PROPERTIES OF THE OPTICAL 2-SECOND OSCILLATIONS IN E1405-451*

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ABSTRACT. The AM Her type system E1405-451 is known to show 1 - 3 second variability in its optical emission. Our observations show this variability to be due to quasi-periodic oscillations with a coherence time on the order of one minute. The observations also reveal variations in the color of the oscillating light source. These variations are difficult to explain with present cyclotron emission models.

1. INTRODUCTION.

AM Her type systems consist of a magnetic (20-40 megagauss) white dwarf accreting matter from a red dwarf companion. The strong magnetic field directs the flow onto the magnetic pole(s), where a strong shock is formed. A thermal instability in the shocked plasma (Langer et al., 1982; Imamura et al., 1984), leading to oscillations in shock height, is suspected to be the cause of 1-3 second variability observed in two of these objects (Middleditch, 1982; Mason et al., 1983). We obtained optical high speed photometry of E1405-451

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in May 1984 and in April 1985 in order to study the properties of this variability. In an earlier paper (Larsson, 1985) we discussed the modulation of oscillation strength with orbital phase and the oscillation color as determined from the 1984 data. In this paper we report on a remarkable difference in oscillation color between the 1984 and 1985 data.

2. ANALYSIS AND RESULTS.

Most of our results are based on power spectra calculated from 40.96 second segments of the time series data. Oscillation strengths were calculated from the power excess in the frequency range 0.3 - 0.9 Hz. The analysis revealed erratic amplitude and frequency variations on time scales of minutes. The broad (0.4 - 0.8 Hz) frequency distribution seen in time averaged power spectra is mainly due to these frequency variations. At maximum strength the oscillation amplitude (half peak-to-peak difference) was found to reach 7 - 8 % in white light. In such cases the oscillations are clearly seen directly in the light curve (figure 1). From the light curves of the strongest oscillations the coherence time can be estimated to be on the order of one minute.

In order to determine the pulse shape of the oscillations we folded 20 second data segments with a period and period variation determined from a least-square fitted sine wave. As seen in figure 2 the pulse shape is slightly asymmetric with the increasing branch being steeper than the decreasing one.

The non-simultaneous BVRI-observations in 1984 indicated (Larsson, 1985) that the oscillating light source is red, which suggested an identification with the cyclotron radiation component, and hence an origin within the accretion column. Since those observations were not simultaneous, part of the differences in oscillation strength could be due to changes from one orbital period to the

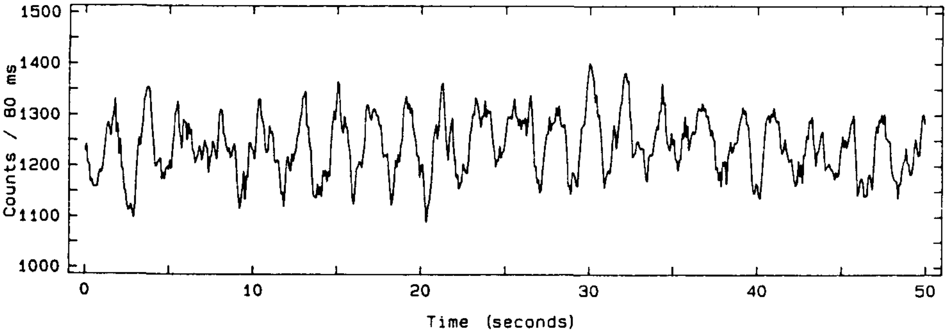

Figure 1. Data sequence from an observing run with the 1.5 m Danish telescope at ESO in May 1984. An oscillation with a 2 second period is clearly visible. The count rate incudes a background of 130 counts / 80 ms.

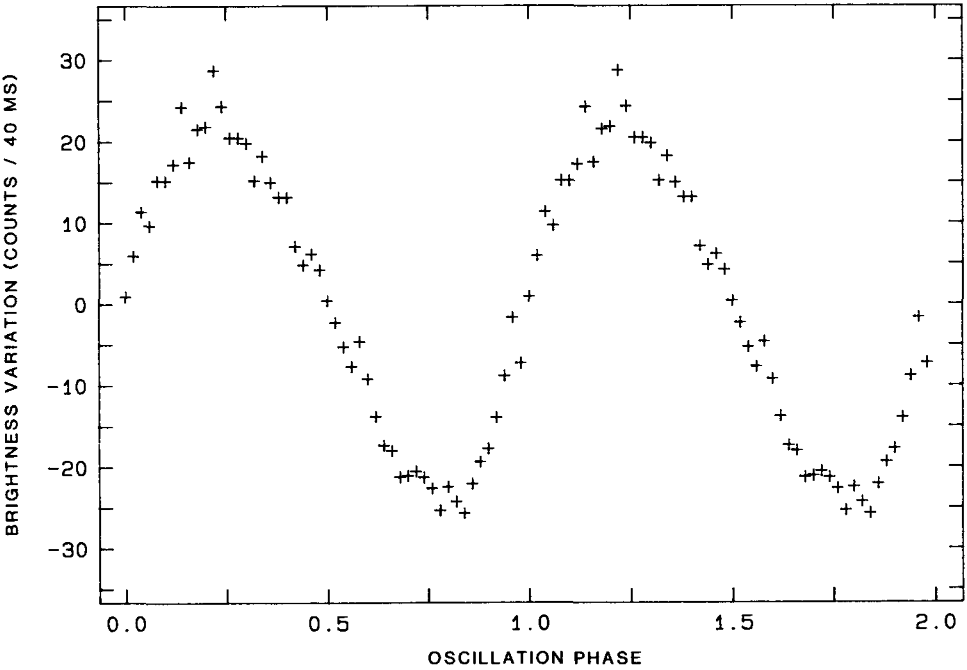

Figure 2. Pulse shape of the oscillations in E1405-451. The plotted profile is the average of ≈160 oscillation cycles, observed in white light. The same pulse profile is plotted twice.

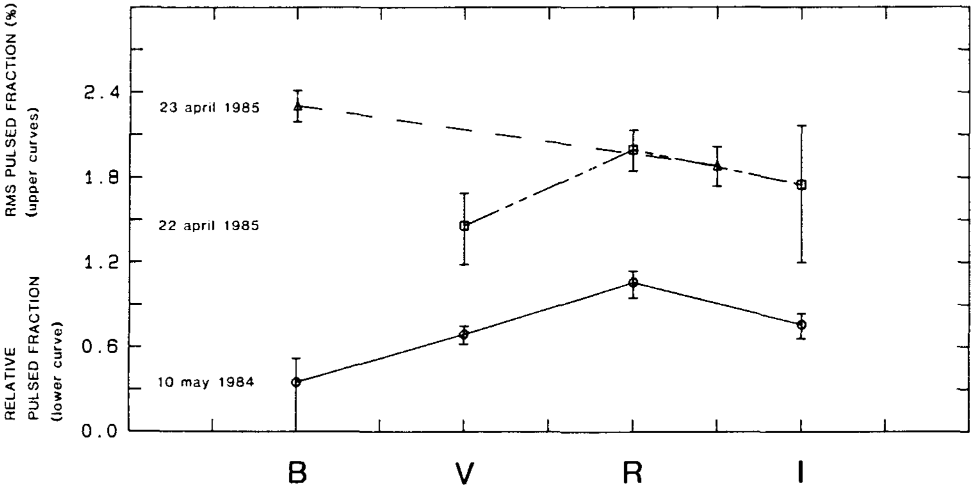

Figure 3. The pulsed fraction in different wavelength bands, as determined from the power excess in the frequency range 0.3-0.9 Hz. The 1984 observations covered different orbital phases. The points shown (lower curve) therefore give the pulsed fraction for different colors relative to the white light value for the corresponding phases. The observation on the 23 April 1985 show in contrast to the 1984 data strong oscillations in the B band.

next. However, judging from white light observations covering a number of orbital periods, this is unlikely to be responsible for the large difference between the B and R bands. The 1985 observations were made with two telescopes (the 1.5 m Danish and the 3.6 m telescopes at ESO) allowing us to make simultaneous observations in two wavelength bands. Some preliminary results from these observations are shown in figure 3 together with the 1984 results. Note the difference in unit for the two sets of data. The V, R and I points on 22 April 1985 were calculated from pair wise simultaneous observations, and the two points for the following night are from a simultaneous observation in B and in a broad red (5700-9000 Å) band. The strong B band oscillations contrasts strongly with the result from the previous year. This difference is

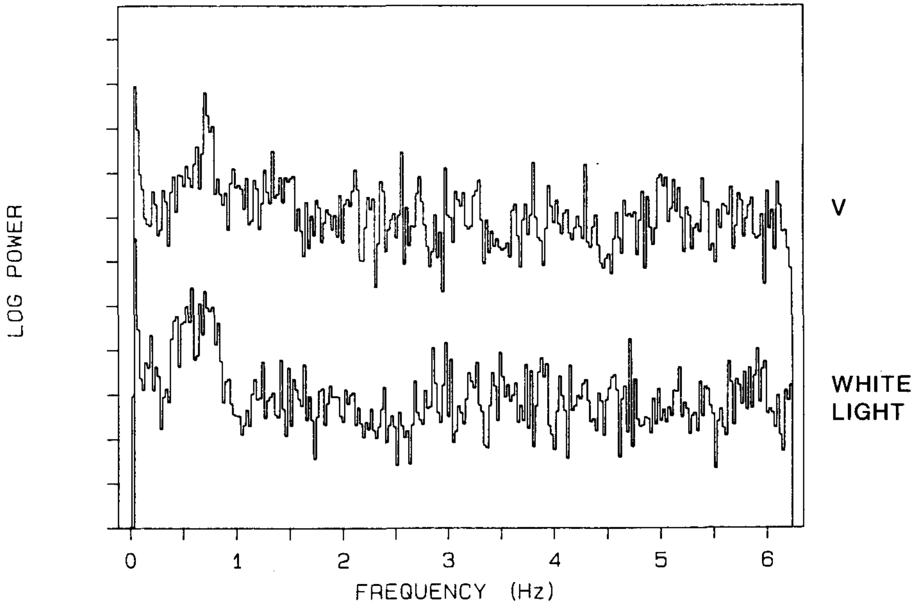

Figure 4. Power spectra from a simultaneous observation in the V band and in white light (4000-9000 Å). Of the white light oscillations in the frequency range 0.4-0.8 Hz only the highest frequency part is clearly seen in the V band.

apparently associated with the markedly bluer color of E1405-451 during the 1985 observation. A similar color change has been seen in this source also by other observers (M. Mouchet, private communication). In figure 4 we give an example of power spectra from a simultaneous observation in the V band and in white light (4000-9000 Å). Of the broad range (0.4-0.8 Hz) of oscillation frequencies present in the white light power spectrum only the high frequency part is clearly seen in the V band. Other simultaneous data seem to show similar effects, but since the power spectra are rather noisy, the reality of differences like that in figure 4 needs to be confirmed by more accurate observations.

3. DISCUSSION.

The observed color changes both in the oscillating light source and in total light imply that the spectral distribution of the cyclotron emission can change with time. It is interesting to note that when the color became bluer in 1985 the total white light (4000-9000 Å) brightness at the maximum was 40 % lower than in 1984. In addition to the spectral changes with time, radiation from different regions of the column may have different spectral distribution. Different parts of the column could then oscillate with different frequency and emit cyclotron radiation with different spectral distributon. Maybe this is the reason for the difference between the two power spectra in figure 4. Theoretically there are difficulties in explaining the color variations, which are not expected from the standard models of the cyclotron emission (e.g. Chanmugam and Dulk, 1981).

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