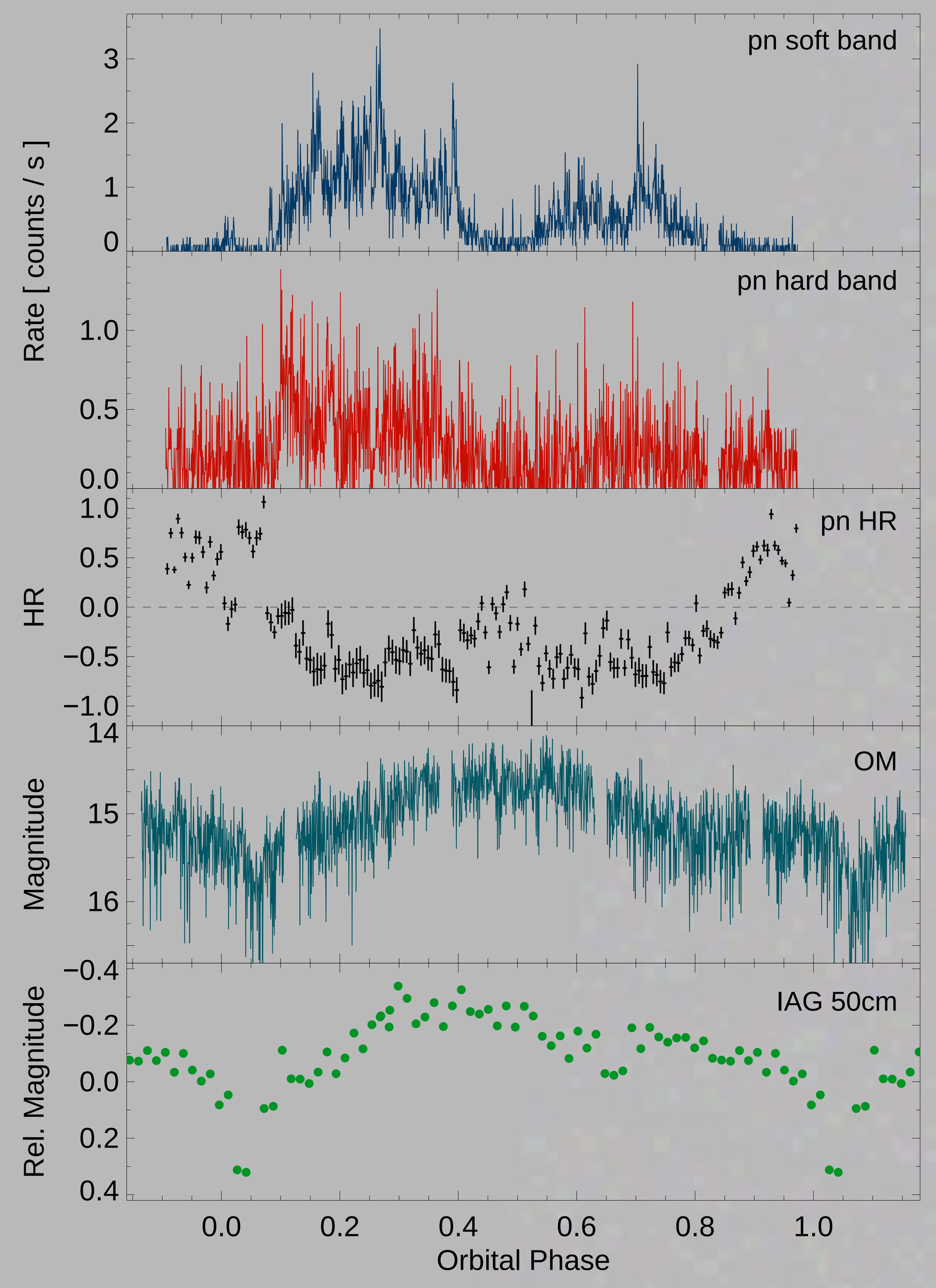
XMM-Newton Observations of Two Soft X-Ray Selected Magnetic CVs

Iris Traulsen, Klaus Reinsch, Stefan Dreizler

Institut für Astrophysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

AI Tri – Photometry

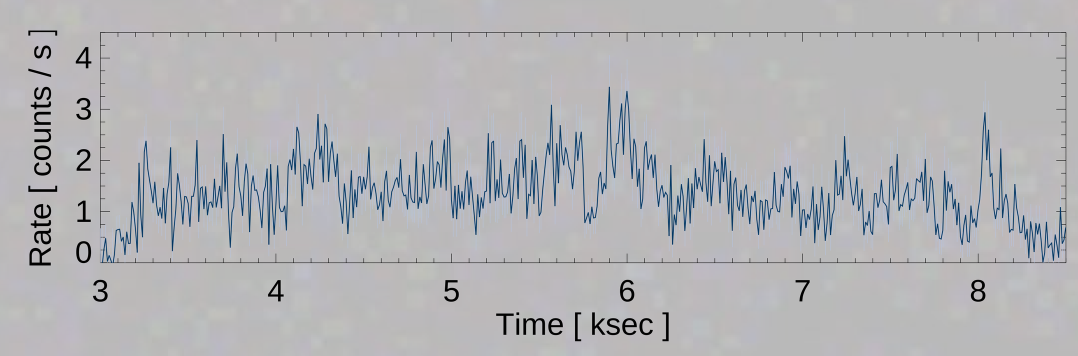


The long-period system AI Tri has been monitored for the first time over a whole orbital cycle in X-rays. The light curve is dominated by highly variable soft X-ray emission over about 70% of the binary orbit, in addition to a weak, nearly constant hard component. The hardness ratio HR = (H−S)/(H+S) conforms largely with the light curve in the soft energy band, tending to 1 during low and to −1 during high soft emission phases (S: $E \leq 0.5\,\mathrm{keV}$, H: $E \geq 0.5\,\mathrm{keV}$). Non-sinusoidal variation with the orbital period and a sharp dip close to phase 0 characterize the ultraviolet OM and optical light curves. Those shapes suggest a one-pole accreting system with the accretion region visible nearly all the time, only eclipsed by the stream at phase 0.5, when a broad dip in the soft X-ray emission is seen.

White Dwarfs in Magnetic CVs

AM Her type Cataclysmic Variables comprise an accreting White Dwarf with a high magnetic field strength ($B \approx 7 - 230\,\mathrm{MG}$), accompanied by a late type secondary filling its Roche lobe and donating mass to the primary. The accretion stream follows the magnetic field lines and reaches, decelerated in a strong shock, the White Dwarf in the immediate vicinity of its magnetic poles, where the heated surface of the White Dwarf is mainly seen in the UV or the soft X-ray regime. Several systems show an unexpected dominance of soft over hard X-ray emission from the shock region, which is believed to be linked to the strong magnetic field.
With the X-ray satellite *XMM-Newton*, we have obtained 20 ksec exposures of two of those systems, AI Tri and QS Tel, simultaneously measured by the EPIC instruments in the X-ray regime between 0.1 and 10 keV and by the Optical Monitor in the ultraviolet UVM2 filter. Additional optical photometry has been performed at several sites during their high states of accretion.

Evidence for 'Blobby' Accretion in AI Tri?

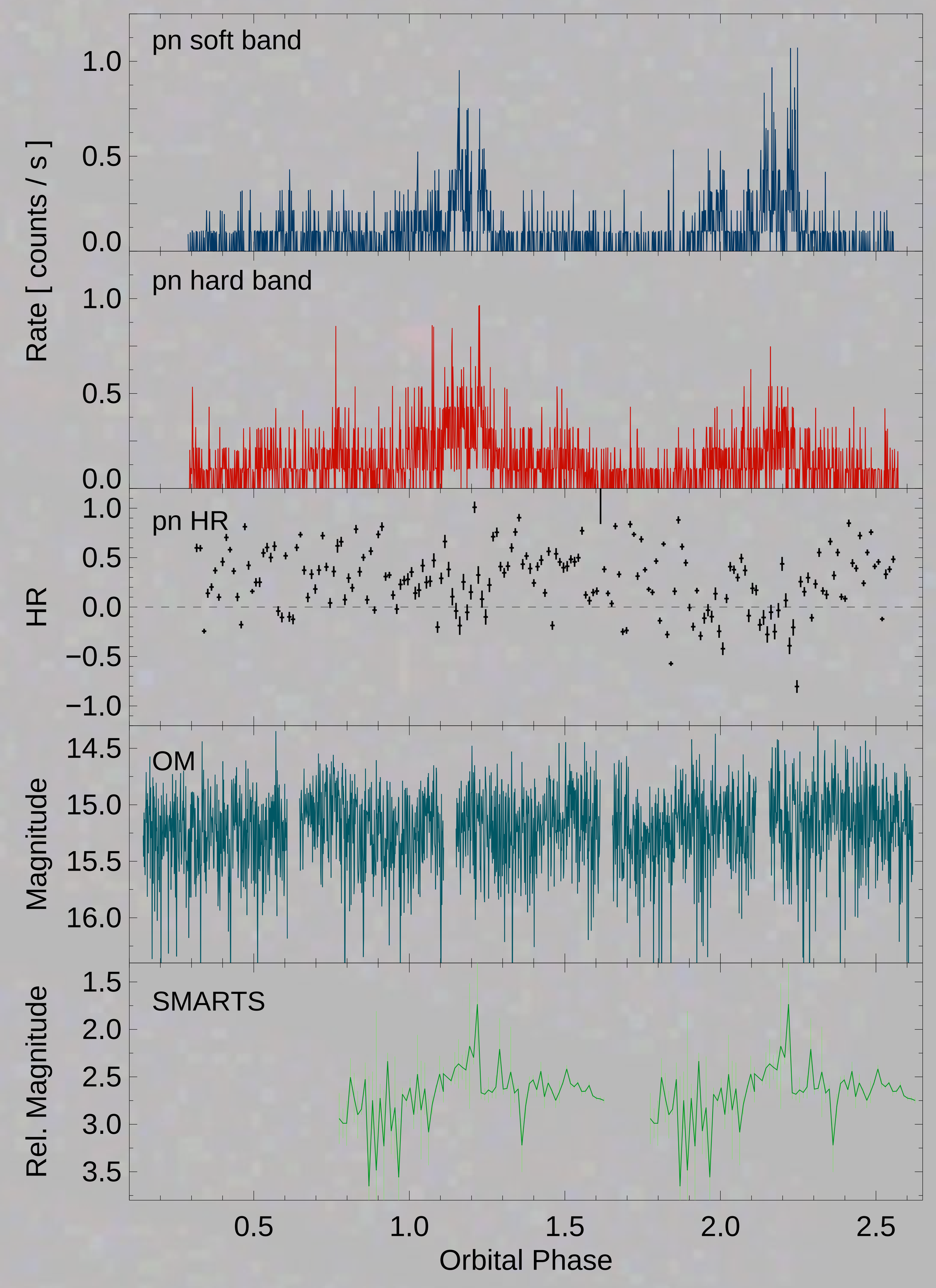


The striking variable shape of the high-resolved soft X-ray light curve implies an inhomogeneous structure of the accretion stream with regions of high density, so-called accretion 'blobs', a scenario introduced by (Kuijpers & Pringle 1982). Causing instabilities in the accretion shock and penetrating the atmosphere of the White Dwarf, they may account for the flaring shape of both the X-ray and the optical light curves. Also, the soft X-ray excess in AM Her type systems is thought to be connected to 'blobby' accretion.

Parameters of the MEKAL Fits

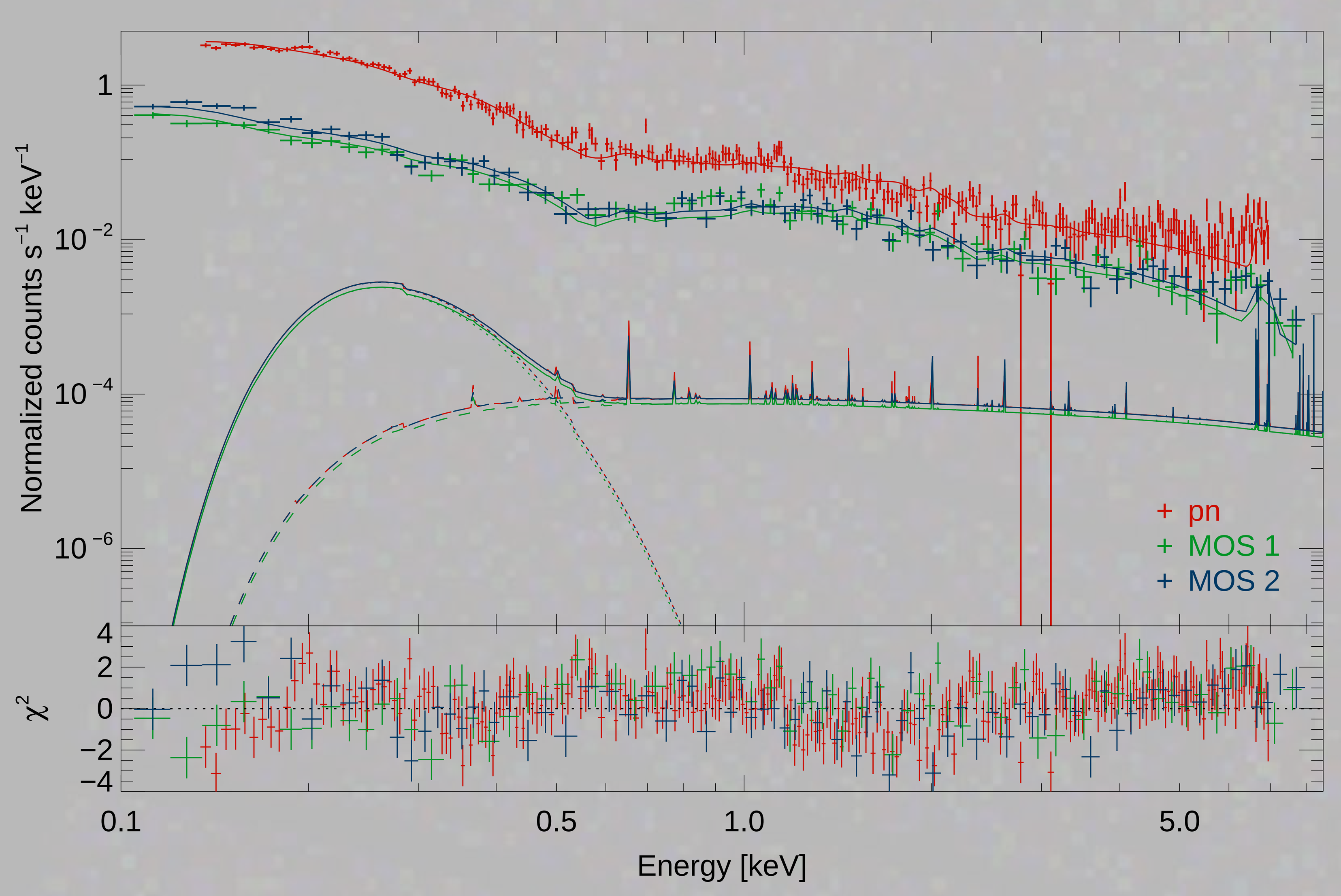
	χ^2	N_H $[10^{19}\mathrm{cm}^{-2}]$	kT_{bb} [eV]	$kT_{Mek,1}$ [keV]	$kT_{Mek,2}$ [keV]	Z (solar)	$F_{X,obs}$ $[10^{-12}\frac{\mathrm{erg}}{\mathrm{cm^2\,s}}]$
AI Tri	1.5	$36.6^{+4.3}_{-4.7}$	$35.8^{+1.5}_{-1.5}$	$13.5^{+5.4}_{-2.5}$	–	$3.4^{+1.4}_{-1.1}$	1.5
QS Tel	1.2	$0.8^{+1.3}_{-0.8}$	$23.2^{+2.9}_{-3.1}$	$0.24^{+0.03}_{-0.03}$	$4.8^{+0.6}_{-0.5}$	$1.2^{+0.4}_{-0.3}$	2.3

QS Tel – Photometry



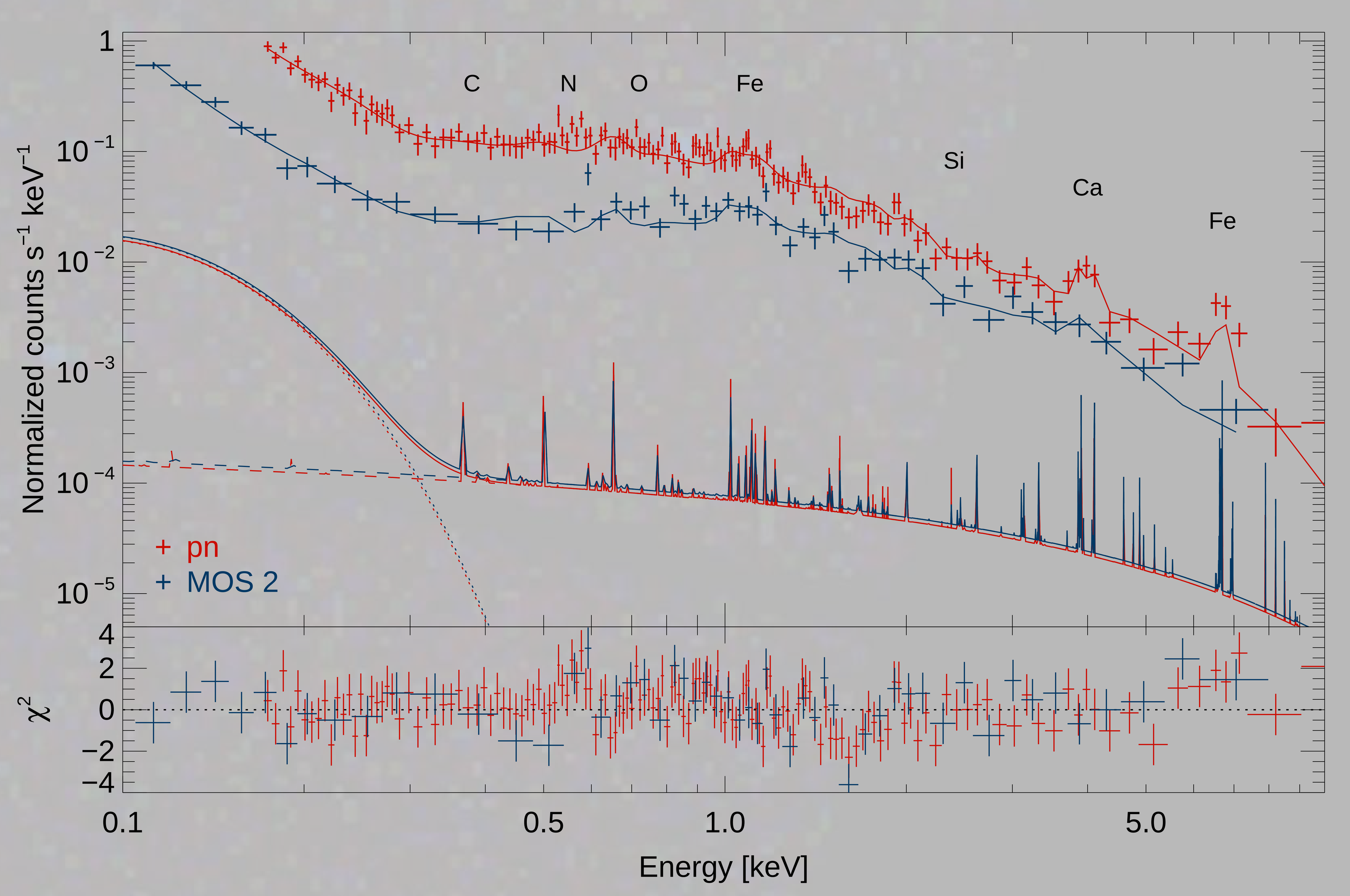
The shape of the complex X-ray light curve of QS Tel, obtained during intermediate high state of accretion, indicates a single active pole at the time of observation. Its bright phase with a double-peaked maximum, somewhat more pronounced in the soft X-ray regime, covers less than half of the orbital period and is disrupted by a deep narrow dip in the soft X-ray emission. The hard X-ray light curve shows a similar shape, but lower amplitude, implying a geometry in which parts of the accretion region as well as of the stream stay visible all the time. In contrary to the nearly constant ultraviolet OM data, the optical light curve is charactarized by a sharp maximum during the bright X-ray phase. In the figure, the data was folded with the orbital period according to the spectroscopical ephemeris derived by Schwope et al. (1995).

AI Tri – Spectroscopy



The best fit to the EPIC spectra of AI Tri is composed of a mildly absorbed blackbody with $kT_{bb} = 35.8^{+1.5}_{-1.5}\,\mathrm{eV}$, associated with the accretion-heated surface of the White Dwarf, plus MEKAL plasma emission (e. g. Mewe et al. 1985; Liedahl et al. 1995) with a mean temperature of $13.5^{+5.4}_{-2.5}\,\mathrm{keV}$, representing the diffuse hot plasma in the post-shock region. Phase-resolved spectral modeling gives nearly identical fits to the two bright phases and supports the picture of a one-pole accreting system which undergoes a self-eclipse of the accretion region. The low hydrogen absorption ($N_H = 3.66^{+0.43}_{-0.47} \cdot 10^{20}\,\mathrm{cm}^{-2}$) lies in the same range as the galactic absorption and is therefore rather of interstellar origin than intrinsic in the system.

QS Tel – Spectroscopy



QS Tel was seen in an intermediate high state of accretion during our *XMM-Newton* observation, about a factor of 20 fainter than expected in high state. Accordingly, the hard spectrum of the accretion column can be described by a multi-component MEKAL model at relatively low temperatures between 0.1 and 5 keV. The soft blackbody component, reflecting the primary's contribution, is barely affected by hydrogen absorption ($N_H \leq 2.5 \cdot 10^{19}\,\mathrm{cm}^{-2}$) and is with $kT_{bb} = 23.2^{+2.9}_{-3.1}\,\mathrm{eV}$ slightly cooler than in AI Tri. In the figure showing the EPIC spectra and a MEKAL model with variable element abundances, Fe Kα and L emission are evident as well as emission lines of C, N, O, Si and Ca indicating moderate overabundance, possibly connected with the composition of the M star secondary.

Conclusions

Although different in detail, the photometrical data of the two systems shows a White Dwarf with a strong magnetic field and one active accretion region, visible over large parts of the orbital period. A combination of mildly absorbed blackbody and plasma emission models turned out to give the best fit available both to the line-rich spectrum of QS Tel and the hotter components of AI Tri. The integrated fluxes of the individual unabsorbed model components indicate an approximate flux balance of $F_{bb} : F_{Mekal} \approx 10 : 1$ for AI Tri and $F_{bb} : F_{Mekal} \approx 6 : 1$ for QS Tel respectively. Evident discrepancies between observed X-ray spectrum and blackbody approximation emphasize the need for accurate models including radiative transfer to reproduce the White Dwarf's contribution in a more realistic way.

References

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