Multiplicity of Solar X-Ray Corona in Time and Space

--- initial views by "HINODE" XRT ---

R. Kano, H. Hara (NAOJ), and the XRT team
Instruments aboard “Hinode”

**SOT**: Solar Optical Telescope
Magnetic Activities at Photosphere

**EIS**: EUV Imaging Spectrometer
Dynamics in Transition Region & Corona.

**XRT**: X-Ray Telescope
Coronal Activities

“Coronal Heating”
How are coronal structures heated?
Solar Atmosphere and Target for Each Instruments

- SOT
- EIS
- XRT
Targets of XRT Observations

• Photosphere/Corona Coupling
  – Can a direct connection be established between coronal and photospheric events?

• Coronal Heating
  – How do coronal structures brighten?

– Coronal Loop Structures & Coronal Loop Heating

• Flare Energetics
  – What are the relations to the photospheric magnetic fields?

• CMEs, Jets and other coronal dynamical events
SXT Loops vs. EIT/TRACE Loops

Are they really different? Are they heated in a different way?

- We would like to observe all of the coronal plasma with a single telescope.
- However, we would like to distinguish between SXT loops and EIT/TRACE loops. (Importance of temperature diagnostics.)

Do **SXT** loops have a dense plasma at the top? Is it an apparent feature in a loop (by change of filling factor)?

- **EIS** can derive the coronal density with density-sensitive line pairs. (Importance of the coordinated observation between **EIS** and **XRT**.)

Kano & Tsuneta (1996, PASJ)  
# HINODE/XRT vs. Yohkoh/SXT

<table>
<thead>
<tr>
<th></th>
<th>HINODE/XRT</th>
<th>Yohkoh/SXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Optics</td>
<td>Grazing Incidence</td>
<td>Grazing Incidence</td>
</tr>
<tr>
<td>FOV</td>
<td>34 arcmin</td>
<td>42 arcmin</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>1 arcsec</td>
<td>2.5 arcsec</td>
</tr>
<tr>
<td>PSF FWHM</td>
<td>&lt;1 arcsec @ center</td>
<td>~ 3 arcsec</td>
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<tr>
<td>Bandpass</td>
<td>3 ~ 200Å</td>
<td>3 ~ 45Å</td>
</tr>
<tr>
<td>Temp. Coverage</td>
<td>1MK ~ 30MK</td>
<td>3MK ~ 30MK</td>
</tr>
<tr>
<td>Time Cadence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Frame, Full-res.</td>
<td>min 9.5sec</td>
<td>256sec (Half Frame)</td>
</tr>
<tr>
<td>Full Frame, Half-res.</td>
<td>min 5.0sec avg. 102sec</td>
<td>128sec</td>
</tr>
<tr>
<td>Partial Frame, Full-res. (FOV = 300”~400”</td>
<td>min 2.0sec avg. 15sec</td>
<td>8 sec in flare mode 32 sec in Quiet mode</td>
</tr>
<tr>
<td>Other New Items</td>
<td>Pre-flare Buffer Focus Mechanism</td>
<td>----</td>
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</table>
XRT characteristics

• Temperature Response
  – TRACE-like image and SXT-like image

• Field-of-View and Spatial Resolution
  – Focus Mechanism

• Observation control by MDP
  – Table Observation
  – Image Compression
  – Time Cadences
  – Preflare Buffer
**X-ray Analysis Filters**

- **XRT** has 9 X-ray analysis filters and a G-Band filter.

<table>
<thead>
<tr>
<th>Name</th>
<th>Metal</th>
<th>Metal Thickness</th>
<th>Substrate</th>
<th>Substrate Thickness</th>
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<tbody>
<tr>
<td>Thin-Al/Mesh</td>
<td>Al</td>
<td>1600 Å</td>
<td>Mesh</td>
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<tr>
<td>Thin-Al/Poly</td>
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<td>1250 Å</td>
<td>Polyimide</td>
<td>2500 Å</td>
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<tr>
<td>C/Poly</td>
<td>C</td>
<td>6000 Å</td>
<td>Polyimide</td>
<td>2500 Å</td>
</tr>
<tr>
<td>Ti/Poly</td>
<td>Ti</td>
<td>3000 Å</td>
<td>Polyimide</td>
<td>2300 Å</td>
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<td>Thin-Be</td>
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<td>9 µm</td>
<td>Mesh</td>
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<tr>
<td>Med-Al</td>
<td>Al</td>
<td>12.5 µm</td>
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<tr>
<td>Med-Be</td>
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<td>30 µm</td>
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<td>Thick-Al</td>
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<td>25 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick-Be</td>
<td>Be</td>
<td>300 µm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
XRT Temperature Response

TRACE-like

SXT-like

Count from unit EM

Plasma Temperature (log K)
• To point SOT at a certain target on the solar disk, we have to change HINODE pointing. Therefore, XRT will not always observe the full solar disk.

• Many varieties of FOV size are available.

• Especially, for high-res.-observation, we recommend FOV= 1024”x1024” around CCD center.
Aberration at Different Focus Pos.

(Only Geometrical Optics)

$\varphi_{512''}$  $\varphi_{1024''}$

RMS = $\varphi_{1''}$

Distance from the Center

Field Angle (arcmin)
Observation of XRT

Mission Data Processor

- Observation Tables
- Autonomous Functions
  - Exposure Control
  - Region Selection
  - Flare Detection
- Image Compression
- Pre-Flare Buffer

Data Recorder

SOT

EIS
Flare Observation

**XRT**
- Detect a flare.
- Report the location to all telescopes.
- Switch the current observation to **Flare** one.
- Lock the Pre-Flare Buffer.
- (There is an option not to switch to Flare observation.)

**SOT**
- Switch the current observation to **Flare** one, if the flare location is in **SOT**-FOV.
- (There is an option not to switch to Flare observation.)

**EIS**
- Switch the current observation to **Flare** one, if the flare location is in **EIS**-FOV.
- (There is an option not to switch to Flare observation.)
Solar Corona observed with X-Ray Telescope

- **Coronal Holes**
  - X-ray Bright Points
- **Quiet Sun**
  - Formation of Arcade Structures associated with Filament Disappearance
  - Streamers
- **Active Regions**
  - Flares, Micro-flares
  - Jets, Coronal Mass Ejection
  - Thermal Structures for (quasi-Steady) Coronal Loops
X-ray Bright Points

28 October 2006
Flare

Thinner Metal Filter

Thicker Metal Filter
Micro Flares (1)

Al/Poly.
Micro Flares (2)
Summary

- **XRT** has high sensitivity for low (1MK) temperature plasma, as well as high temperature plasma.
- **XRT** has the highest spatial resolution as GI imager.
  - **Pixel Size = 1 arcsec**
- **Observation Tables** respond to various observations.
- **Autonomous functions** support **XRT** automatic operation.
- Observers can select types of **Image Compression**
- **Built-in visible light optic** allows us to align **XRT** images with **SOT** images with sub-arcsec accuracy.