THE 71-SECOND OSCILLATION OF DQ HER AT 2180 Å

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Abstract. The 71-s modulation in the light curve of the old nova DQ Her has a mean semi-amplitude of 1.8% at 2180 Å, although the amplitude varies by at least a factor of two from orbit to orbit. The disturbance in the amplitude and phase of the modulation during eclipses is similar to that observed at visual wavelengths. We conclude that at 2180 Å, as at visual wavelengths, the modulated flux is reprocessed and comes from the accretion disk.

1. Introduction

The visual light curve of the old nova DQ Her has a highly-coherent, sinusoidal modulation with a period of 71.06 s and an amplitude of 1% induced by rotation of the magnetic, accreting white dwarf in the system [1]. The light curve also shows eclipses, which recur every 4 h 39 m. The visual flux from DQ Her is dominated by the accretion disk around the white dwarf and, consequently, the eclipses, which are occultations of the white dwarf and its accretion disk by their cool companion star, are wide, lasting ~ 0.2 of the orbital period. The phase of the oscillation is disturbed during the eclipses: it increases by at least 100° during eclipse ingress, then jumps

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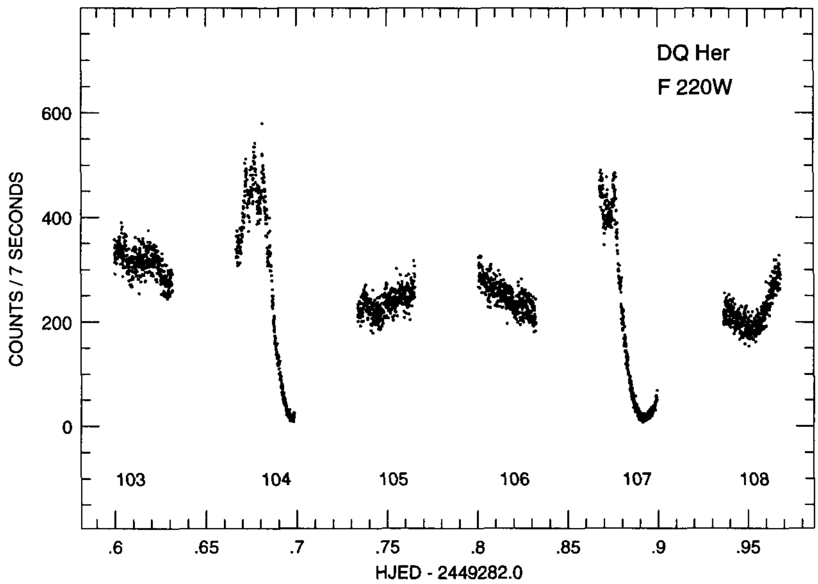

Figure 1. The ultraviolet light curve of DQ Her. The F220W filter has a full width at half maximum of 480 Å and an effective wavelength of 2180 Å. The light curve has been compressed to 7 s per sample in the figure.

by ~ 120° at mid eclipse, and finally climbs smoothly by another ~ 140° during eclipse egress, returning to its phase outside of eclipse [3]. The amplitude is also disturbed: it is greater than its uneclipsed value near the beginning and end of eclipse, but fades to less than 10% of its uneclipsed average at mid-eclipse. Since the amplitude and phase disturbances take place throughout the entire eclipse, most of the flux in the 71-s modulation is reprocessed light coming from the accretion disk. Quantitative modeling shows that little or no modulated flux is received directly from the white dwarf [2, 3].

2. The observations

We observed DQ Her for six successive HST orbits in 1993 October with the HST high-speed photometer and the F220W filter, which has an effective wavelength near 2180 Å. The light curve is shown in Fig. 1, where the sections of light curve from each HST orbit are labeled by a number from 103 to 108; the gaps between sections are caused by earth occultations. The light curve covers two orbits of DQ Her. In addition to the deep eclipse, it has an unexpectedly prominent hump with strong flickering just before the eclipse. The hump is similar to the humps in the light curves of many

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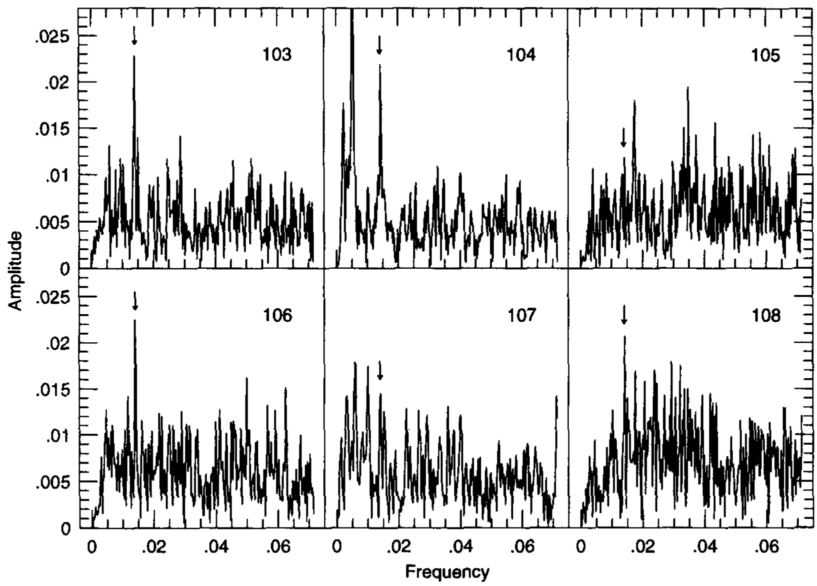

Figure 2. Power spectra of each section of the ultraviolet light curve of DQ Her. Only the portions of the power spectra near 71 s are shown; the expected positions of the 71-s modulation are marked by arrows.

dwarf novae leading us to presume that, as in the dwarf novae, the hump is caused by a bright spot on the disk.

3. The 71-second modulation

We calculated the power spectrum of each section of the light curve to test for the presence of the 71-s modulation. The pertinent portions of the power spectra are shown in Fig. 2; the expected positions of the 71-s modulation are shown by arrows. We detected the modulation in four sections of the ultraviolet light curve – 103, 104, 106, and 108 – but not in section 105 and probably not in section 107. The measured semi-amplitude varied from 2.3% in section 103 to less than 1.2% in section 105. The variation in amplitude is mostly uncorrelated with orbital phase since the amplitude of the modulation at a given orbital phase can be different at different times (compare the amplitudes in sections 105 and 108, both of which cover orbital phases near $\phi = 0.3$). The mean semi-amplitude during our observations was 1.8%.

Two sections of the ultraviolet light curve cover eclipse ingresses, sections 104 and 107. The 71-s modulation was too weak to detect during section 107, leaving section 104 for measuring the phase and amplitude of

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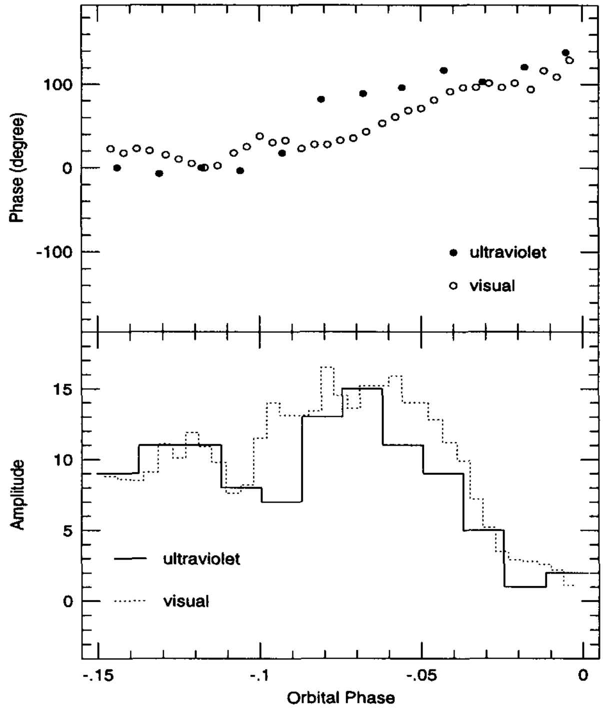

Figure 3. The amplitude (lower panel) and phase (upper panel) of the 71-s oscillation as a function of orbital phase during section 104 of the ultraviolet light curve. The phase and amplitude at optical wavelengths are shown for comparison [1].

the 71-s oscillation during eclipse. We extracted the phase and amplitude from section 104 in the usual way, by fitting a sine curve with a period of 71.06 s to the light curve. The measured amplitude and phase are shown in Fig. 3, where we have fitted a sine curve with 6 cycles, shifting 3 cycles between fits. The amplitude and phase variations at visual wavelengths are shown for comparison. The variations at ultraviolet wavelengths mimic those at visual wavelengths; the differences, if any, are too small to measure.

We conclude that at 2180 Å, as at visual wavelengths, the flux in the 71-s oscillation is reprocessed and comes from the accretion disk, not directly from the white dwarf.

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