Chandra observations of Jupiter's X-ray aurora during Juno upstream and apojove intervals

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1. ABSTRACT

The Chandra space telescope has recently conducted a number of campaigns to observe Jupiter's X-ray aurora. The first set of campaigns took place in summer 2016 while the Juno spacecraft was upstream of the planet sampling the solar wind. The second set of campaigns took place in February, June and August 2017 at times when the Juno spacecraft was at apojove (expected close to the magnetopause). We report on these upstream and apojove campaigns including intensities and periodicities of auroral X-ray emissions. This new era of jovian X-ray astronomy means we have more data than ever before, long observing windows (up to 72 ks for this Chandra set), and successive observations relatively closely spaced in time. These features combine to allow us to pursue novel methods for examining periodicities in the X-ray emission. Our work will explore significance testing of emerging periodicities, and the search for coherence in X-ray pulsing over weeks and months, seeking to understand the robustness and regularity of previously reported hot spot X-ray emissions. The periods that emerge from our analysis will be compared against those which emerge from radio and UV wavelengths.

2. Dataset and analysis method

- Correction applied to raw Chandra image to account for motion of Jupiter across the FOV
- Manual extraction of northern and southern auroral zones (emission dominates background)
- Disk poorly defined during times of low solar X-ray flux
- Northern hot spot: longitude 155 to 190°, latitude 60 to 80° [after Gladstone et al., 2002]
- Southern hot spot: longitude 0 to 90°, latitude -90 to -70° [after Dunn et al., 2017]

3. Periodicities in auroral X-ray emissions

Previously reported periodicities in jovian X-rays: northern hot spot ~45 minutes [Gladstone et al., 2002], southern hot spot ~11 minutes [Dunn et al., 2017].

In the 24 pre-Juno era Chandra observations (Fig. 2), only 2 statistically significant periods found (~45 minutes and ~33 minutes in the north).

4. Case study with significant periodicity

- Statistically significant 37-minute quasi-period from northern hot spot on June 18th 2017 apojove observation.

- Lomb-Scargle periodogram of unsmoothed, 60-second binned light curve data (B, C). Log-power per frequency goes up to ~13.6, 37-minute period. Monte Carlo analysis (D): initial period randomly shuffled, then Lomb periodogram carried out. Process repeated 10,000 times. Histogram of maximum powers shown (plus cumulative distribution in red). The highest power associated with the real (unshuffled) data is at the 99.99th percentile (~7.7 sigma result assuming a normal distribution).

5. Summary statistics

- Analysis of 5 X-ray observation (2 Juno upstream, 3 Juno apojove):
  - Periodic pulsing may be confined to a spatially limited hot spot region [June 1st 2016 southern hot spot (Dunn et al., 2017)]
  - Orbit-to-orbit variability present in jovian X-rays [June 18th 2017]
  - Northern photon counts consistently higher than south... Primarily visibility effect.
  - Periodic pulsing is relatively rare... what light can this shed on possible drivers of jovian X-rays?

REFERENCES