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The Solar Optical Telescope for the *Hinode* Mission: An Overview

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Abstract The Solar Optical Telescope (SOT) aboard the *Hinode* satellite (formerly called *Solar-B*) consists of the Optical Telescope Assembly (OTA) and the Focal Plane Package (FPP). The OTA is a 50-cm diffraction-limited Gregorian telescope, and the FPP includes the narrowband filtergraph (NFI) and the broadband filtergraph (BFI), plus the Stokes Spectro-Polarimeter (SP). The SOT provides unprecedented high-resolution photometric and vector magnetic images of the photosphere and chromosphere with a very stable point spread function and is equipped with an image-stabilization system with performance better than 0.01 arcsec rms. Together with the other two instruments on *Hinode* (the X-Ray Telescope

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(XRT) and the EUV Imaging Spectrometer (EIS)), the SOT is poised to address many fundamental questions about solar magnetohydrodynamics. This paper provides an overview; the details of the instrument are presented in a series of companion papers.

Keywords Solar-B · Hinode · Sun: magnetic fields · Sun: photosphere · Sun: chromosphere · Sun: MHD

1. Introduction

The Sun has strong magnetic fields and emits intense X-rays from its outer atmosphere. Though observations with the *Yohkoh* satellite point to magnetic reconnection as a necessary ingredient for sporadic coronal heating on various scales from major flares to ubiquitous tiny bursts (Tsuneta, 1996; Yoshida and Tsuneta, 1996), the specific mechanisms of coronal and chromospheric heating remain essentially unknown. Recent progress from ground-based observations show that the solar magnetic field consists of an ensemble of fine-scale ($\approx 0.1'' - 0.2''$) magnetic fields in addition to sunspots and pores (Solanki, Inhester, and Schüssler, 2006). Detailed properties of solar magnetic fields are, however, still unknown owing to limitations of spatial resolution and accuracy of magnetic field measurements.

Solar magnetic fields are believed to arise as a result of a global dynamo operating at the base of the convection zone, and also possibly from a local dynamo process (Cattaneo, 1999). Ultimately, we need to improve our knowledge of the solar interior to fully understand the dynamo mechanisms. Even so, the emergence, dispersal, and decay of magnetic features at and above the solar photosphere provide an extremely valuable tool for exploring the mechanism of how magnetic flux is generated in the interior and is transported to the surface (Fisher *et al.*, 2000).

The main objective of the *Solar-B* (renamed *Hinode* after launch; Kosugi *et al.*, 2007; Figure 1) mission is to use a systems approach to understand the generation, transport, and ultimate dissipation of solar magnetic fields with a complex of three coordinated telescopes. For this purpose, *Hinode* carries the X-ray Telescope (XRT; Golub *et al.*, 2007; Kano *et al.*, 2007), the EUV Imaging Spectrometer (EIS; Culhane *et al.*, 2007), and the Solar Optical Telescope (SOT). The energy release and dissipation phase of the magnetic fields are observed with the XRT and EIS; the SOT performs high-resolution photometric and magnetic observations of the magnetic flux emergence and their subsequent evolution in the photosphere and chromosphere. The uniqueness of the *Hinode* mission is in using its coordinated and simultaneous observations of the photosphere, the chromosphere, the transition region, and the corona to understand how the changing photospheric and chromospheric magnetic fields results in the dynamic response of the coronal plasma.

In the early concept design phase of 1995 – 1996, the baseline configuration of the SOT was established to be a 50-cm diffraction-limited ($0.2'' - 0.3''$) telescope with both a filtergraph and a spectropolarimeter, by considering a balance between the scientific advantage over existing ground-based observations and technical constraints. The filtergraph was needed for high spatial and temporal resolution of the photometric and magnetic observations for both the photosphere and the chromosphere, whereas the spectropolarimeter was needed for precise observations of vector magnetic fields. In the course of the 10-year development, progress in high-resolution ground-based observations has been remarkable: The Swedish Solar Telescope (SST; *e.g.*, Scharmer *et al.*, 2002) delivered $\approx 0.1''$ photometric images and $\approx 0.2''$ longitudinal magnetograms. Spectropolarimetric observations with the German Vacuum Tower Telescope (VTT; *e.g.*, Bello Gonzalez *et al.*, 2005) and the Dunn