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AE AQUARII IN 1993: CESSATION OF THE 33^s OSCILLATIONS?

AE Aqr is normally classified as a novalike variable. However, in many ways it is a rather unique object (Bruch 1991). It is also the intermediate polar with the shortest known rotation period of the compact object. Patterson (1979) detected very stable oscillations with a period of $33\overset{s}{.}08$ and a second harmonic at half this value. It is supposed to be due to radiation from two magnetic poles with different intensities rotating with the primary of AE Aqr. This view is supported by the detection of x-ray emission with the same period by Patterson et al. (1980). More recently, Eracleous et al. (1993) presented a comprehensive study of the UV and optical characteristics of the 33^s oscillations based on simultaneous *HST* and earthbound observations.

The 33^s oscillation of AE Aqr is a persistent characteristic of the system. Most power spectra of light curves with a sufficient time resolution clearly show a prominent peak at both the fundamental frequency and the first harmonic (Patterson 1979). In less numerous cases one of the peaks dominates over the other while even more rarely one or both of them hide among a quasi continuum of peaks caused by quasi-periodic oscillations (QPOs) close to the characteristic frequency. However, as we will show in this small contribution, the oscillations of AE Aqr can also vanish below a detectable limit.

In July and August 1993 we performed time resolved photometry of AE Aqr at the 6m–telescope of the Special Astrophysical Observatory at Nizhnij Arkhyz, Russia, and at the 60cm–telescope of the Laboratório Nacional de Astrofísica on Pico dos Dias, Brazil. The 6m–telescope data consisted of three sets per night with a duration of either 30^mor 1^h, separated by intervals of about the same size. An ultraviolet filter was used, and the sampling time was $0\overset{s}{.}5$. The 60cm–telescope data consist of light curves with durations between 2 and 6 hours, obtained quasi-simultaneously in white light and the Cron–Cousins *UBVRI* system at a sampling time of 5^s. Table 1 contains a journal of observations.

As a typical example, the unfiltered light curve of Aug. 26 is displayed in Fig. 1. It is quite characteristic for AE Aqr in showing a phase of violent activity which is followed without any noticeable transition by a quiescent phase. This kind of photometric behaviour is not observed in any other cataclysmic variable (Bruch 1991). While a study of the flaring activity is currently underway, we will concentrate here on the behaviour of the 33^s oscillation in AE Aqr.

We have calculated power spectra using discrete Fourier transforms for all our data sets. Surprisingly, none of them contained a clear signature of either a period of $33\overset{s}{.}08$ or of $16\overset{s}{.}04$. Not even a recognizable enhancement of power around the corresponding frequencies, indicating QSOs, is present. While in some power spectra peaks at approximately

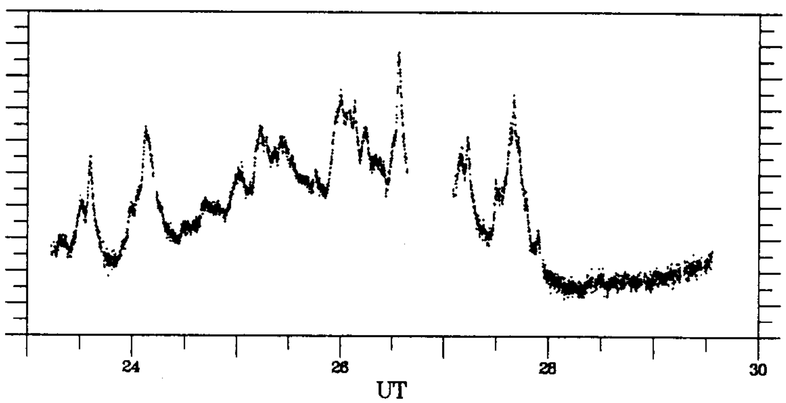

Figure 1. Unfiltered light curve of AE Aqr on 1993, August 26

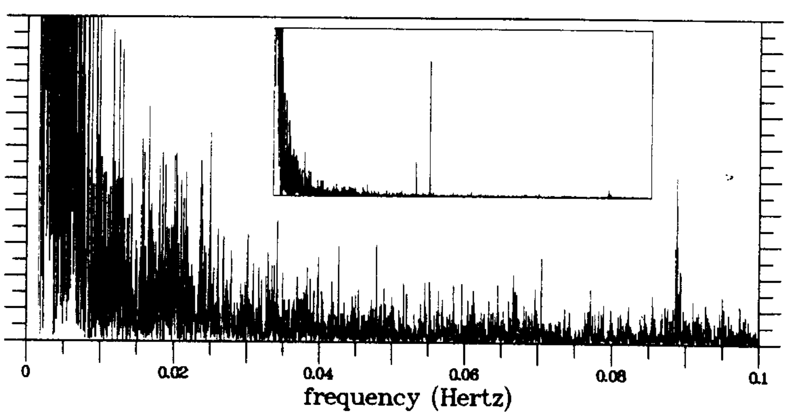

Figure 2. Power spectrum of the light curve of AE Aqr on 1993, August 26. The inset contains the power spectrum of the same light curve to which two tracer signals have been added.

Table 1 : Journal of observations

Date (1993)	Start time	End time	No. of integr.	Time resolution (sec)
Jul. 28	1^h20^m	4^h11^m	9000	0.5
Jul. 28	23^h0^m	27^h19^m	17340	0.5
Aug. 13	23^h12^m	25^h8^m	1215	5.0
Aug. 18	0^h42^m	2^h55^m	1517	5.0
Aug. 26	23^h13^m	29^h33^m	3978	5.0

the expected frequencies occur, they are not higher than numerous peaks at neighbouring frequencies and can thus not be considered as reliable detections of the 33^s oscillation or its harmonic. In Fig. 2 the power spectrum of the light curve of Aug. 26 is shown. The other power spectra look similar. In order to test the reliability of this surprising result we added tracer signals of amplitude $0\overset{m}{.}01$ (period 21^s) and $0\overset{m}{.}005$ (period $26\overset{s}{.}3$) to the light curve and repeated the calculations. In all resulting power spectra the tracer signals appear as strong features (see inset in Fig. 2 for the case of Aug. 26).

In order to investigate if this behaviour is unprecedented or not, and to test the proper performance of our reduction software we calculated power spectra of 46 light curves of AE Aqr obtained between 1978 and 1992 (kindly made available to us by Profs. Nather and Robinson). Among these are several of the light curves used by Patterson (1979) in his original detection of the 33^s oscillations, and the optical light curve used in the study of Eracleous et al. (1993). In order to make sure that the absence of oscillations in our data is not just due to our procedures not being sensitive enough, we added tracer signals of different strengths of several of these light curves and binned them in various ways in order to simulate different time resolutions. These tests clearly showed that the oscillations would have been detected in our data if they had been comparable in strength to those in the test light curves.

Among the 46 light curves we found only two cases (observed with a separation of only a few hours on 1978, Aug. 27) where neither the typical coherent oscillations nor QPOs at the corresponding frequencies could be detected. Thus, the 33^s oscillation of AE Aqr falling below the detection threshold – while possibly not being unprecedented – appears to be at least a rare event. The only report about such an event of which we are aware is given by van Paradijs et al. (1989). They suspect, however, that their inability to detect the oscillations may well be due to an insufficient sensitivity of their measurements.

There are no strong limits on the duration of the undetectability of the 33^s oscillations. They remained unseen for at least 4 weeks (provided that no variations on shorter time scales occur). The last detection before our observations was reported by Eracleous et al. (1993). We do not know of observations obtained after those described here.

The power spectrum of Aug. 26 contains an interesting feature which is not observed during the other nights, namely an enhancement of power close to 8.88×10^{-2} Hz, indicating QPOs at approximately $11\overset{s}{.}26$ (see Fig. 2). This is close to, but significantly different from the third harmonic of the 33^s oscillations. Regarding the flaring and the quiescent parts of the light curve separately, it is found that while the fundamental oscillation and its first harmonic remain invisible in both cases, these QPOs are definitely stronger when AE Aqr is flaring, but are also detectable in quiescence.

In order to explain the temporal variations of the relative strength of the 33^s oscillations and its first harmonic, Eracleous et al. (1993) discuss variations in the height of the shock above the surface of the central body. In an extreme case, i.e. if the shock height over both poles is very low it appears conceivable that the oscillations cease to be detectable. Their alternative explanation, that one of the magnetic poles becomes inactive does not really solve the problem but shifts it only to the question as to why it stops to be active. Moreover, a cessation of the oscillations would imply inactivity of both poles. Also their third alternative – the optical light being dominated by reprocessed UV/X-radiation from the vicinity of the central body – cannot easily explain the complete absence of the oscillations.

Other explanations might invoke precession of the rotational axis of the primary – as in the case of Her X–1 – of a warped accretion disk causing "on" and "off" stages of the x-ray pulsations. In this case the cessation of the oscillations in AE Aqr must be a periodic phenomenon. The light curves available to us are very unequally spaced in time which makes it difficult to check this consequence.

However, more appealing than the analogy to Her X–1 might be the idea that the oscillating light source is temporarily screened from view by surrounding matter. If it is possible that matter in the accretion disk near the Alfvén surface is drawn out of the equatorial plane not only locally but around the entire azimuth, it appears possible that one or both (depending on the details of the geometry) of the magnetic poles become invisible, causing the observed variations of the strength of the 33^s oscillations and its harmonic or even leading to their temporary cessation. Moreover, temporal and spatial stochastic variations of the optical depth of the screening matter may even explain the QPOs which are sometimes observed to replace the coherent oscillations.

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