Classical Accreting Pulsars with NICER

Colleen A. Wilson-Hodge
NASA/MSFC
Classical Accreting X-ray Pulsars

- Roche lobe overflow
- Wind accretion
- Be star’s circumstellar disk
Soft X-ray Excesses

Fig. 1.—Observed $N_H$ and unabsorbed fluxes for the XBPs in Table 1 of Bildsten et al. (1997) plus EXO 053109–6609.2. Sources with a known soft excess are shown as stars, while those without are shown as squares. The low-luminosity source X Per is shown as an asterisk (see text for details).


- Soft excesses are very common
- $L_x > 10^{38}$ erg/s – reprocessing by optically thick material at the inner edge of the accretion disk
- $L_x < 10^{36}$ erg/s – photoionized or collisionally heated diffuse gas or thermal emission from the NS surface
- $L_x \sim 10^{37}$ erg/s – either or both types of emission
- NICER observations of soft excesses in bright X-ray pulsars combined with reflection modeling will constrain the ionization state, metallicity and dynamics of the inner edge of the magnetically truncated accretion disk
Figure 3. Swift/BAT pulse frequency history covering this second reversal torque (from 2004 October to the present time). Error bars are smaller than the plotted symbols.

Camero-Arranz et al 2010
Fig. 2. Top panels: Eight Gaussian lines from the 1 keV complex detected by Suzaku, before (left panel) and after (right panel) the 2008 torque reversal. Here the dotted lines in the model denote the components that were fixed. The residuals after fitting only the continuum model are shown in the middle panel, with no line emission included. The bottom panel shows the residuals after fitting the line complex with those 8 lines (see Table 2 for more information about these lines).

Possible Changes in Disk Ionization?

Ballanyne et al. 2012

- Reflection models of an accretion disk for a hard power law
  - Strong soft excess below 3 keV from hot X-ray heated disk
  - For weakly ionized case: strong recombination lines
  - Are we seeing changes in the disk ionization in 4U1626-26?

*Figure 1.* Reflection spectra from a constant density slab irradiated by a power law with a high-energy cutoff (Equation (2)) with $\Gamma = 0.7$, $E_{\text{cut}} = 10$ keV, and $E_{\text{fold}} = 25$ keV (dashed lines). The solid lines plot the reflection spectra for both a weakly ionized slab ($\log \xi = 1.5$) and a strongly ionized one ($\log \xi = 3.0$). The highly irradiated slab produces a strong bremsstrahlung-dominated soft excess at energies $\lesssim 3$ keV.
SMC Pulsars

- 13 years of weekly monitoring with RXTE PCA
- Revealed an unexpectedly large population of Be/X-ray binaries compared to the Milky Way
- Plotted luminosities are typical of “normal” outbursts (once per orbit)
- The SMC provides an excellent opportunity to study a homogenous population of HMXBs with low interstellar absorption for accretion disk studies.


Figure 4. The histogram of the estimated peak X-ray luminosities for the outbursts discussed in this work. The exceptionally large outburst from SXP2.37 is excluded from this plot.
Summary and Future Work

• Monitoring with NICER will enable studies of accretion disk physics in X-ray pulsars
• The SMC provides a potential homogeneous low-absorption population for this study
• NICER monitoring and TOO observations will also provide measurements of spin-frequencies, QPOs, pulsed fluxes, and energy spectra.