve the value of the period. But if our analysis is based on the photometric data, far less noisier than polarimetric ones, we immediately see that there are no signs of the periods proposed by KB and CMG. We can only suppose that the period searched for may be shorter then the smoothing interval though Kemp and Barbour did not find significant peaks in that frequency range of the power spectrum.

This very superficial analysis shows that neither photometric nor polarimetric data in the period of Kemp and Barbour's observations confirm the 290/580-day or 1-day periods. The data are more indicative of a 800-day characteristic timescale of variability both in photometry and polarimetry. It should be noted that the variability with that timescale was present only in the period of 1973–1980.

Having found these correlations, one can pose the question whether the intrinsic polarization of X Per grows or falls with the light and, at last, what is the origin of the polarized light in this system. We are not ready yet to give a clear answer to this question because it needs a thorough investigation of the interstellar polarization in the direction of X Per. Based on the observations of neighbouring stars we can state only that its amount is near 1% and its positional angle is near 45 deg; the values are so much near the polarization observed that the slight changes in either parameter of the interstellar polarization can change the signs of the intrinsic parameters. The only way to solve this problem seems to be multifrequency polarimetric observations.

3. CONCLUSIONS

An attempt to reanalyse the polarimetric observations of X Per by Kemp and Barbour (1983) has shown that neither a 290/580-day nor a 1-day periodicity can be confirmed using these data. Only an 800-day characteristic timescale of variability was present in 1977–1982 period; the variations were correlated with the changes in optical brightness. Further analysis of the origin of polarimetric variations needs correct separation of the interstellar and intrinsic components of the polarization parameters.

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