

Temperature Structures above Coronal Hole and Quiet Sun derived with “*Hinode*” / XRT

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Abstract

The X-ray Telescope (XRT) on board the *Hinode* satellite has the capability to derive coronal temperature with the filter ratio method. To derive the height dependence of the temperature above the solar limb, we used the solar eclipse data, and carefully estimated the scattered light from the disk corona. The temperature in polar plumes surrounding the south coronal hole increases with height until 100Mm, and stays at the constant level or decreases above. It may suggest that coronal heating is taking place around 100Mm height. The temperature gradient below 100Mm is consistent with the conductive flux of $0.9\text{-}1.5 \times 10^6$ erg/sec/cm². However, the temperature above a quiet Sun region decreases with height. The temperature structure is probably suggest a scaling low between temperature and size of closed loops in quiet Sun.

Data & Analysis

At the orbit of the *Hinode* satellite, the Moon occulted the Sun once on February 17, 2007 and three times on March 19, 2007. We used two partial occultations; one for the southern polar region and the other for north-east quiet Sun.

Eclipse on February 17, 2007

- The Moon passed the south polar limb (Fig 1a) during 16:06–16:13UT.
- XRT observed with “Al/Mesh” filter and “Ti/Poly” filter.
- 6 pairs before/after the occultation & 2 pairs during the occultation.

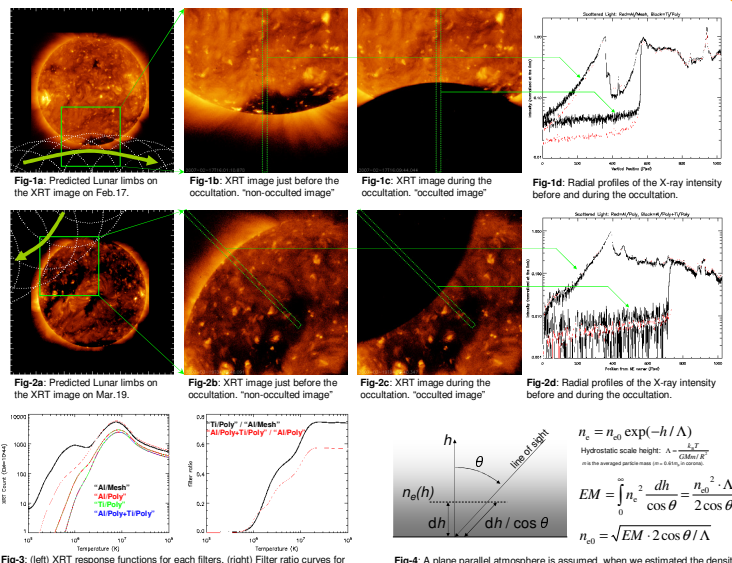
Eclipse on March 19, 2007

- The Moon passed the north-east limb (Fig 2a) during 04:21–04:28UT.
- XRT observed with “Al/Poly” filter and “Al/Poly+Ti/Poly” filter.
- 4 pairs before/after the occultation & 2 pairs during the occultation.

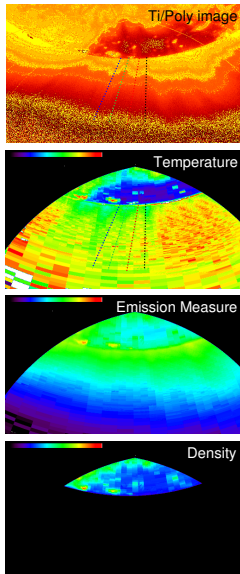
Because the Moon occulted a small and faint region in the solar corona, we assumed the there was no significant change in the spatial distribution of the scattered light during each observations. Fig-1d and 2d show the scattered light is non-negligible for the analysis over the limb.

After the usual data calibration for X-ray images, we subtracted “occulted image” from “non-occulted image”, and then utilized the filter-ratio method (Fig 3) to derive temperature and emission measure in the region which was occulted by the Moon in all of the “occulted images”.

For structures in a solar disk, we estimated a base density from the emission measure by assuming a plane-parallel atmosphere (Fig 4).



Results above Coronal Hole



Features on the solar disk.

Fig 5 shows the coronal hole is cooler than the surrounding quiet Sun.

- Coronal Hole: $1.0 \sim 1.5$ MK, $0.5 \times 10^8 \sim 1.0 \times 10^8$ cm⁻³
- X-ray Bright Points: >1.5 MK, $1.0 \times 10^8 \sim 2.5 \times 10^8$ cm⁻³

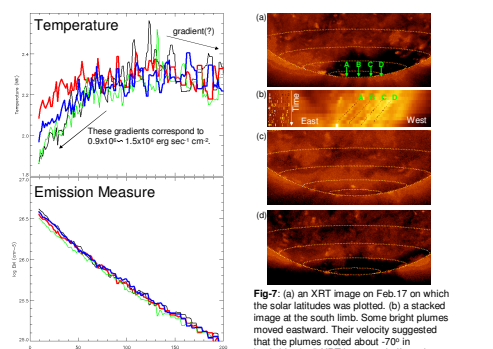


Fig-6: Temperature and Emission Measure profiles along bright plumes (red and blue) and dark plumes (black and green) seen above the coronal hole. Fig-7: (a) an XRT image on Feb.17 on which the solar latitudes was plotted. (b) a stacked image at the south limb. (c-d) XRT images a half rotation before and after the eclipse. The coronal hole boundary was located about -70°.

Plums above the solar limb.

- Temperature increases with height until $h=100$ Mm. The gradient corresponds to the conductive flux of $0.9 \times 10^6 \sim 1.5 \times 10^6$ erg sec⁻¹ cm⁻²
- Above that, it is constant (or it might decrease with height).
- At the bottom, brighter plumes have higher temperature than dark plumes.
- Fig 7 suggests the plumes rooted around the coronal hole boundary in backside at the timing of the solar eclipse.

Results above Quiet Sun

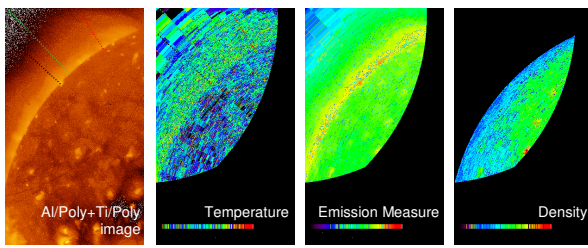


Fig-8: Maps for X-ray intensity, Temperature, Emission Measure and (Base) Density derived from the eclipse on March 19. White lines show the lunar limb in four “occulted images”. In the density map, the solar limb is also shown by another white line.

Features on the solar disk.

- Quiet Sun: $1.7 \sim 2.0$ MK, $0.5 \times 10^8 \sim 1.5 \times 10^8$ cm⁻³
- X-ray Bright Points: ~ 2.2 MK, $1.5 \times 10^8 \sim 2.5 \times 10^8$ cm⁻³

Structures above the solar limb.

- Temperature decreases with height.
- Above the quiet Sun, corona is probably filled with a variety of closed magnetic loops.
- The temperature structure is probably suggest a scaling low between temperature and size of closed loops in quiet Sun.

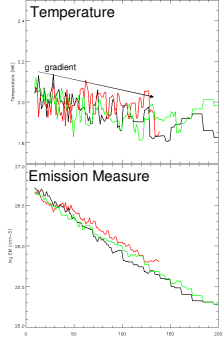


Fig-9: Vertical structures of Temperature and Emission Measure along the lines shown in Fig 8.