# Variability in the X-ray warm absorber in GX 339-4

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We have previously reported evidence for a Seyfert-like warm absorber in the stellar-mass Galactic black hole GX 339-4, based on a Chandra/HETGS spectrum obtained during a 75 ksec observation during its 2002-2003 outburst starting on 2003 March 17.8 [1].

The ionized absorption lines detected with this observation were strong, but showed little variability on the timescale of the observation. Variability is perhaps the most important property for ascribing X-ray absorption lines to an accreting source, rather than to absorption in the ISM (which is also a possibility for GX 339-4). There are weak indications for a variable warm absorber in XTE J1650-500 [1]. To search for variability in the putative absorber in GX 339-4, we have analyzed the XMM-Newton/RGS spectra obtained during our 76 ksec observation starting on 2002 Sept. 29.4. Note that the XMM-Newton observation preceded the Chandra observation by half a year. Deconvolution of the broad-band XMM-Newton spectrum gives an unabsorbed 0.5-10.0 keV flux of 2.1 E-8 erg/cm^2/s [2]; the flux during the Chandra observation was 4.2 E-9 erg/cm^2/s [1].

The RGS spectra were reduced using SAS version 5.4.1, and analyzed using ISIS version 1.1.3. To reduce pile-up, single CCDs covering the same wavelength range in the RGS-1 and RGS-2 arrays were read-out for approximately 36 minutes at a time. Comparison with the Chandra/HETGS spectra revealed that pile-up was negligible in the ranges considered here. The spectra were fit jointly; the continua were fit with local power-law spectra and absorption line upper limits were calculated using Gaussians with wavelength and FWHM values fixed to those measured with Chandra [1].

O VIII (18.967 A), Ne II (14.631 A), Ne III (14.526 A), and Ne IX (13.447 A) absorption line equivalent widths of 19(5) mA, 13(1) mA, 11(1) mA, and 17(1) mA (respectively) were measured in the later Chandra/HETGS spectrum. In constrast, the 95% confidence upper limits on these lines in the prior XMM-Newton/RGS spectra are 23 mA, 8 mA, 6 mA, and 2 mA (respectively). Equivalent width is directly related to the absorbing column density. Where the XMM-Newton spectra are most sensitive, it is clear that the column density was significantly lower in the early/bright phase of the outburst, than in the decline of the outburst. Absorption in the coronal ISM provides an attractive explanation for these absorption lines [1], and even the variability measured here cannot definitively rule-out such an explanation. However, this variability strongly suggests that a significant part of the absorbing gas is local to the source, and suggests that the ISM plays a lesser role. A modest disk wind or shell ejection is capable of producing a warm absorber of the kind implied in GX 339-4 [1].

[1] Miller, J. M., et al., 2004a, ApJ, in press, astro-ph/0307394
[2] Miller, J. M., et al., 2004b, ApJ, subm., astro-ph/0312033