X–ray emission from Saturn

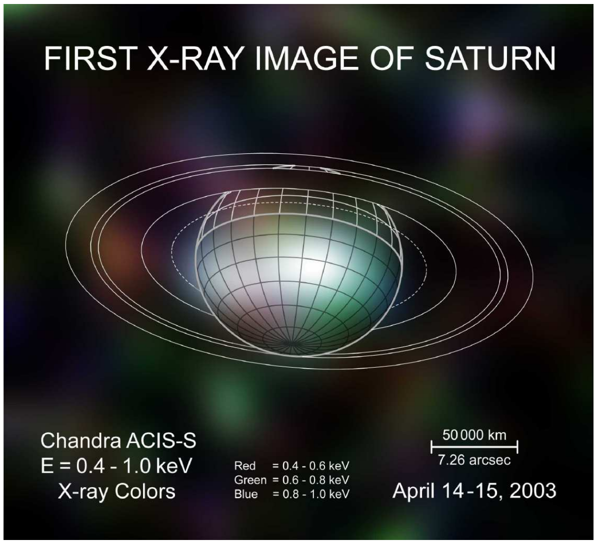

Fig. 1. *The first X–ray image of Saturn, obtained on April 14-15, 2003, with Chandra ACIS–S3. The distribution of the photons was smoothed using a Gaussian with a FWHM of 5 arcsec, and the information about the energy of the X-ray photons was transformed into colors. A drawing of Saturn and its rings at the time of the observation was overlaid for clarity (Ness et al. 2004).*

X–rays from Saturn were unambiguously detected for the first time with Chandra. The X-ray photons were found to come almost exclusively from the southern hemisphere, which is curently tilted toward us. No X–ray photons were detected from the regions which are covered by the rings (Fig. 1). This is an indication that the rings of Saturn are optically thick to X–rays and have a low X–ray albedo. Saturn was found to be a very faint X–ray source: during 18 hours of observing time, Chandra ACIS–S3 detected 106 photons from Saturn. This corresponds to an average of only one photon every 10 minutes. The X–ray flux derived from the best–fit spectral model is $\sim 6.8 \cdot 10^{-15}$ erg cm^{-2} s^{-1} in the energy range 0.1 – 2.0 keV, which corresponds to an X–ray luminosity of ~ 87 MW.

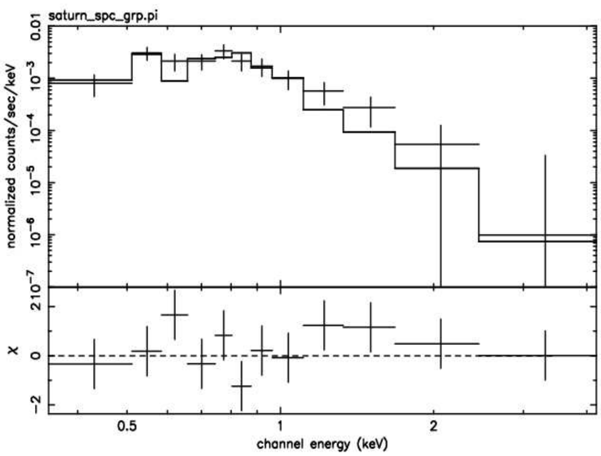

Fig. 2. *Observed ACIS–S3 spectrum of Saturn, modelled with thermal emission of a hot plasma (MEKAL, $kT = 0.39 \pm 0.08$ keV and solar abundances) and a single emission line at 0.527 keV, only instrumentally broadened (Ness et al. 2004).*

Despite the low number of photons, it is difficult to find a simple spectral model which reproduces the measured energy distribution. The only formally acceptable single component model, a 0.18 keV blackbody, is physically not plausible. A 0.39 keV thermal spectrum, with an oxygen fluorescence emission line superimposed, however, provides an acceptable and physically motivated fit (Fig. 2). The oxygen line accounts for one quarter of the energy emitted in the 0.3 – 2.0 keV band. This suggests that the X–rays from Saturn are due to solar X–rays, scattered in its upper atmosphere, by a superposition of elastic scattering, mainly on hydrogen, and fluorescent scattering, mainly on oxygen. The intensity of the oxygen fluorescence line is comparable to that observed from Mars, if the different size of both planets and their different distance from Sun and Earth are taken into account.

The X–ray intensity of Saturn, however, exceeds the intensity which is expected for scattering of solar X–rays, suggesting the presence of an additional emission mechanism. There are similarities between the X–ray emission of Saturn and the equatorial X–ray emission of Jupiter. However, while the X–ray intensity of Jupiter increases towards the magnetic poles, it decreases towards Saturn's south pole.

With this observation, all planets from Venus to Saturn have now been revealed to be X–ray sources, with MPE being involved in more than half of the original discoveries.

Reference: Ness, J.-U., Schmitt, J.H.M.M., Wolk, S.J., Dennerl, K., Burwitz, V., *"X–ray emission from Saturn"*, 2004, A&A 418, 337 – 345

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