

EGU21-13004

<https://doi.org/10.5194/egusphere-egu21-13004>

EGU General Assembly 2021

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Detailed Calibration of the Off-Axis Optical Characteristics for the X-Ray Telescope onboard Hinode

Junho Shin¹, Ryouhei Kano², Takashi Sakurai², Yeon-Han Kim³, and Yong-Jae Moon¹

¹Kyung Hee University, School of Space Research, Yongin, Korea, Republic of (junhosn@khu.ac.kr)

²Solar Science Observatory, NAOJ, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

³Solar and Space Weather Research Group, Korea Astronomy and Space Science Institute, Daejeon 305-348, Korea, Republic of

The X-Ray Telescope (XRT) onboard the Hinode satellite has a specially designed Wolter type grazing-incidence (GI) optics with a paraboloid-hyperboloid mirror assembly to measure the solar coronal plasma of temperatures up to 10 MK with a resolution of about one arc sec. One of the main purposes of this scientific mission is to investigate the detailed mechanism of energy transfer processes from the photosphere to the upper coronal region leading to its heating and the solar wind acceleration. An astronomical telescope is in general designed such that the best-focused image of an object is achieved at or very close to the optical axis, and inevitably the optical performance deteriorates away from the on-axis position. The Sun is, however, a large astronomical object and thus targets near the limb of full-disk images are placed at the outskirts of the field of view. The design of a solar telescope should thus consider the uniformity of imaging quality over a wide FOV, and it is particularly so for X-ray telescopes whose targets can be in the corona high above the limb.

We will explain in this presentation the importance of detailed calibration of the off-axis optical characteristics for Hinode/XRT. It has been revealed that the scattered light caused by the GI mirror surface has a power-law distribution and shows an energy dependence. We will also introduce the basic scheme of how the level of scattering wing is determined and connected to the core from the analysis of highly saturated in-flight data. Vignetting is another important optical characteristic for describing the telescope's performance, which reflects the ability to collect incoming light at different locations and photon energies. We have evaluated the vignetting effect in Hinode/XRT by analyzing the ground experimental data and found that the degree of vignetting varies linearly from the optical center and its pattern shows an energy dependence. Many interesting results on the calibration of Hinode/XRT optical characteristics will be introduced and discussed thoroughly.