Preliminary Results from 2003 Chandra Observations of the Jovian System

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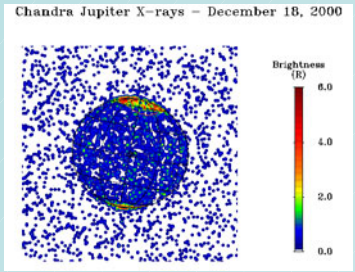
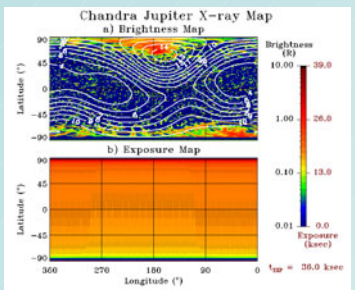
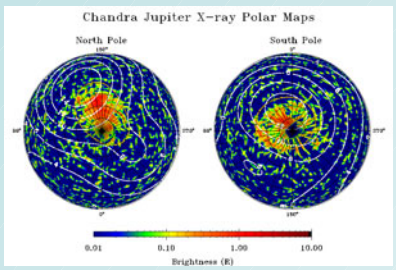
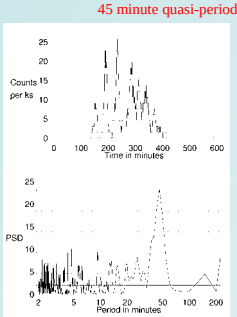






45 minute quasi-periodic oscillations



The Dec, 2000, Chandra HRC-I data from the northern hot spot within the auroral oval showed strong quasiperiodic oscillations at approximately 45 minutes. Cassini solar wind data acquired upstream at 200 Jupiter radii showed no comparable periodicity, even accounting for the 5-10 hour delay time for propagation from the S/C to the planet. However 45 minute variability was seen in the Galileo and Cassini energetic particle and plasma wave measurements at the time of the Chandra observation. Such periodicity is also seen at other times. Oscillations may arise from processes interior to the magnetosphere rather than in the solar wind. (Quasi-periodic radio bursts with a 45 minute timescale were observed for several months from high southern latitudes following the Ulysses flyby of Jupiter.

Feb 24-26, 2003 Simultaneous Chandra/HST Observations

ACIS-S HRC-1 ACIS-S

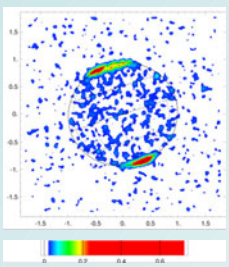
Black bars: HST/STIS F25SRF2 filter
Green bars: HST/STIS with no filter

Introduction

Picture that emerged from ROSAT data: X-ray emission thought to result from charge exchange and excitation of energetic (>1 MeV/nucleon) sulfur and oxygen ions precipitating from the outer edge of the Io Plasma Torus (IPT). S and O ions, originating in Io's volcanoes, are transported outward from the IPT, accelerated by unknown processes in the outer magnetosphere, diffuse back toward Jupiter, and are finally scattered into the Jovian atmosphere by plasma wave interactions at about 8-12 Jupiter radii.

Dec 2000 Chandra HRC-I observations forced a reconsideration of this picture: Most of Jupiter's northern auroral x-rays come from a hot spot located poleward of the main auroral oval and magnetically connected to a region in the outer magnetosphere beyond 30 Jupiter radii. This called into question the association with the outer edge of the IPT and the Io flux tube. The x-ray hot spot is fixed in magnetic latitude and longitude, located at roughly 60-70 degrees north latitude and 160-180 degrees system III longitude.

Feb, 2003, Chandra HRC-I Image of Jupiter



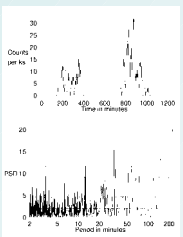
Counts per ks per sq. arcsec (on the sky)

The view of the southern auroral zone was much better for these observations. The image shows the x-ray bright northern and southern polar caps. The emission from the rest of the disk is probably due to reprocessing of solar x-rays.

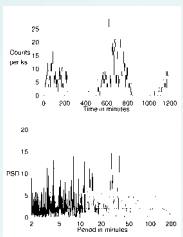
The Feb, 2003, HRC-I count rate from the planet's disk was 0.0362+/-0.0007 c/s versus 0.0656+/-0.0013 c/s in Dec, 2000. The entire Jovian system was fainter in x-rays during the 2003 observations.

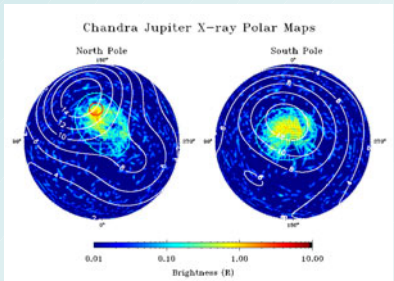
Timing Analysis for Feb, 2003, HRC-I Data

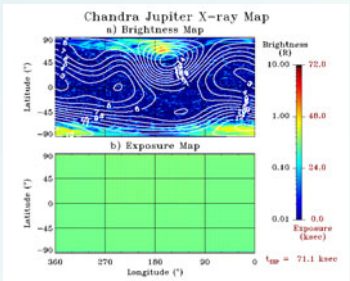
Northern auroral hot spot



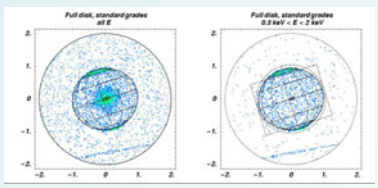
Southern auroral band





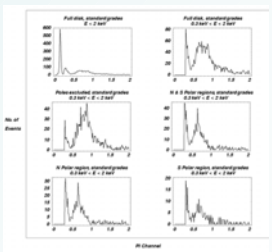


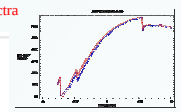
Feb, 2003, Chandra ACIS-S Image



Use of higher event thresholds and restricting the analysis to E > 300 eV has solved the 'red leak' problem that plagued the first ACIS observations of Jupiter. We were thus able to obtain the first moderate resolution x-ray spectra of the auroral zones as well as the planet's disk excluding the auroral zones. The planet itself blocks out the diffuse soft x-ray background.

Feb, 2003, Chandra ACIS-S X-ray Spectra

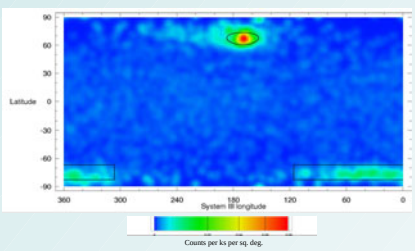




ACIS-S effective area vs. energy

These are the **first** moderate resolution x-ray spectra ever obtained for Jupiter's x-ray emission. The dip in the spectra near 400 eV does not correspond to any feature in the instrument's response, and so any continuum model such as bremsstrahlung is unable to reproduce the observed spectra. For the auroral zones, most likely we are seeing blended lines due to charge exchange involving precipitating oxygen and sulfur ions. Detailed modeling is underway.

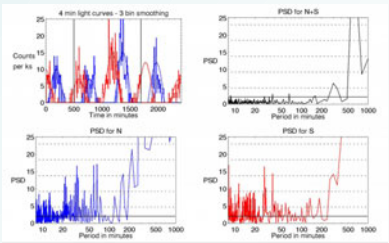
Feb, 2003, X-ray Map: HRC + Both ACIS Exposures



The northern polar emission is mostly confined to a hot spot. The southern polar emission is more spread out in longitude and out of phase with the northern emission. The regions outlined in black were used to select events for the timing analysis.

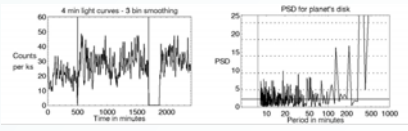
Timing Analysis for Feb, 2003: HRC + Both ACIS Exposures

Auroral Zones



Timing Analysis for Feb, 2003: HRC + Both ACIS Exposures

Planetary Disk Excluding Auroral Zones



The 45 minute oscillations seen in Dec, 2000, are not present in these data. However, the power spectra at periods between 10 and 100 min shows three significant peaks for the northern auroral zone and two for the southern auroral zone. No significant peaks at periods shorter than 100 min are seen in the power spectrum for the planet's disk excluding the auroral zones.

	P (min)	Pr		P (min)	Pr
North	65	0.00019	South	37	0.00073
	59	0.00022		28	0.00028
	33	0.00024			