X–rays from Mars

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X–ray radiation from Mars was first detected in July 2001 with the satellite Chandra. The main source of this radiation was fluorescent scattering of solar X–rays in its upper atmosphere. In addition, the presence of an extended X–ray halo was indicated, probably resulting from charge exchange interactions between highly charged heavy ions in the solar wind and neutrals in the Martian exosphere. The statistical significance of the X–ray halo, however, was very low.

In November 2003, Mars was observed again in X–rays, this time with the satellite XMM–Newton. This observation, characterized by a considerably higher sensitivity, confirms the presence of the X–ray halo. It also proofs that charge exchange is indeed the origin of the emission. This is the first definite detection of charge exchange induced X–ray emission from the exosphere of another planet.

During the XMM–Newton observation, Mars was a highly variable X–ray source. The X–ray flux observed from close to the planet was clearly correlated with solar flares. However, X–rays from the halo exhibited variations on independent time scales. X–ray spectroscopy reveals that close to the planet the radiation is caused by fluorescence of neutral molecules, while the halo emission results from de-excitation of highly charged ions. Spectral fine structure observed in the O^{6+} emission rules out that the high ionization occurs in the Mars environment.

All these findings are fully consistent with the idea that the X–ray halo is the direct result of charge exchange interactions between atmospheric constituents and solar wind ions. Since this process is considered as an important nonthermal escape mechanism, probably responsible for a significant loss of the Martian atmosphere, X–ray observatins may lead to a better understanding of the present state of the Martian atmosphere and its evolution.

X–ray images of the Martian exosphere in individual emission lines exhibit a highly anisotropic morphology. Most of the emission is observed several 1000 km above the Martian poles. The detailed morphology, however, is different between individual ions and ionization states. With its capability to trace the X–ray emission out to at least 8 Mars radii, XMM–Newton proceeds into exospheric regions far beyond those that have been observationally explored to date. Thus, X–ray observations provide a novel method for studying processes in the Martian exosphere on a global scale.