Joint X-ray observations of Cygnus X-1 at orbital phase zero

Katja Pottschmidt[1], Manfred Hanke[2], Jörn Wilms[2], Mike Nowak[3], Norbert S. Schulz[3], Julia C. Lee[4], Ingo Kreykenbohm[2], Laura Barragán[2], Felix Fürst[2], Moritz Böck[2], Stefan Pirner[2]

[1] CRESST-UMBC / NASA-GSFC, Greenbelt, MD, United States — [2] Remeis-Observatory & ECAP, FAU, Bamberg, Germany

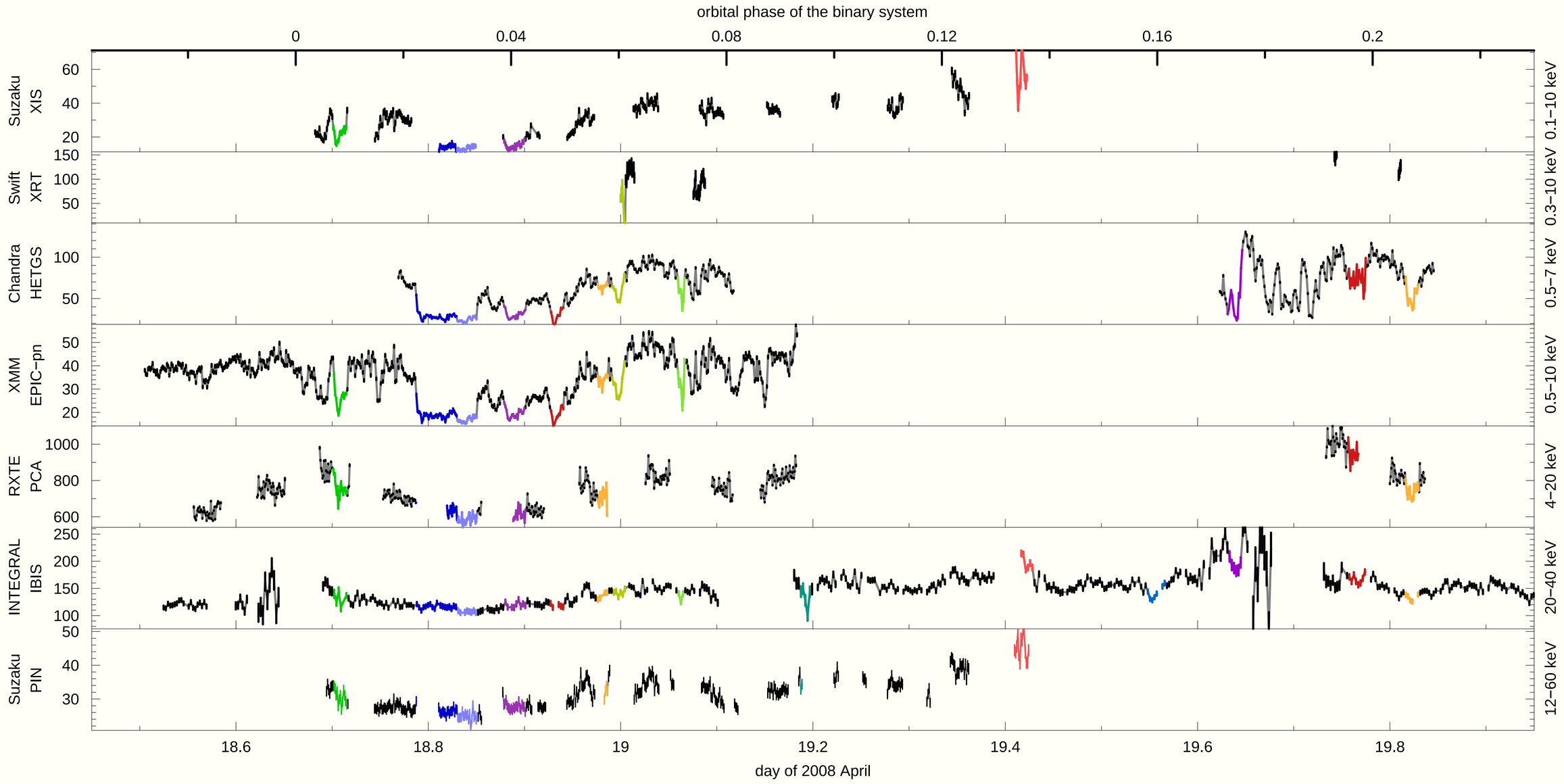
[3] MIT-CXC, Cambridge, MA, United States — [4] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, United States

Abstract

We present first results of simultaneous observations of the high mass X-ray binary Cygnus X-1 for 50 ks with *XMM-Newton*, *Chandra*-HETGS, *RXTE*, *Suzaku*, *INTEGRAL*, and *Swift* in 2008 April. The observations are performed close to phase 0 of the 5.6 d orbit when pronounced dips in the X-ray emission from the black hole are known to occur. The dips are due to highly variable absorption in the focused wind from the O-star companion to the black hole. Compared to previous high resolution spectroscopy studies of the dip and non-dip emission with *Chandra*[a], the addition of *XMM* EPIC-pn and *Suzaku*-XIS data allows for a better determination of the continuum through the broad iron line region, while *RXTE* and *INTEGRAL* constrain the >10keV continuum.

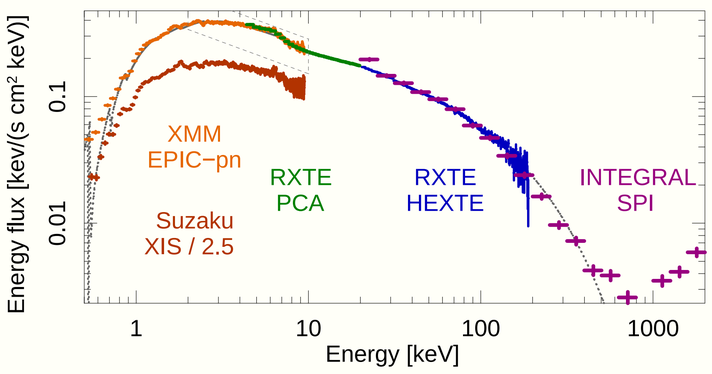
[a] Hanke, Wilms, Nowak, Pottschmidt, Schulz, & Lee (2008), ApJ [submitted]; Hanke, Wilms, Nowak, Pottschmidt, Schulz, & Lee [in preparation]

Lightcurves of Cygnus X-1, observed with various instruments in different energy bands



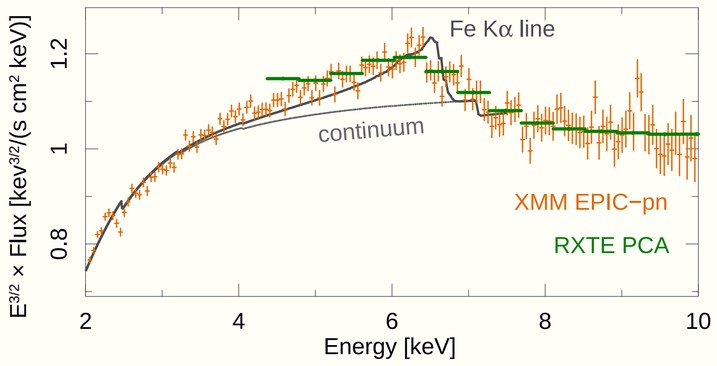
Several absorption dips with complex substructure severely reduce the count rate in the soft X-ray band (*Suzaku*-XIS, *Chandra*-HETGS, *XMM*-EPIC-pn). Some of the dips are also apparent above 4 keV (*RXTE*-PCA), and few appear even in the 20–40 keV band (*INTEGRAL*-IBIS). In order to guide the eye when comparing the different instruments, selected dip-structures are shown in color. Hard X-rays above 12 keV (*INTEGRAL*-IBIS, *Suzaku*-PIN) are influenced by scattering in the wind around orbital phase 0.

The broad-band spectrum



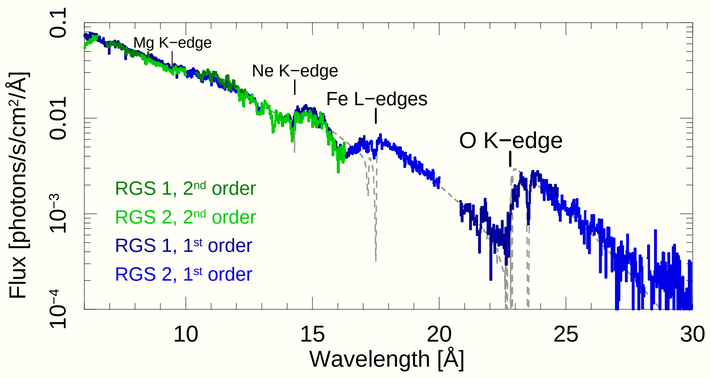
The broad-band spectrum from *XMM*-EPIC-pn, *RXTE*-PCA, *RXTE*-HEXTE, and *INTEGRAL*-SPI can be described by a photoabsorbed broken power law with exponential cut-off, which is typical for the hard state. The SPI data indicate a nonthermal tail above 500 keV.

The iron Kα line



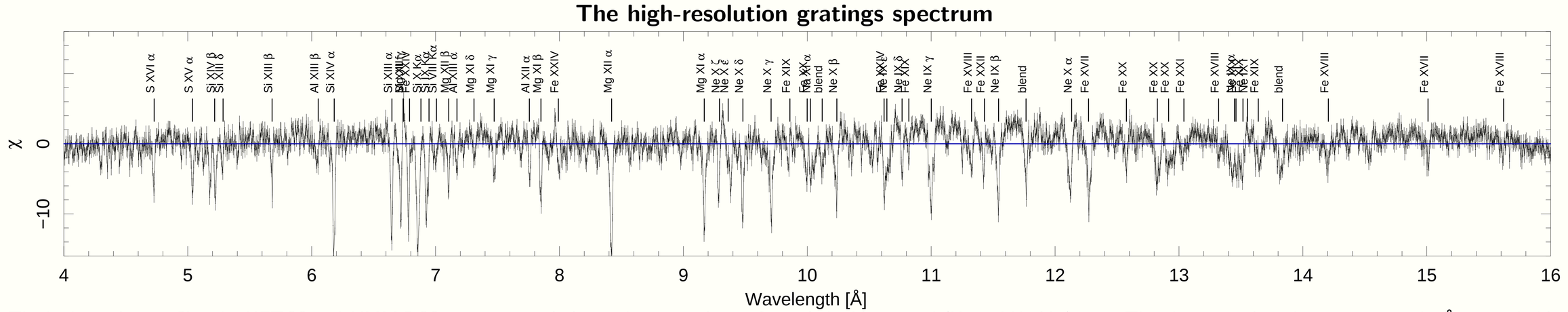
The spectrum measured by *XMM-Newton*'s EPIC-pn camera provides a high enough signal-to-noise ratio at a resolution that allows for the investigation of the relativistically broadened iron Kα line. Within the joint observation, the continuum can be determined more easily.

Soft X-ray absorption edges



The neutral absorption edges (e.g., O-K, Fe-L, Ne-K) seen with *XMM*-RGS show fine-structure, which can be modeled with the photoabsorption model `tbnew` (see `http://pulsar.sternwarte.uni-erlangen.de/wilms`).

The high-resolution gratings spectrum



The high resolution *Chandra*-HETGS and *XMM*-RGS spectra reveal plenty absorption lines of mostly highly ionized (H- and He-like) ions. The absorption lines between 6.6 and 7 Å are probably from lower ionized Si and related to the dips. (All spectra shown on this poster are averaged over dip and non-dip phases.) The absorption lines are formed in the focused wind of the supergiant companion star, which is photoionized by the X-ray source. The analysis of redshifts and equivalent widths (via the curve of growth), which constrains the accretion flow, is still ongoing.

Mh