FO Aqr, 'King' of the Intermediate Polars

E. Breedt, T.R. Marsh, D.T.H Steeghs, B.T. Gänsicke (University of Warwick, UK)

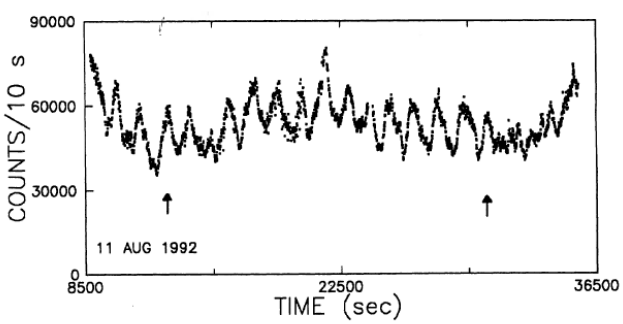
Intermediate polars (IPs) are binaries in which magnetic white dwarfs accrete from close, late-type main-sequence companions. An accretion disc forms around the white dwarf, but the inner disc is truncated by the white dwarf magnetosphere. From this boundary, the gas is channelled along the field lines and onto the magnetic poles of the white dwarf, creating accretion hot spots on the magnetic poles of white dwarf.

FO Aqr is an intermediate polar with an orbital period of 4.85 hr. It falls into the K2 Campaign 3 field-of-view and will be the first intermediate polar to be observed with Kepler/K2. In addition to the orbital signal, its optical lightcurve (Fig. 1) also displays a 1254.5 s periodicity, interpreted as an accretion hot spot rotating into and out of view on the white dwarf spin period. (It is the large amplitude (0.2 mag) and coherence of this spin signal that gives FO Aqr its 'royal' status — Patterson & Steiner 1983 ApJ 264 L61).

These periods show that the white dwarf is rotating much faster than the binary – the magnetic field is not strong enough to synchronise the system. The asynchronous rotation causes obvious additional signals in the light curve, on the beat period between the white dwarf rotation (ω) and the orbital period (Ω). The optical power spectrum of FO Aqr displays weak signals at $\omega - 2\Omega$, $\omega - \Omega$ and weakly at $\omega + \Omega$ (Fig. 2), the strength of which change from night to night (Patterson 1994 PASP 106 209). The beat signals are due to reprocessing of emission from the accretion hot spots, by structures fixed in the binary frame, e.g. the secondary star or the accretion disc. This opens up the potential to see changes in the accretion geometry as the disc itself varies, e.g. through precessional effects. The timescales of such changes are of order a day or two, making such an experiment practically impossible from the ground.

The accretion process also cause the white dwarf to spin up or down. FO Aqr displayed a lengthening spin period (spin down) until 1987, but then started spinning up again (Williams 2003 PASP 115 618), reflecting changes in the average accretion mass rate of the white dwarf. *Short cadence observations* are essential to resolve this spin period, detect variations in the spin period and the various beat signals and to investigate the poorly understood interaction between the magnetosphere and inner truncated disc. The unique capability of K2 to provide uninterrupted, high precision, high cadence photometry over a long baseline is key to understand the accretion variability over such a wide range of timescales.

This is the first opportunity to acquire Kepler/K2 data for any intermediate polar. It will provide a stunning first light upon the long term behaviour of the multiple-signal power spectra of these binaries.



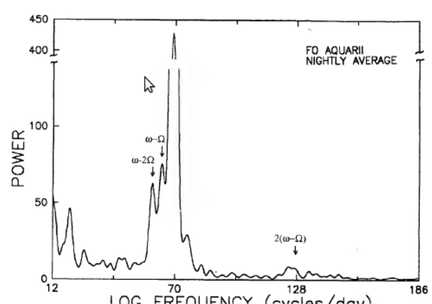


Fig. 1: (Left) Optical light curve of the intermediate polar FO Aqr over 1 night. The spin modulation and orbital signal can clearly be seen. The arrows indicate the orbital minima. **Fig. 2:** (Right) Power spectrum of FO Aqr, averaged over nine single-night observations. The weak orbital sidebands change in relative strength from night to night. (both figures from Patterson 1994 PASP 106 209)