Discovery of X–rays from Mars with Chandra

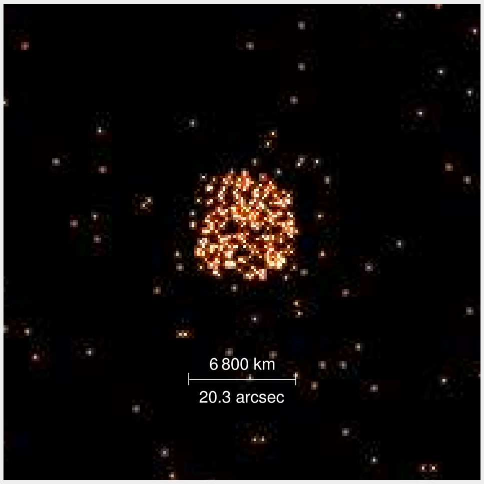

Fig. 1. *First X–ray image of Mars, obtained with Chandra ACIS–I (Dennerl 2002).*

X–rays from Mars were detected for the first time with Chandra. Mars is clearly resolved as an almost fully illuminated disk (Fig. 1), with an indication of limb brightening at the sunward side, accompanied by some fading on the opposite side. The morphology and the X–ray luminosity of ~ 4 MW are fully consistent with fluorescent scattering of solar X–rays in the upper Mars atmosphere. The X–ray spectrum is dominated by a single narrow emission line, which is most likely caused by O–K_α fluorescence. In addition to the X–ray fluorescence, there is evidence for an additional source of X–ray emission, indicated by a faint X–ray halo which can be traced to about three Mars radii, and by an additional component in the X–ray spectrum of Mars, which has a similar spectral shape as the halo. Within the available limited statistics, the spectrum of this component can be characterized by 0.2 keV thermal bremsstrahlung emission. This is indicative of charge exchange interactions between highly charged heavy ions in the solar wind and exospheric hydrogen and oxygen around Mars.

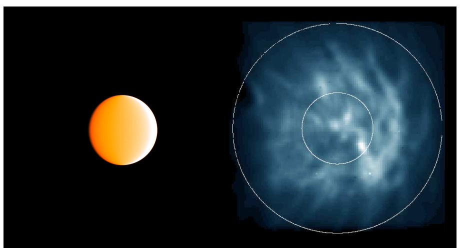

Fig. 2. *Simulated X–ray images due to K_α fluorescent scattering of solar X–rays (left, Dennerl 2002) and due to solar wind charge exchange (right, Gunell et al. 2004).*

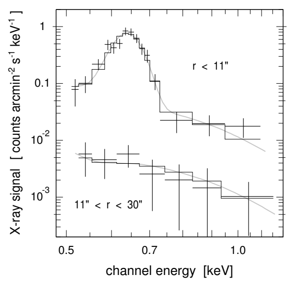

Fig. 3. *X–ray spectra from the disk of Mars (top) and its halo (bottom; Dennerl 2002).*

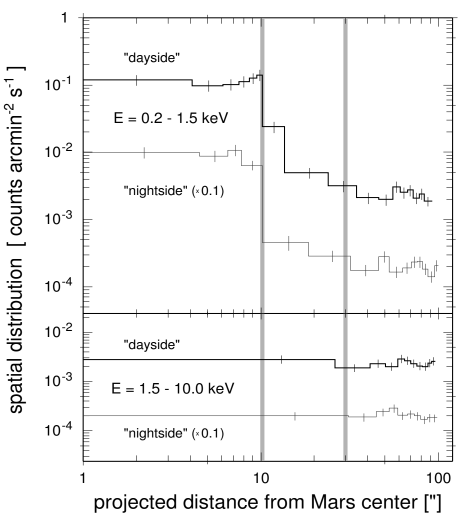

Fig. 4. *X–ray surface brightness for soft (top) and hard (bottom) energies, displayed separately for the "dayside" and the "nightside". For better clarity the nightside histograms were shifted by one decade downward. The two vertical lines mark the radius of Mars and 3 Mars radii. Note the gradual drop of the soft X–ray flux between these radii (Dennerl 2002).*

The detection of a faint X–ray halo around Mars (Figs. 2 - 4) is particularly exciting. This halo is most likely caused by charge exchange interactions between highly ionized heavy solar wind atoms and exospheric gas. Recent detailed simulations of this process by Gunell et al. (2004) agree well with the observation.

The first direct detection of such a mechanism in a planetary exosphere strongly suggests that a similar process occurs also in the geocorona. This result has important consequences for the interpretation of many soft X–ray observations from satellites orbiting the Earth, as these satellites are looking through a faint X–ray glow, which imposes characteristic spectral emission lines onto the diffuse X–ray background.

Mars is an ideal object to investigate this effect: it is sufficiently far away to get the whole halo into the field of view, but still sufficiently close for spatially separating the halo emission from the brighter, fluorescence dominated radiation of its atmosphere.

References: Dennerl, K., *"Discovery of X–rays from Mars with Chandra"*, 2002, A&A 394, 1119 – 1128

Gunell, H., Holmström, M., Kallio, E., Janhunen, P. and Dennerl, K., *"X–rays from solar wind charge exchange at Mars: a comparison of simulations and observations"*, 2004, submitted to GRL

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