

HST/UV PERIODIC VARIATIONS IN THE INTERMEDIATE POLAR FO AQR

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Abstract. A preliminary analysis of high temporal HST UV spectroscopy, as well as SAAO *BVRI* photometry, has revealed that FO Aqr, differently from all previous observations, has changed from a spin dominated to an orbital dominated variability, both in lines and continuum. The spectral dependence of the orbital continuum, however, has not changed with time. The periodical variations are discussed in terms of standard accretion models.

Key words: stars: cataclysmic variables, intermediate polars, individual: FO Aqr

1. INTRODUCTION

The intermediate polar FO Aqr (H 2215-086) was known to show, in all energy ranges, strong periodic pulsations at spin frequency ($\omega = 1/P_{\text{spin}} = 20.9$ min) and lower amplitude variations at the beat ($\omega - \Omega$) and orbital ($\Omega = 1/P_{\text{orb}} = 4.85$ h) periods (see review by Patterson 1994). Recent X-ray observations also showed changes in the relative proportion of spin to orbital modulation fractions on

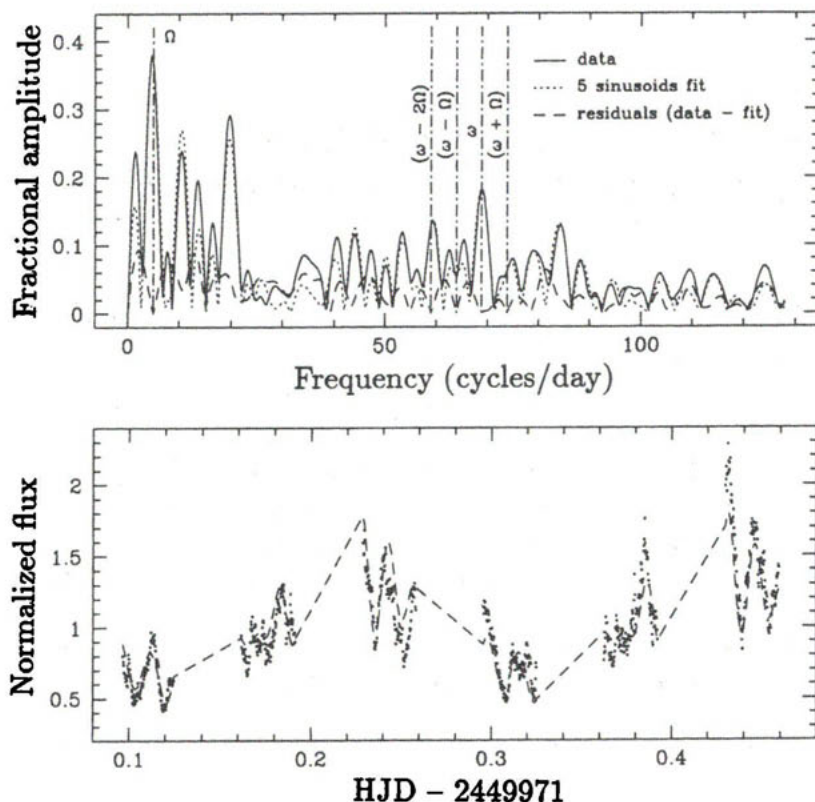


Fig. 1. Total continuum light curve and relative DFT. Note that the two peaks at ~ 10.3 and 19.7 c/day are artifacts due to the HST orbital period (96 min). Small differences between the exact and the observed orbital frequencies are related to poor sampling of the data (1.8 orbital cycles).

time scales of years, the rotational modulation being the dominant one, however (Beardmore et al. 1996).

Differently from X-ray and optical/IR ranges, the behavior of FO Aqr in ultraviolet on timescales shorter than P_{orb} was totally unstudied (de Martino et al. 1994). We have, therefore, obtained HST/FOS observation in September 1995, using the G160L blue digicon configuration covering the range $1154\text{--}2508 \text{ \AA}$ at a resolution of $6.8 \text{ \AA/diode}$. A total number of 797 spectra have been collected,

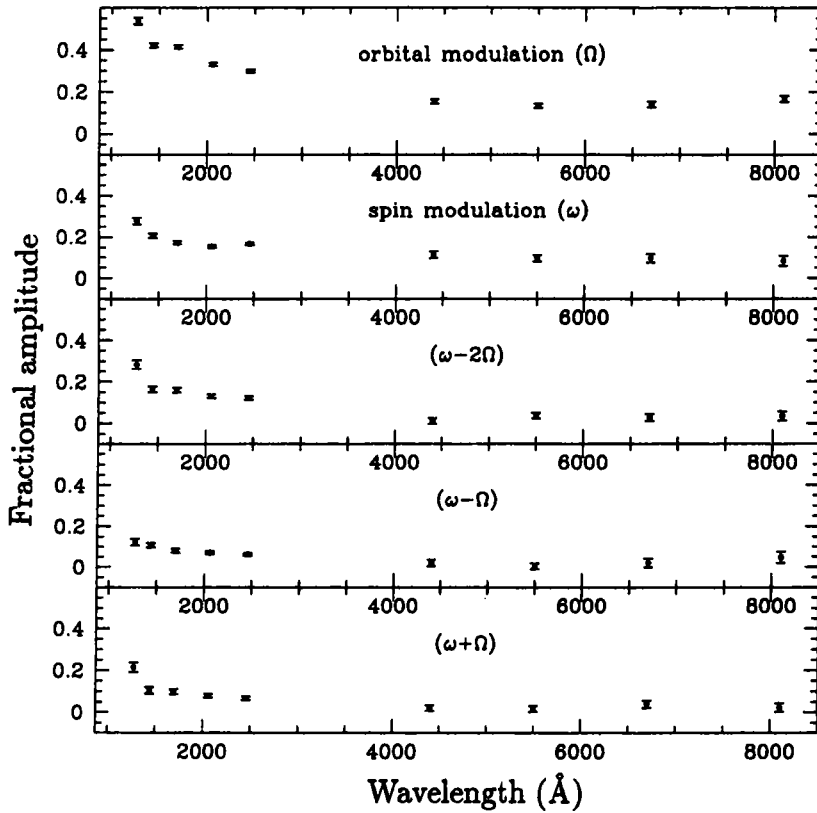


Fig. 2. Fractional amplitude of the modulated light (UV continuum + *BVRI* data) vs. wavelength.

with an effective exposure time of ~ 19 s each. One month later, FO Aqr was also observed in the *BVRI* passbands at SAAO.

Our investigations were carried out in five line-free continuum bands (1265–1275 Å, 1425–1450 Å, 1675–1710 Å, 2020–2100 Å, 2410–2500 Å), in the main line emissions (N V, Si IV, C IV and He II), as well as in the *BVRI* passbands.

2. THE UV AND OPTICAL CONTINUUM

A time series analysis has been performed. The total continuum light curve and the relative DFT are shown in Fig. 1, together with a 5-sinusoidal fit, corresponding to the main frequencies present in

the power spectrum: the spin (ω), the orbital (Ω), the two negative side-bands ($\omega - \Omega$, the beat, and $\omega - 2\Omega$) and the first positive ($\omega + \Omega$). Similarly the *BVRI* light curves have been fitted with the same 5-sinusoidal functions. In both UV and optical ranges the orbital modulation is the dominant one.

This is in contrast with all previous observations in the X-ray and optical ranges, where the spin pulsation was always found to dominate. A comparison with the orbital variability as previously detected by IUE and SAAO data (de Martino et al. 1994), shows an increase by a factor of ~ 1.5 in the UV and ~ 1.1 in the optical ranges, indicating that the proportion of the orbital contribution has changed with time. Although long term changes in the relative proportion of spin and orbital amplitudes have been observed in X-rays (Beardmore et al. 1996), this is the first evidence that FO Aqr has switched from a spin to an orbital dominated system.

A similar behavior has been observed in the optical range of the intermediate polar BG CMi (de Martino et al. 1995), thus indicating that these variations are a potential tool to study long-term changes in the accretion pattern.

A color effect is also observed, the modulated fractions being blue with a sharper rise in the far-UV and flatten at longer wavelengths (Fig. 2). Given the low quality of the optical data, we restrict the study of the spectral shapes of the modulation to the UV range only. The UV spin pulsation appears too steep in the far-UV and too flat in the near-UV with respect to any single blackbody or power law distribution. This indicates the presence of more than one spectral component: a hotter one, possibly the heated white dwarf, and a cooler one. The latter is consistent with the previously determined 11 000 K blackbody, ascribed to the accretion curtain which dominates the optical range. On the other hand, the spectral dependencies of the orbital and side-bands modulations are closer to a 20 000 K blackbody, although the far-UV is steeper. The inferred temperature and phasing of the orbital modulation are consistent with the previous results from IUE data, which were interpreted in terms of X-ray reprocessing at the inner face of the hot spot of the accretion disk.

3. THE UV EMISSION LINES

Fig. 3 shows the light curve and the DFT of UV emission line fluxes. The data have been fitted with a 4-sinusoidal functions corre-

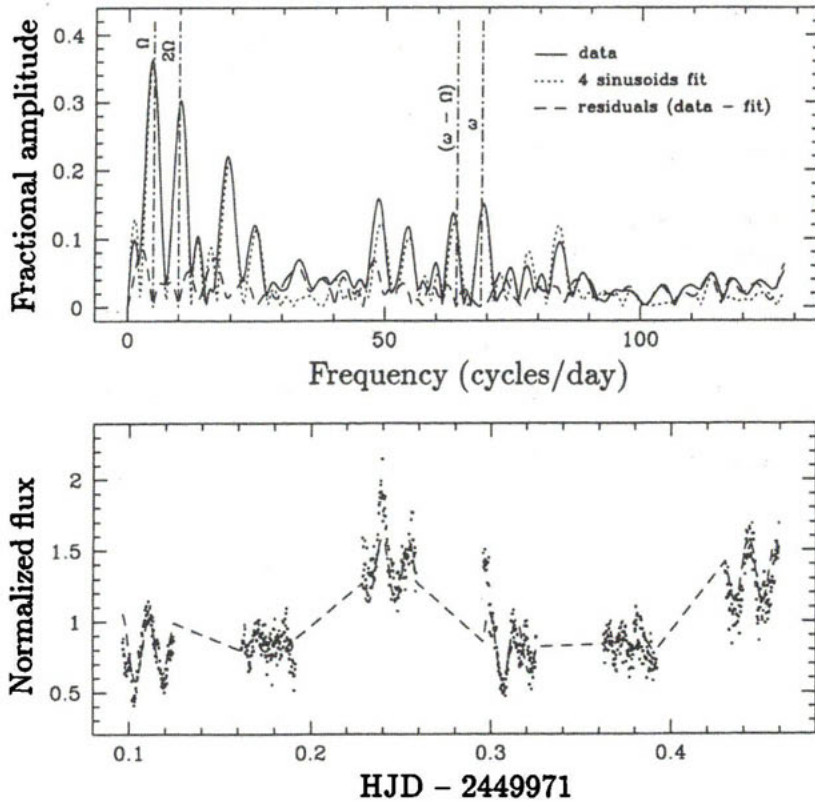


Fig. 3. Light curve and relative DFT of the UV emission line fluxes (NV + Si IV + CIV + He II).

sponding to the spin (ω), the orbital (Ω), its first harmonic (2Ω) and the beat ($\omega - \Omega$). Differently from the continuum, the first harmonic of the orbital period is detected but no side-band is seen except for the beat. Fractional amplitudes indicate that the orbital modulation is the dominant variability also in the UV emission lines. The orbital maxima of the continuum and the absorption lines are mostly in phase with light curves suggesting that the orbital variabilities arise from a common region. On the other hand, the spin pulses in the emission lines appear to lag by ~ 0.15 in phase the continuum ones, indicating that they are formed further out in the accretion curtain above the white dwarf. However, the differences in the presence

of side-bands between continuum and lines give hints on a less tight relation between their origin, which still needs detailed investigation.

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