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Mapping Quasi-Periodic Oscillations from the Outbursting Intermediate Polar GK Persei

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Abstract. We provide a kinematically-resolved analysis of 5000 s QPOs found in the optical emission lines of GK Per during a dwarf nova outburst. These are consistent with models of reprocessing off blobs of gas orbiting within the inner accretion disc.

We have detected 5000 s QPOs in the optical emission lines of the intermediate polar GK Per on the rise to outburst and resolved their velocity distributions (Fig. 1). The observations here are consistent with the picture of dense blobs of material orbiting in the inner accretion disc (Hellier & Livio 1994), where the characteristic QPO velocities extend to where the impact of a ballistic accretion stream, overflowing the disc, is likely to occur ($540 \sin i \,\mathrm{km\,s^{-1}}$; where i is the orbital inclination). However, QPO power is not restricted to high velocity material and occurs over a range of values down to the order of velocities expected from the outer disc rim, $< 350 \sin i \,\mathrm{km\,s^{-1}}$. It therefore seems unlikely that we are observing blobs directly, unless blob emission is dominated by a broadening mechanism other than the Doppler effect. We can also interpret the optical modulation as variable irradiation of the entire disc from the characteristic QPO radius outwards, caused by the obscuration of the X-ray source by an accreting blob. A Tomographic analysis of the line profiles confirms that the QPO source is a single component moving sinusoidally about the white dwarf rest-velocity.

Fig. 1 illustrates that the QPO frequency is an approximately constant function of velocity. If line broadening is purely Doppler in nature, this is at odds with the QPO models associated directly with radial or vertical perturbations across the accretion disc (e.g. Carroll et al. 1985), which predict that the frequency of oscillation is a linear function of the Keplerian frequency at a given disc annulus. In such a case we would expect the QPO frequency to increase as V^3_{Kep}.

The daily variation of QPO properties is possibly because we are observing different blobs on each night. However, the evolution of QPO frequencies and velocities to larger values is a natural phenomenon in this model, since if blobs can survive within the disc for durations greater than the dynamical timescale, they are expected to migrate towards the accretor via viscous interaction with the surrounding medium. The QPO distribution on the 3rd night appears more complex. Perhaps this is caused by the deposition of further blobs into the disc, or the fragmentation of the original blob.

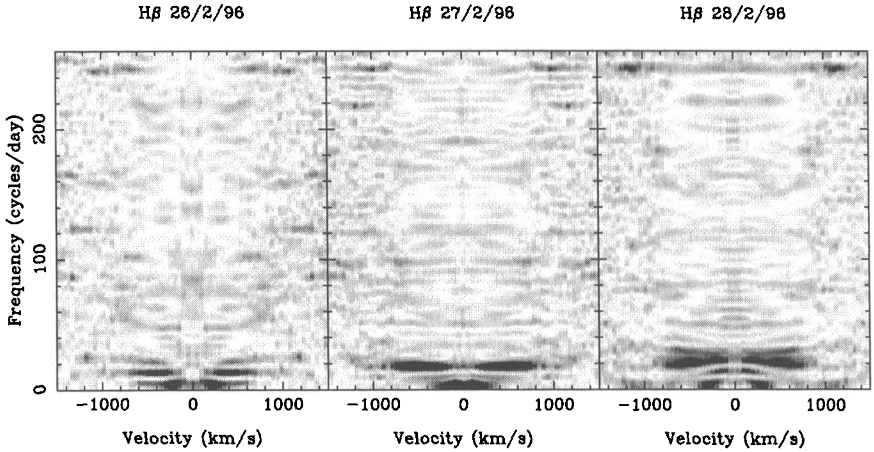

Figure 1. Power maps of frequency versus line velocity from the Hβ emission feature from GK Per, displaying significant power at the 5000 s QPO frequency (18-20 cycles d^{-1}), the spin frequency at 246 cycles d^{-1}, and at 5 cycles d^{-1}, which is an alias. These particular searches were conducted on radial velocities sampled in discrete wavelength bins of the line profile.

A similar time-series analysis was performed sampling the line flux variations as a function of velocity. In these cases power was predictably found on the 5000 s QPOs in discrete bins. However, within the limits of the data, flux is conserved across the integrated line profiles over the QPO cycle. This is consistent with the Hellier & Livio (1994) model, provided we have unrestricted viewing over the entire surface of the illuminated disc – a possibility given the predicted range of orbital inclinations. In this case, the Watson, King & Osborne (1985) model of variable mass transfer through the accretion curtain suffers because an increase in accretion rate is expected to have an observable effect on the line fluxes. However, a reservation concerning the Hellier & Livio model is provided by the result that QPO power determined from the line intensities is biased towards blue velocities. Because of the persistence of this bias on all three nights, we have difficulty accommodating it in the overflow picture.

References

Carroll, B. W., Cabot, W., McDermott, P. N., Savedoff, M. P., van Horn, H. M., 1985, ApJ, 296, 529

Hellier, C., Livio, M., 1994, ApJ, 424, L57

Watson, M.G., King, A.R., Osborne, J., 1985, MNRAS, 212, 917

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