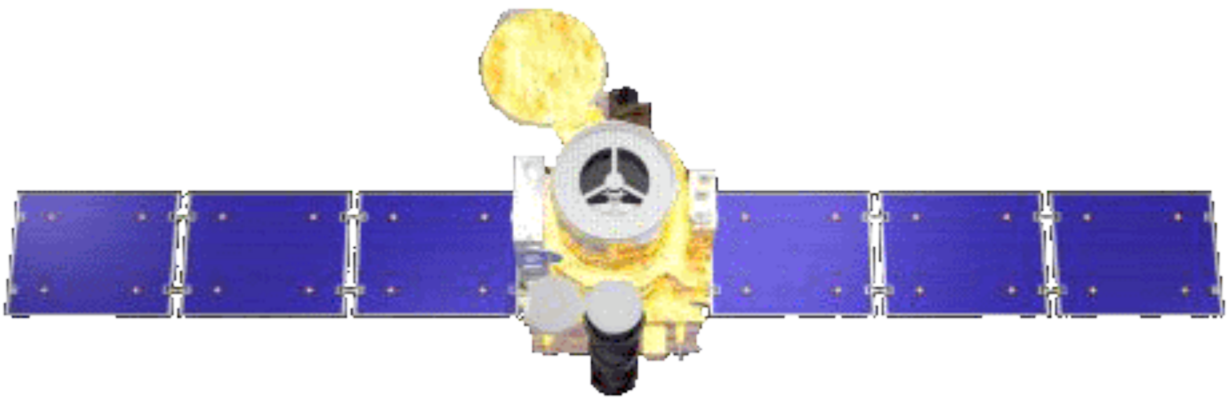
Hinode Solar Optical Telescope Data Analysis Guide



Author	Date	Version Number
Neal Hurlburt	25 June 2007	1.00
Greg Slater	19 October 2007	2.2
Ted Tarbell	11 November 2007	2.2a_TDT
Tom Berger	12 November 2007	3.0
Greg Slater	14 November 2007	3.1
Yukio Katsukawa	23 January 2008	3.2

Table of Contents

TABLE OF CONTENTS 2

INTRODUCTION 4

I. SOT INSTRUMENT GUIDE 5

SOT OVERVIEW 5

BROADBAND FILTER IMAGER (BFI) 8

BFI Observables 8

NARROWBAND FILTER IMAGER (NFI) 11

NFI Observables 12

SPECTROPOLARIMETER (SP) 17

SP Observables 17

II SOT DATA ANALYSIS GUIDE 19

A. OVERVIEW OF THE DATA ANALYSIS PIPELINE 19

1. Data Transport 19

2. Data Products 19

B. ACCESSING SOT DATA 20

1. Web Browser Access 20

2. IDL Session Access 20

C. SOT DATA ANALYSIS EXAMPLES 21

Example fg_demo01: 09-December-2006 Data Analysis 21

Example sp_demo01: accessing and displaying remote Level-1 SP data 27

Example sp_demo02: Analyzing SP Data using sp_prep 28

DATA POLICY 32

OTHER USEFUL ROUTINES 34

APPENDIX A. SOT SSW ROUTINE LIST 36

APPENDIX B: MISCELLANEOUS USEFUL SOFTWARE 41

APPENDIX C: SOT CATALOG STRUCTURE TAGS 42

APPENDIX D: SOT FITS HEADER TAGS 44

FG 44

SP 48

APPENDIX E: RELEVANT WEB LINKS TO INSTRUMENT AND DATA SITES 52

Introduction

This document describes how to access and process SOT data for scientific analysis. Section I is an overview of the SOT instrument and operational modes. Section II offers examples on how to calibrate and analyze SOT data using the SolarSoft package for the IDL data language. Further details on the SOT instrument, and mission operations, etc can be found on the SOT webpages http://sot.lmsal.com/ and http://solar-b.nao.ac.jp/sot_e/index_e.shtml. Details on IDL can be found at http://www.ittvis.com/idl. Further information on SolarSoft can be found at http://www.lmsal.com/solarsoft/ssw_whatitis.html.

I. SOT Instrument Guide

SOT Overview

Hinode is a joint mission between the space agencies of Japan, United States, Europe, and United Kingdom. The spacecraft carries three instruments: the Solar Optical Telescope (SOT), the Extreme Ultraviolet Imaging Spectrometer (EIS) and the X-Ray Telescope (XRT). Together, they are designed to provide multi-wavelength data from the photosphere to the upper corona. The 875-kg craft was launched on September 23, 2006 into a polar, sun-synchronous orbit at 600 kilometers with an inclination of -98^{o} allowing 9 months of continuous observations and a 3-month eclipse season. Hinode provides approximately 20 GB of data daily. The baseline duration of the mission is 3 years. Currently XRT, SOT and EIS are operated from the Institute of Space and Astronautical Science (ISAS) in Sagamihara, Japan.

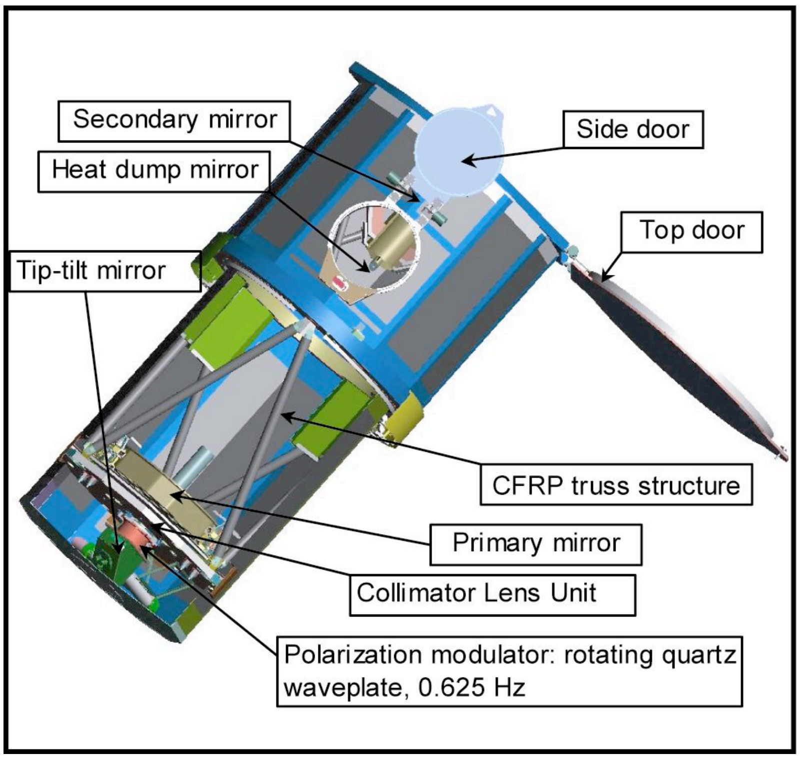


***Figure 1**. The SOT Optical Telescope Assembly (OTA)*

The SOT/OTA is a diffraction-limited Gregorian telescope with a 0.5 meter aperture. The distance between the primary and secondary vertices is about 1.5 meters. The field of view is approximately 360 x 200 arcsec^2. The wavelength band observed is between 380 nm and 670 nm. The OTA is provided by ISAS and NAOJ. They also provide the tip-tilt mirror (TTM) assembly, which is an integral part of the SOT Image Stabilization System.

The SOT's instrument package, provided by NASA/LMSAL and referred to as the Focal Plane Package (FPP), contains four distinct sub-systems:

- The Broad-band Filter Imager (BFI)
- The Narrow-band Filter Imager (NFI)
- The Spectropolarimeter (SP)
- Correlation Tracker (CT)

Figure 1 shows a schematic of the Optical Telescope Assembly (OTA) of the SOT. Figure 2 shows the layout of the optics of the FPP.

The SOT provides quantitative measurements of the Sun's full vector magnetic field on spatial scales of 150 to 200 km over a field of view large enough to contain small active regions. The instrument fields of view, sensitivities, and cadence allow changes in the Sun's magnetic energy to be related to both steady state (coronal heating) and transient (flares, coronal mass ejections) changes in the solar atmosphere.

The FPP broadband filter imager (BFI) records diffraction-limited images, over a range of wavelengths from 388.3 nm to 668.4 nm, to observe both photospheric and chromospheric structure under quiet and active solar conditions. Irradiance data will be obtained over this time period from observations in the blue (450.4 nm), green (555.0 nm) and red (668.4 nm) continuum.

The FPP narrowband filter imager (NFI) records high spatial resolution (250 km) rapid, six frames per hour, for large (320 x 160 arcsec^2) field of view, moderate polarimetric accuracy (4x10^{-3}) magnetograms over the full range of magnetic conditions from quiet sun to moderate scale active regions. The filtergraph images are recorded on a dedicated camera using a 4096 x 2048 pixel, frame transfer, CCD camera. Full or partial frames can be recorded.

The SOT Spectro-Polarimeter records the photospheric vector magnetic fields of both quiet and active regions with the highest possible precision (polarimetric accuracy better than 10^{-3}), observing changes in the vector magnetic field over spatial scales of 250 km.

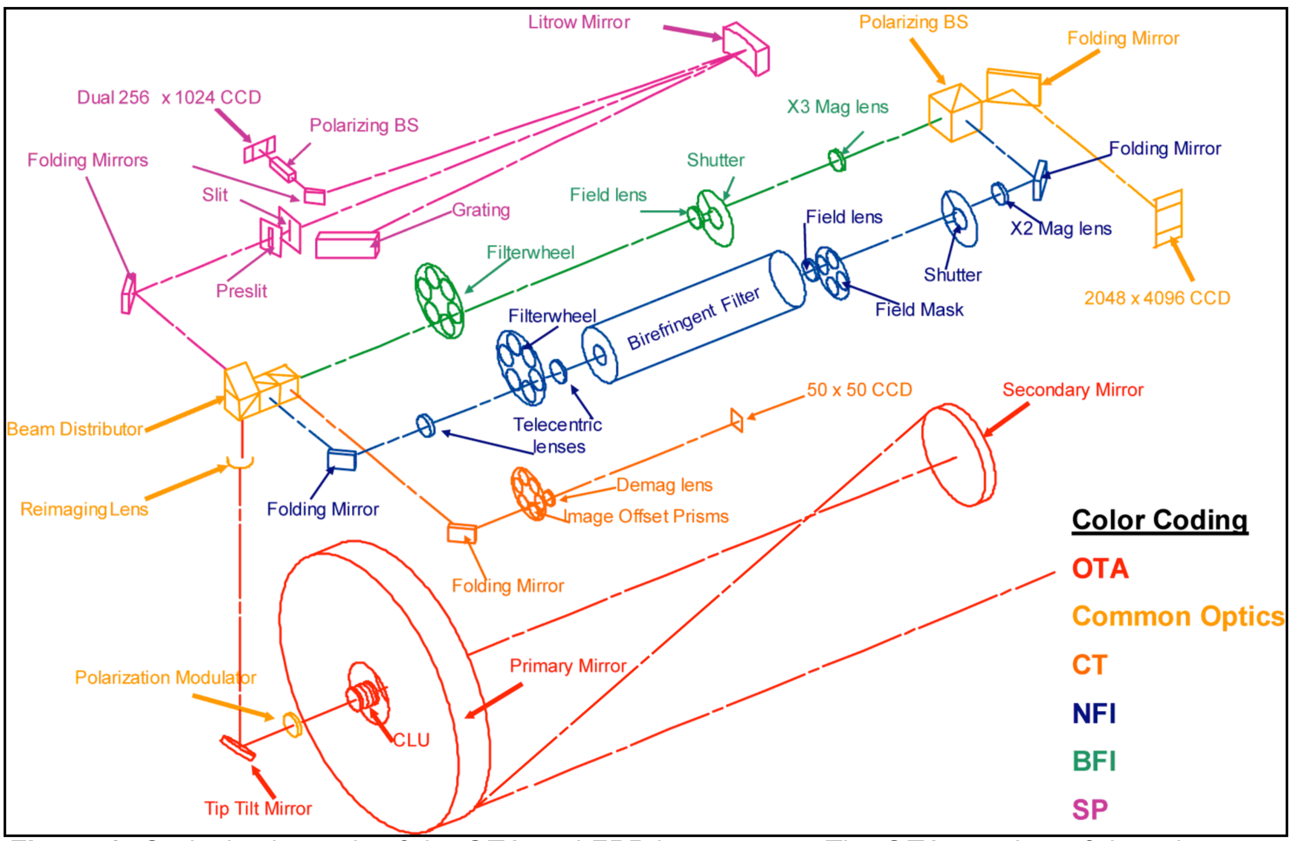


Figure 2*. Optical schematic of the OTA and FPP instruments. The OTA consists of the primary and secondary mirrors, the CLU, PMU, and the TTM. The FPP consists of all of the elements in the upper plane.*

The basic properties of the SOT are:

- 0.5 meter clear aperture.
- 562 mm diameter ULE glass primary mirror.
- 262 mm diameter ULE glass secondary mirror.
- Linear central obscuration 0.344.
- Axisymmetric design for minimal instrumental polarization.
- Effective focal length = 4527 mm.
- 361” x 197” diffraction limited field-of-view (FOV), defined by the heat stop rejection mirror at the Gregorian focus.
- Exit beam 30 mm diameter, collimated by the Collimator Lens Unit (CLU).
- UV and IR rejection coatings on the CLU limit the heat load passed to the FPP instrument.
- Carbon fiber and invar structural elements for maximum thermal stability.

The theoretical diffraction limit of the SOT (using the Rayleigh criterion) over a range of wavelengths available for observations is shown in **Table 1**.

Wavelength nm	Spectral Region	Diffraction Limit arcsec
388.3	CN molecular band, photospheric network	0.19
430.5	CH molecular “G-band”, photospheric network	0.22
512.7	Chromospheric magnetograms	0.26
525.0	Photopheric magnetograms	0.26
557.6	Photospheric dopplergrams	0.28
589.6	Na I D chromospheric magnetograms	0.30
630.2	Fe I photospheric magnetograms	0.32
656.3	H-alpha chromospheric diagnostics	0.33

Table 1. Diffraction limits for spectral bands available in the FPP.

The science observer can propose to use any or all of the FPP instruments in a given observation program. The observables of each instrument are described in the following sections.

Broadband Filter Imager (BFI)

The Broadband Filter Imager (BFI) produces photometric images with broad spectral resolution in 6 bands (CN band, Ca II H-line, G-band, and 3 continuum bands) at the highest spatial resolution available from the SOT (0.0541 arcsec/pixel sampling) and at rapid cadence (10--20 sec typical) over a 218" × 109" FOV. Exposure times are typically 0.03 - 0.8 sec, but longer exposures are possible, if desired.

The BFI allows accurate measurements of horizontal flows and temperature in the photosphere, and measurements in the short wavelength bands permit identification of sites of strong magnetic field. **Table 2** summarizes the properties of the BFI.

The BFI consists of a six interference filters mounted in a user-controlled filterwheel. The filters have bandpasses of 3—8 Å and therefore produce the highest resolution (0.2"), lowest exposure time (30 ms), filtergrams from the SOT. The basic characteristics of the BFI are as follows:

- 6 Interference filters in user-selectable filterwheel.
- 3-8 Å spectral resolution.
- EFL = 4650 cm, 0.054" pixels.
- Spatial resolution = 0.2" - 0.3".
- Temporal cadence = 3.4s including CCD readout.
- 4096 x 2048 130 Ke- full well frame transfer CCD, shared with NFI.
- Highest spatial and temporal resolution images from FPP.

Field of view	218" × 109" (full FOV)		
CCD	4k × 2k pixel (full FOV), shared with the NFI		
Spatial Sampling	0.0541 arcsec/pixel (full resolution)		
Exposure time	0.03 - 0.8 sec (typical)		
Pixel Size	0.054"		
Typical Frame Sizes	4K x 2K = 218" x 109", 2K x 2K = 109" x 109", 1K x 1K = 54" x 54", 512 x 512 = 27" x 27"		
Summing	1x1, 2x2, or 4x4 pixels		
Readout Time	3.4 sec (4K x 2K, 1x1 summing), 1.7 sec (4K x 2K, 2x2 summing), 0.9 sec (4K x 2K, 4x4 summing); faster cadence for partial frame readouts.		
Reconfigure Time	< 2.5 sec (for changing filter wheels, etc.)		
Spectral Coverage			
Center (nm)	**Band width (nm)**	**Line of interest**	**Purpose**
388.35	0.7	CN I	Magnetic elements
396.85	0.3	Ca II H	Chromospheric structure
430.50	0.8	CH I	Magnetic elements
450.45	0.4	Blue continuum	Temperature
555.05	0.4	Green continuum	Temperature
668.40	0.4	Red continuum	Temperature

Table 2. SOT BFI specifications.

BFI Observables

Field-of-view. The BFI field-of-view (FOV) is determined by the instrument focal length and CCD pixel size. The BFI shares a 4096x2048-pixel CCD camera with the NFI, known as the FG camera. The 0.054" pixel scale of BFI results in a 218"x109" FOV. Figure 3 shows the BFI FOV on a SOHO/MDI full-disk magnetogram.

The BFI FOV is large enough to encompass most large active regions on the Sun; however very large active regions such as those of October 2003 are larger than the BFI view. The FG camera can be programmed for sub-frame readout. Therefore the FOV chosen for any given BFI program can vary from the full-frame FOV down to very small sub-fields.

Using smaller sub-fields is advised for programs in which high cadence and low-memory usage are needed. In addition the FG camera can be programmed to sum pixels in the serial and parallel directions.

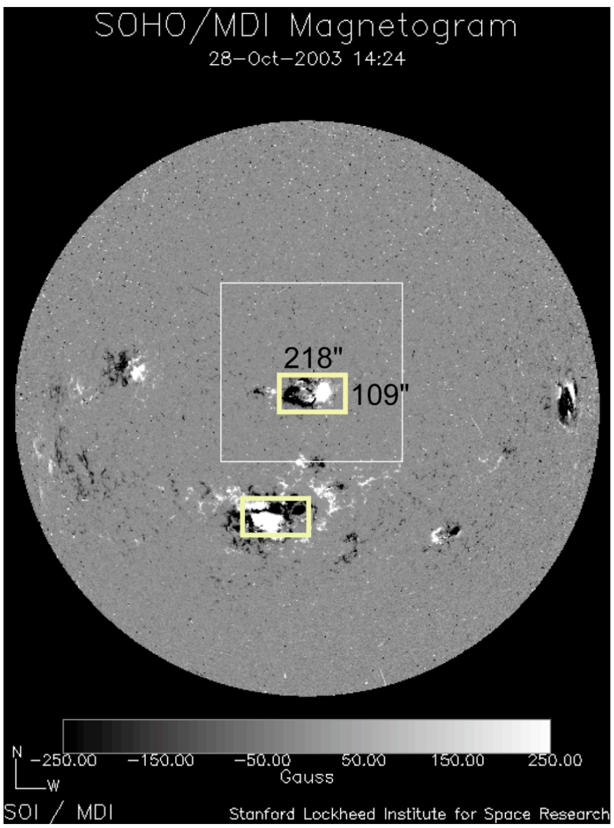


Figure 3. BFI field-of-view superimposed on a SOHO/MDI full-disk magnetogram.

Observables. The only observables of the BFI are filtergram images in any of the six available interference filter bandpasses. Table 2 lists the available BFI bandpasses. Individual images in the Blue, Red, and Green continuum bandpasses of the BFI can be combined to measure the black-body irradiance temperature of structures within the FOV. BFI filtergram sequences can be used to create several typical data products. Most commonly, the BFI sequences will be made into "movies" of the solar photosphere and chromosphere with diffraction-limited resolution and cadences on the order of 10—100 seconds. Additional possibilities using BFI image time sequences include:

- Surface flow mapping via Local Correlation Tracking (LCT) on features in BFI images. Horizontal velocities on spatial grids as small as 0.5” will be possible using BFI time series in the photospheric bandpasses. LCT is not as successful in measuring horizontal flows in the chromospheric H-line due to the rapidly changing acoustic emission patterns that dominate the images.

- Horizontal velocity divergence and curl. Derivatives of the LCT horizontal velocity images can be calculated to map the source and sink regions in the photospheric flowfield. Figure X shows an example of a velocity divergence image derived from a G-band 430.5 nm filtergram time sequence.

- “Cork flow maps”. Using the LCT derived horizontal flow velocities, BFI time series can be used to produce maps showing the traces of passive scalars (“corks floating in the photosphere”) over the course of an observation.

Narrowband Filter Imager (NFI)

The Narrowband Filter Imager (NFI; Table 3) provides intensity, Doppler, and full Stokes polarimetric imaging at high spatial resolution (0.08 arcsec/pixel) in any one of 10 spectral lines, including Fe lines having a range of sensitivity to the Zeeman effect, MgIb, NaD lines, and H-alpha.

The NFI consists of a tunable Lyot filter with selectable bandpasses in six key solar spectral regions. The six spectral regions are determined by wide-band interference filters preceding the Lyot filter. The bandpass of the Lyot filter is narrow enough for taking magnetogram and dopplergram measurements in a number of the available spectral lines. The NFI can be operated in synchronous mode with the polarization modulator of SOT in order to take Stokes I, Q, U, and V images.

The available spectral lines span the photosphere to the lower chromosphere for analysis of dynamical behavior of magnetic and velocity fields in the lower atomosphere. The Lyot filter can also be tuned to nearby continuum in any of the six spectral regions.

The edges of the NFI field-of-view are slightly vignetted due to the limited size of the optical elements of the tunable filter residing in a telecentric beam. The un-vignetted area is 264" in diameter. Exposure times for the NFI are typically 0.1—1.0sec, but like the BFI, longer exposures are possible.

The basic characteristics of the NFI are as follows:

- Tunable Lyot filter.
- Intensity, Stokes, and Doppler images in 6 spectral regions.
- Temperature calibrated, no active thermal control.
- 60-100 mA spectral resolution.
- EFL = 3100 cm, 0.08” pixels.
- Polarization precision ~0.4%.
- Spatial resolution ~ 0.25”.
- Maximum temporal cadence = 3.4s including CCD readout.
- 4096 x 2048 pixel frame transfer CCD, shared with BFI.

Field of view	328"×164" (unvignetted 264"×164")
CCD	4k×2k pixel (full FOV), shared with BFI
Spatial sampling	0.08 arcsec/pixel (full resolution)
Spectral resolution	0.009nm (90mÅ) at 630nm
Exposure time	0.1 - 1.6 sec (typical)
Pixel Size	0.080”
Typical Frame Sizes	4K x 2K = 328” x 164”, 2K x 2K = 164” x 164”, 1K x 1K = 82” x 82”, 512 x 512 = 41” x 41”
Summing	1x1, 2x2, or 4x4 pixels
Readout Time	3.4 sec (4K x 2K, 1x1 summing), 1.7 sec (4K x 2K, 2x2 summing), 0.9 sec (4K x 2K, 4x4 summing); faster cadence for partial frame readouts.
Reconfigure Time	~5 sec (for tuning the Lyot filter, etc.)

Spectral Coverage				
Center (nm)	Tunable range (nm)	Lines	g_{eff}	Purpose
517.2	0.8	Mg I b 517.27	1.75	Chromospheric dopplergrams and magnetgrams
525.0	0.8	Fe I 524.71	2.00	Photospheric magnetograms
		Fe I 525.02	3.00	
		Fe I 525.06	1.50	
557.6	0.8	Fe I 557.61	0.00	Photospheric dopplergrams
589.6	0.8	Na I D 589.6	1.33	Photospheric and Chromospheric fields
630.2	0.8	Fe I 630.15	1.67	Photospheric magnetograms
		Fe I 630.25	2.50	
		Ti I 630.38	0.92	Umbral magnetograms
656.3	0.8	H I 656.28	-	Chromospheric structure

Table 3. SOT NFI specifications.

Images from the NFI contain blemishes which degrade or obscure the image over part of the field-of-view. The artifacts are caused by air bubbles in the index matching fluid inside the tunable filter. They distort and move when the filter is tuned. For this reason, NFI observing is usually done in one spectral line at one or a small number of wavelengths for extended periods of time. Rapid switching between lines is not allowed.

Software changes made since launch have given us control over the location of the bubbles; targets can usually be placed in large blemish-free areas of the CCD. Tuning schemes have been developed which permit tuning to different positions in a line profile without disturbing the bubbles. This has enabled collection of the various observations listed above.

Flat field correction of NFI images is still a challenge, but progress is being made on this; magnetograms and dopplergrams are usually self-correcting since they are made from ratios of intensity differences. The Solarsoft routine fg_prep is being updated to handle the additional observation types. Na D 589.6 nm is now the default line for longitudinal magnetic and Doppler observations, due to its higher light level and more robust prefilter. Specific questions about NFI images and their processing may be sent to sot_nfi@lmsal.com.

NFI Observables

Field-of-View. The NFI shares the same CCD camera as the BFI but has a slightly larger plate scale due to the relaxed requirements on Nyquist sampling the PSF of the longer wavelengths observed with the NFI. The pixel size of the NFI is 0.08” resulting in a full-CCD frame FOV of 328” x 164”. **Figure 4** shows the NFI FOV overlain on a SOHO/MDI full-disk magnetogram. The significantly larger FOV of the NFI captures even the largest of the October 2003 active regions.

Observables. The NFI can take individual filtergram images in any of the six available spectral regions of the instrument. In this capacity it is identical to the BFI; the same CCD frame sizes, summing, and readouts that are listed in Table 2 apply to the NFI observations as well. The one difference is that the reconfigure time will be slightly longer due to the need to tune the more complex Lyot filter of the NFI.

Table 3 lists the spectral regions available for NFI observations. Each spectral region is centered on a particular solar spectral line. However the NFI Lyot filter is tunable within a ±4 Å spectral-range of each region. Therefore in addition to the main spectral lines listed, true continuum or other spectral lines within the region can also be imaged.

In addition to simple filtergrams in any of the spectral regions listed in Table 3, the NFI can produce a variety of magnetogram and dopplergram images. These images are derived from two or more filtergrams taken in varying line positions and/or polarization states.

NFI magnetograms. The primary magnetogram product from the NFI will be large FOV longitudinal flux density magnetograms, also known as Stokes V/I magnetograms. The NFI polarization states are modulated by PMU in the OTA and analyzed by a polarizer in the NFI. The Stokes I and V component images are created by integrating exposures over specific rotation phases of the PMU and demodulating them by arithmetic in the "smart memory" buffers in the FPP. Due to limitations of the smart memory sizes, the full field of view can be used for magnetograms only when 2x2 or 4x4 summing is employed. At full pixel resolution, the field of view is limited to the central 1K x 2K pixels or 82 x 164 arcseconds

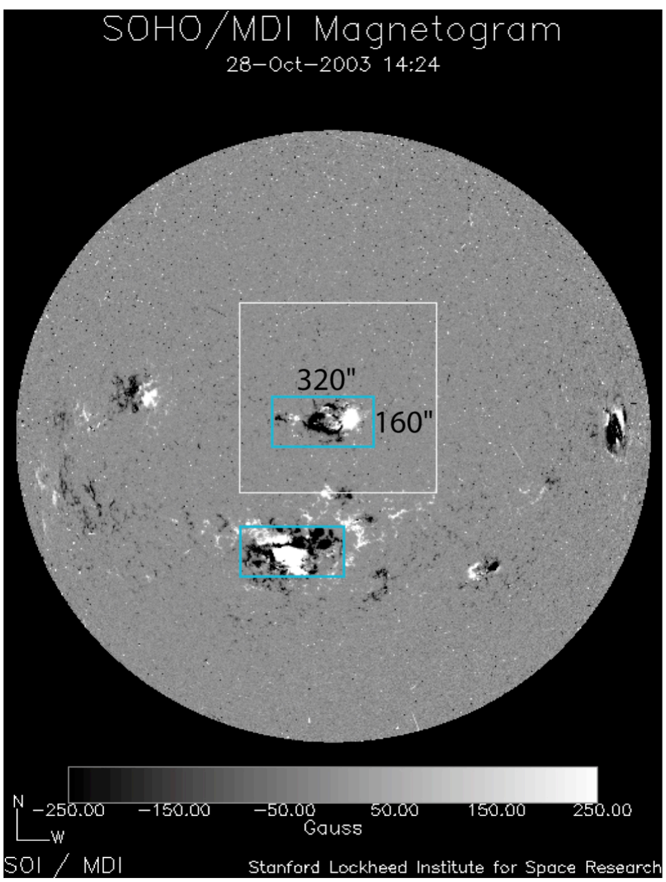


Figure 4. NFI field-of-view superimposed on a SOHO/MDI full-disk magnetogram.

The Fe I 630.25 nm and Na I 589.6 nm spectral lines are most commonly used for photospheric magnetograms. The RMS noise of a typical NFI magnetogram created using only one line position is approximately 10^{15} Mx per pixel. Comparison of NFI V/I magnetograms in any line with the full vector field maps created by the SP will allow precise calibration of the NFI magnetograms in terms of magnetic flux density per pixel in any given summing mode. **Figure 5** shows a typical NFI Fe I 630.25 nm Stokes V/I magnetogram.

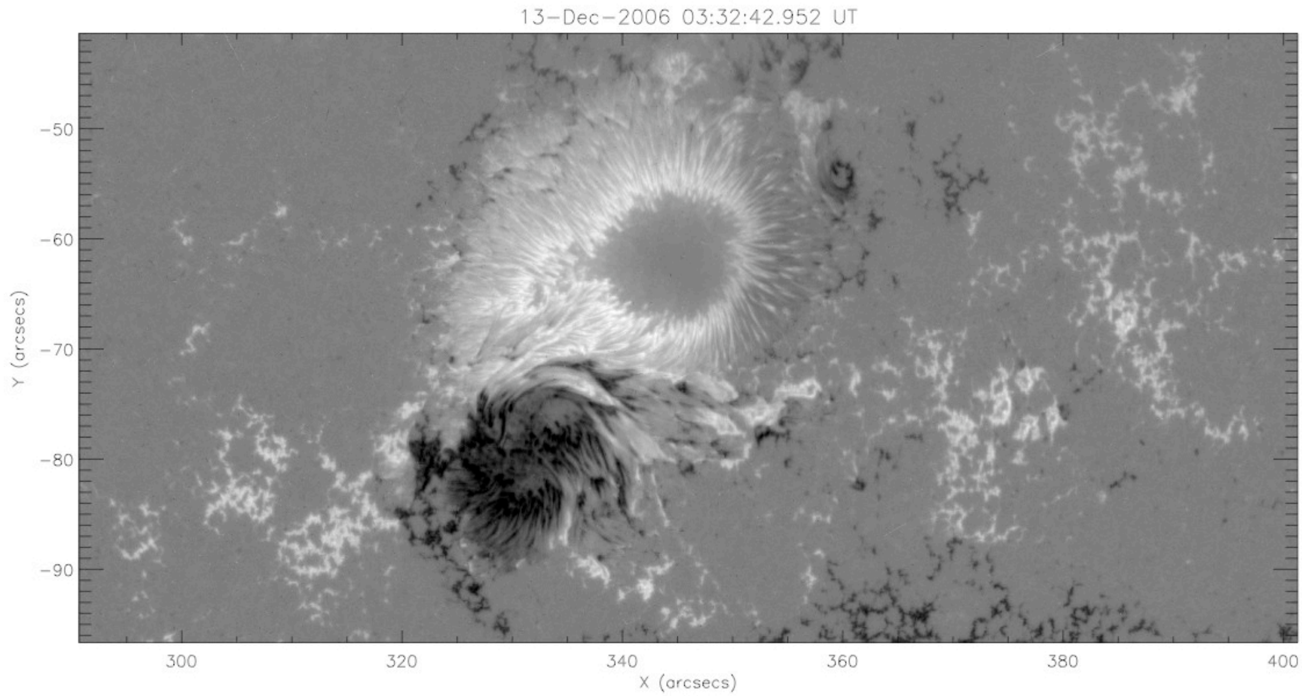


Figure 5. NFI Fe I 630.25 nm Stokes V/I image.

NFI Stokes Vector Images. In addition to the Stokes V/I magnetograms discussed above, the NFI is capable of imaging in full Stokes vector mode. In this mode, the NFI exposures are synchronized with the rotating PMU to create Stokes I, Q, U, and V images in a rapid sequence. The images are created in the on-board smart memories. The Stokes I, Q, U, and V images can give more information about the full magnetic field vector.

There are two methods of obtaining Stokes vector images from the NFI:

Shuttered Mode. The NFI shutter is synchronized to the PMU and gives precise 0.1 sec exposures in all quadrant-phases of the rotation. The allowed frame sizes and pixel summing are the same as for the longitudinal magnetograms. A full complement of Stokes images takes about 20 seconds to capture in this mode.

Shutterless Mode. In this mode, the NFI shutter is left open and one of four focal plane masks is inserted in order to reduce the FOV down to a narrow vertical strip centered on the CCD chip. The CCD is then read out in synchrony with the PMU, accumulating charge in the central strip and then shifting it under the focal mask. The smart memories add or subtract the strip images as they are received from the CCD to create the component Stokes images. The cadence of these observations ranges from 1.6 to 12.8 seconds, and the sensitivity can be very high because of the long integration time. The price paid for this is of course FOV; however, FOV can be increased at the expense of time resolution by reading out different strips on the CCD and combining them afterwards. **Table 4** lists the shutterless Stokes mode exposure selections

Exposure and Observables	Pixel Size (Summing)	CCD Read Size	Field of View
0.1 sec exposure I,Q,U,V measured simultaneously	0.08” (1x1)	64 x 2048	5.2” x 164”
	0.16” (2x2)	160 x 2048	12.8” x 164”
	0.32” (4x4)	320 x 2048	25.6” x 164”
0.2 sec exposure I, U, V or I, Q or I, V	0.08” (1x1)	192 x 2048	15.4” x 164”
	0.16” (2X2)	384 x 2048	30.7” x 164”
	0.32” (4X4)	768 x 2048	61.4” X 164”
0.4 sec exposure I, V only	0.08” (1x1)	400 x 2048	32.0” x 164”
	0.16” (2x2)	800 x 2048	64.0” x 164”
	0.32” (4x4)	1600 x 2048	128.0” x 164”

Table 4. NFI Shutterless Stokes mode observables.

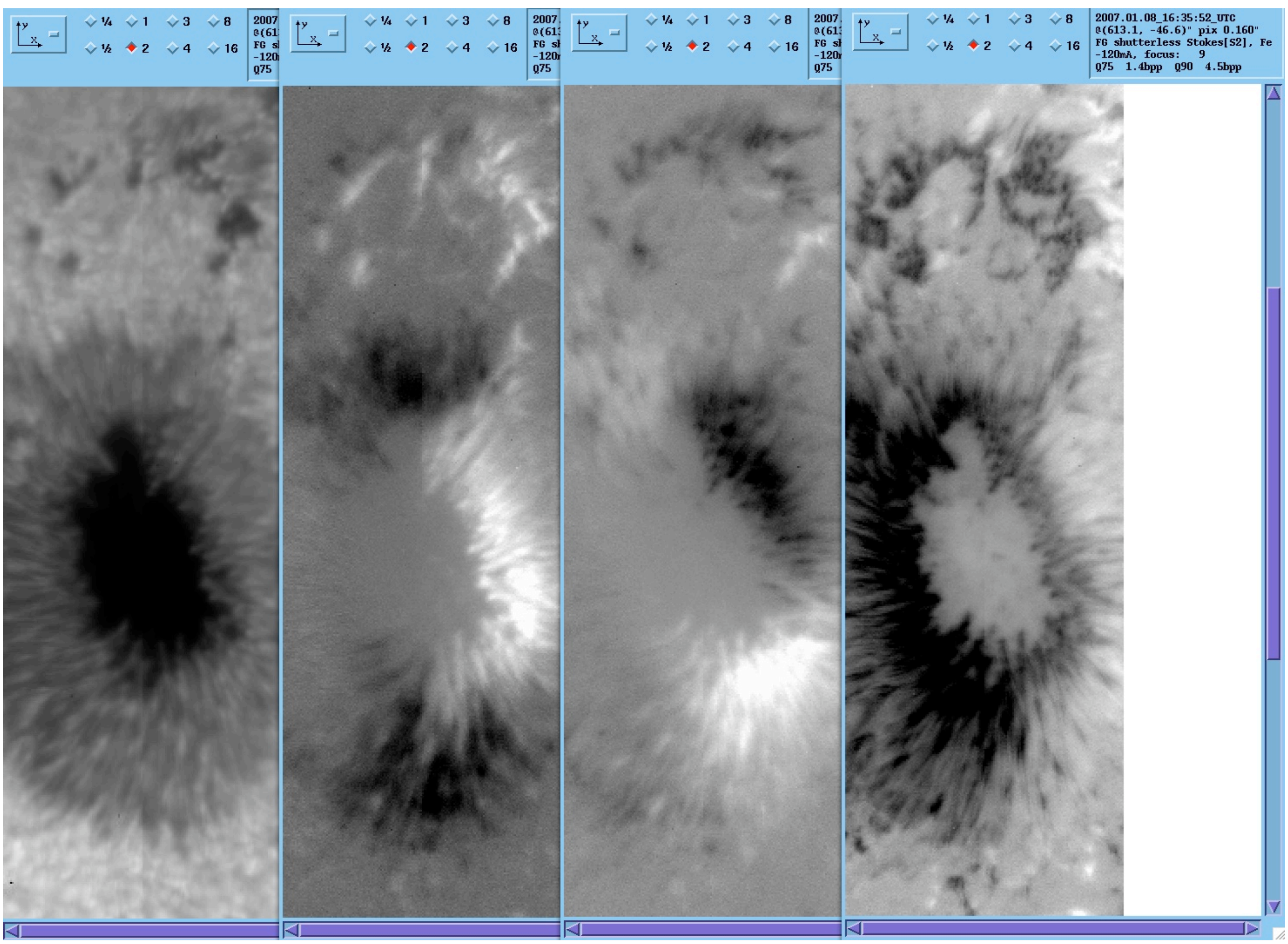


Figure 6. NFI Mg Ib 517.3 nm Stokes component images.

NFI dopplergrams. The NFI instrument can produce line-of-sight velocity maps (“dopplergrams”) in any of the spectral lines shown in Table 3. However the primary photospheric dopplergram line is the Fe I 557.6 nm line which has a Landé factor of 0 and is therefore not broadened by magnetic fields. Chromospheric dopplergrams can be made using the Mg I 517.3 nm or the Na I 589.6 nm lines. Dopplergrams are made from the simple ratio of the difference of blue and red wing intensities divided by their sum. The intensities may be simple filtergrams or Stokes I from I & V observations. Component images may be processed on-board in the smart memories or downlinked for later analysis. As is the case with magnetograms, the field of view is limited to the central 1K x 2K pixels when on-board processing is used at full pixel resolution. The estimated 1-sigma noise level of NFI dopplergrams produced in this way is 30 m/s for a dopplergram formed with 0.16" pixels (2x2 summing) with a 0.8 second exposure time. **Table 5** summarizes the dopplergram characteristics of the NFI. **Figure 7** shows an Fe I 557.6 nm intensity and dopplergram image from the NFI.

Summing	1x1, 2x2, 4x4 pixels
Duration	~12 seconds (4 images, full frame, 2x2 summing, 0.1 second exposure)

Table 5. NFI dopplergram characteristics.

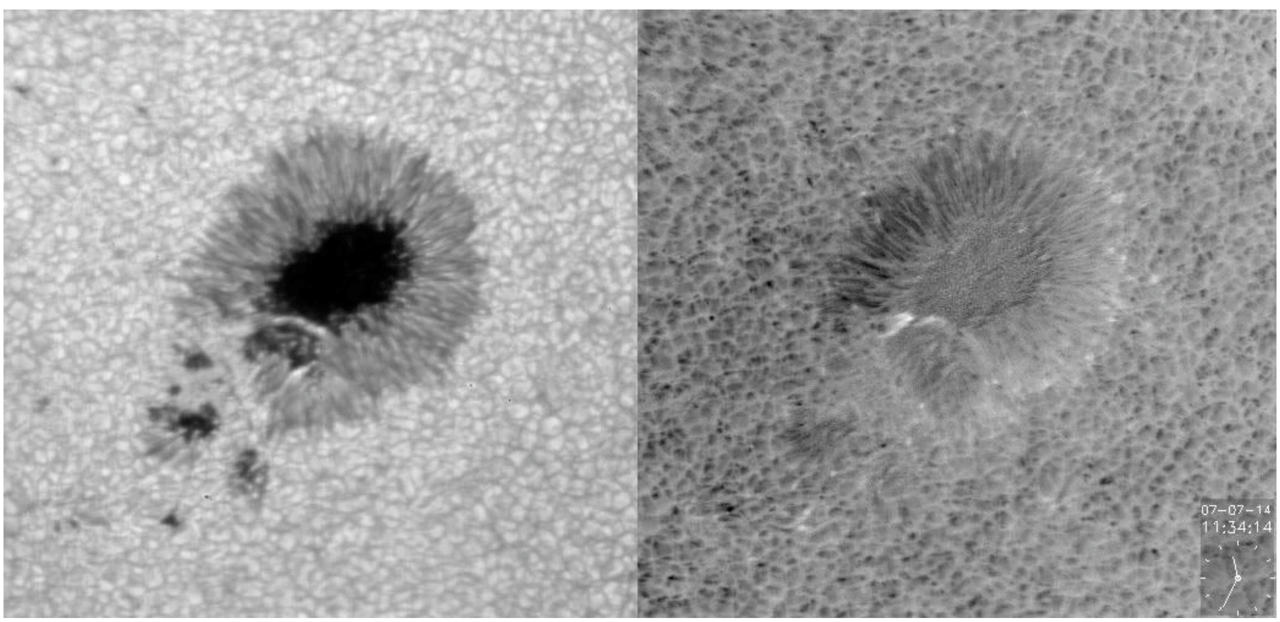


Figure 7. NFI Fe I 557.6 nm intensity (L) and dopplergram (R) image of a sunspot near disk center.

Spectropolarimeter (SP)

The SP is a modified Littrow spectrometer that operates in synchronous mode with the PMU of SOT in order to create high-precision (10^{-3} or better) Stokes polarimetric line profiles of the Fe I 6301.5 and 630.25 nm spectral lines. The primary product of the SP is Stokes IQUV spectra suitable for derivation of vector magnetogram maps of the solar photosphere. These can cover a large area by scanning the spectrograph slit in the E-W solar direction over periods ranging from several minutes to several hours. The basic characteristics of the SP are as follows:

- Fe I 6301.5 and 6302.5 Å spectral lines.
- 21 mÅ spectral resolution.
- Simultaneous orthogonal state images, 10^{-3} precision Stokes polarimetry.
- Spatial resolution = 0.32" (2 pixels).
- Temporal resolution = 4.8 s integrations at each slit position in normal mode.
- 1024 x 448 130 ke- full well split framereadout CCD.
- Slit-scanned vector magnetogram maps.

SP Observables

The FPP Spectropolarimeter instrument is based on the successful design of the Advanced Stokes Polarimeter (ASP); its proto-model became the the Diffraction Limited SpectroPolarimeter (DLSP) instrument installed at the Dunn Solar Telescope (DST). The SP is an all-reflective Littrow design that incorporates a polarizing beam splitter just prior to the camera system in order to record two spectra in orthogonal polarity states simultaneously. The primary characteristics of the SP are as follows.

Spectra of two Fe I lines at 630.15 and 630.25 nm and nearby continuum are taken through a 0.16"x164" slit. The spectral resolution is approximately 21.5 mÅ. Spectra are exposed and readout continuously on a 0.1 second cadence in phase with the PMU rotation. 16 spectra are taken per rotation of the PMU. Two spectra are taken simultaneously in orthogonal linear polarization states via the polarizing beam-splitter just prior to the camera. This eliminates polarization cross-talk due to image jitter during integration and increases the polarization precision to 10^{-4} relative to continuum.

Raw spectra are added and/or subtracted into four on-board memories in phase with the PMU in order to demodulate the Stokes I, Q, U, and V states. A single SP "observable" is two sets of I, Q, U, V spectra in each of two orthogonal linear polarization states.

The FOV of the SP is primarily determined by the 0.16" x 164" slit that is oriented North-South on the heliographic disk. The widest scan available (2047 steps) moves the slit in an E-W heliographic direction over a range of 328". Thus the largest SP maps will closely resemble the NFI filtergrams in terms of FOV.

The SP CCD camera can execute sub-frame readouts and pixel-summing along the slit to give short effective slit lengths in order to increase the data rate. Post-processing on the ground produces vector magnetogram maps, dopplergrams, as well as atmospheric condition measurements such as temperature and density.
Table 6 lists the typical mapping modes of the SP and the characteristics of the data products. **Figure 8** shows typical Stokes spectra taken with the ASP instrument.

	Normal Map Mode	Fast Map Mode	Dynamics Mode	Deep Magnetogram Mode
Time per slit position	4.8 sec (3 rotations)	3.2 sec (2 rotations)	1.6 sec (1 rotation)	Many rotations (Max: 12.8 sec, 8 rot)
FOV along Slit	164”	164”	41”	164”
Effective Pixel Size	0.16” x 0.16”	0.32” x 0.32”	0.16” x 0.16”	0.16” x 0.16”
Photometric S/N	$\sim 10^3$	$\sim 10^3$	~580	$>10^3$
Data rate	191 Kpixels/sec	127 Kpixels/sec	120 Kpixels/sec	—
Time for 160” scan	83 minutes	30 minutes	30 minutes	—
Time for 1.6” scan	50 seconds	18 seconds	18 seconds	—

Table 6. SP Mapping mode characteristics.

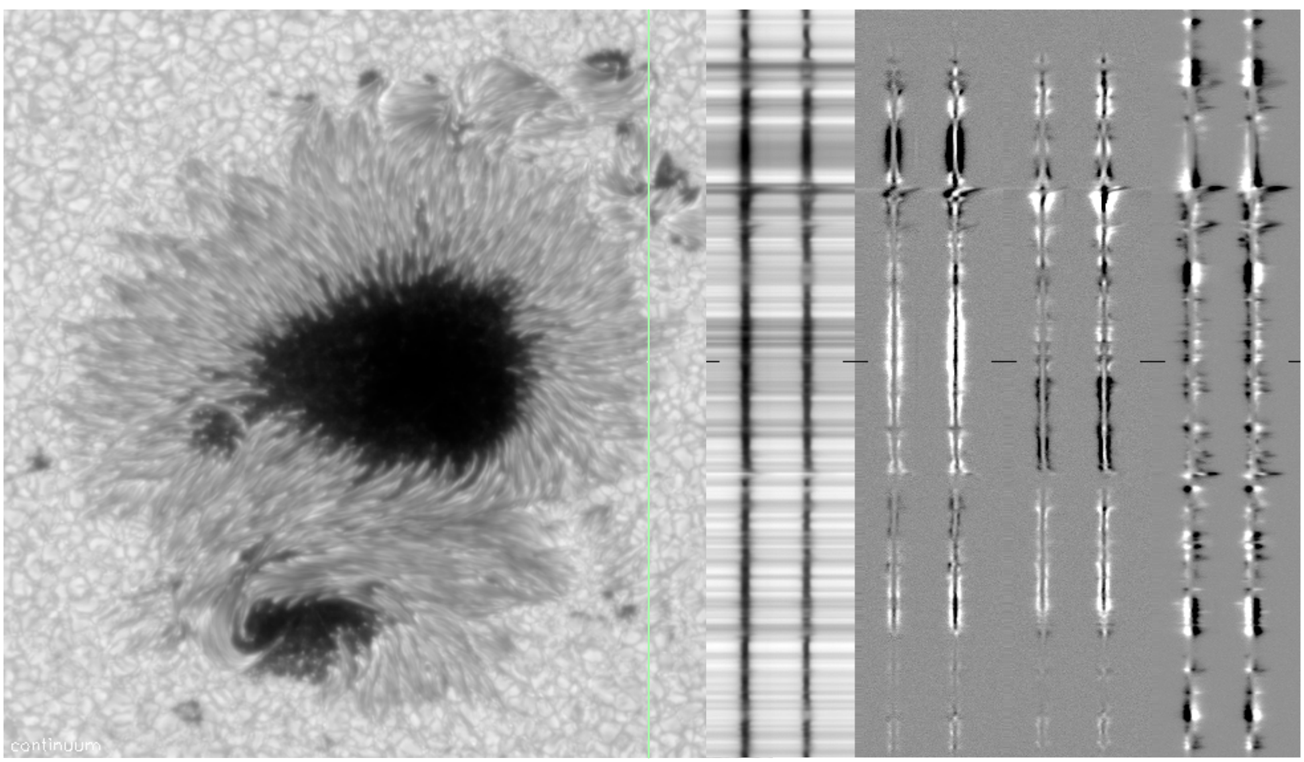


Figure 8. Example SP data: Stokes I, Q, U, and V spectra of the Fe I 630.15 and 630.25 nm spectral lines (L) taken at the location of the green line in the continuum map (R).

II SOT Data Analysis Guide

This section outlines how to analyze SOT data using software publicly available as part of SSWIDL (to add an instrument path to a SSWIDL tree, see http://www.lmsal.com/solarsoft/). This process involves obtaining, searching, reading, calibrating SOT data.

A. Overview of the Data Analysis Pipeline

1. Data Transport

SOT downlinks 15 times daily to the Svalbaard Ground Station, operated by the Norwegian Space Centre (NSC). Downlinks also occur up to four additional times daily at a JAXA ground station antenna in the Kagoshima prefecture. Downlinked SOT data are sent to the ISAS mission archive ("DARTS"), the principal SOT data site, for reformatting to create both "QuickLook" and Level 0 data. QuickLook and Level-0 data are then mirrored to LMSAL, in Palo Alto, CA as well as the Hinode Solar Data Center at the Institute for Theoretical Astrophysics, the University of Oslo, Norway.

2. Data Products

SOT data are available as FITS files, each of which includes a data array and a metadata structure array (the "FITS header") containing a list of keywords (see Appendix 1).

QuickLook data are expedited to ISAS so SOT operation team members can view images a few hours after the data have been taken. However, these data have not been completely reformatted and thus the images may not be whole and the FITS keywords will not be populated completely or correctly.

Level 0 data contains whole images with the complete list of FITS keywords. Level 0 data cannot be created until all the housekeeping data for a particular observation has arrived at ISAS, which may take up to 7 days.

Level 1 data has been calibrated by **fg_prep.pro** or **sp_prep.pro** and has units of instrumental Data Numbers. Level 2 data has been further processed into physical units. **Table 7** describes each of the SOT data products:

Level	Pixel values	File Format	Purpose
QuickLook	Data Number (DN)	FITS	Operations, Data Verification, QuickLook movies
0	DN	FITS	Basic science
1	DN/sec	FITS	Calibrated images
1.5	Physical units	FITS	SP Stokes component maps
2	Physical units	Any	e.g., vector magnetograms

Table 7. Hinode SOT data product definitions.

SOT instrument data are available as single FITS files with names in the the format **DataCodeYYYYMMDD_HHMMSS.S.fits**. where "DataCode" is the string associated with the data type, e.g. "FG" for a simple filtergram, "FGIV" for a filter-based intensity and line-of-sight magnetogram, etc. **Table 8** list the SOT data code symbols and their relation to observation types. The files stored in directories organized by hour beneath directories organized by year, month day and datatype. An example of a directory structure to access an individual FITS file is as follows: **YYYY/MM/DD/ObsType/Hhh00/, or 2007/05/27/FG/H1300**.

Data code	Gen ID #	Obs Type String	Data File Dimensions	Data type
FG	1	FG (simple)	2	Simple 2-D image
FGIV	2	FG Shuttered I and V	3	Stokes I and V 2-D images
FGIQUV	3	FG Shuttered Stokes	3	Stokes I, Q, U, and V 2-D images
FGFOCUS	12	FG focus scan	2	Simple 2-D images at different focus
FGSIV	32	FG Shutterless I and V	3	Stokes I and V 2-D images
FGSIQUV	33	FG Shutterless Stokes	3	Stokes I, Q, U, and V 2-D images
FGSIV200	38	FG Shutterless IV 0.2sec	3	Stokes I and V 2-D images
SP4D	NA	SP IQUV 4D array	4	Stokes I, Q, U, and V spectra

Table 8. SOT Data codes and associated data types. The "Data code" values match the directory structure in the SOT database. The Gen ID and Obs Type string are values in the FITS header. SP data do not have Gen ID values.

B. Accessing SOT Data

There are two basic ways to access SOT data: from the internet via one of the database centers listed below, or from within a SolarSoft IDL session. The former is most useful when you need to retrieve a large amount of data pertaining to a certain event or a given range of dates of observation. The latter is most useful when you want to retrieve a limited sub-set of data during an analysis session.

1. Web Browser Access

Data Search and Download Websites

Japan: ISAS DARTS database: http://hinode.nao.ac.jp/hsc_e/darts_e.shtml
USA: Lockheed Martin Solar and Astrophysics Laboratory: http://sot.lmsal.com/sot-data
Norway: Hinode SDC: http://sdc.uio.no/search/API

2. IDL Session Access

The Hinode/SOT data can be accessed and analyzed using the SolarSoft (SSW) system of routines written in the IDL language. More information on SolarSoft can be found at http://www.lmsal.com/solarsoft. IDL is a commercial software product currently produced by ITT Visual Information Solutions. More information on IDL can be found at http://ittvis.com/idl.

In order to use the Hinode/SOT SSW programs to read and analyze data, it is first necessary to install the SOT SSW libraries on a computer that you can access from your workstation. If SSW is already installed on the computer, you can add the SOT relevant programs by running

```
IDL> ssw_upgrade, /sot, /spawn, /loud
```

Since this routine reads data from a remote server, you may also need the "/passive_ftp" switch to be set if you are behind a firewall. If SSW is not installed on a local machine, see the installation instructions that are on the main SSW website listed above.

The basic mechanism for accessing SOT data through SSW is the the SOT "catalog", a database structure that is composed of a select list of information for each data product produced by the instrument. Specifically, the SOT catalog contains a subset of SOT FITS header keywords, (such as field of view, filter positions, and image type). The main SSW routine for reading and searching the catalog is called "sot_cat.pro" and is described in more detail in the examples below.

The SOT catalog is stored in an ancillary SSW library referred to as the SSW database or "SSWDB". This database needs to be on your local machine in order to access the SOT catalog in an SSW session. If there is already a local copy of the SSWDB, then you can add the relevant SOT data by running

```
IDL> sswdb_upgrade, 'hinode/sot', /spawn, /loud
```

Since the SOT data catalog is constantly expanding as new data is added to the database, you need to upgrade your local copy of the catalog via the ssw_upgrade routine frequently. For more information on installing and upgrading SSW libraries see http://www.lmsal.com/solarsoft/ssw_upgrade.html and http://www.lmsal.com/solarsoft/sswdb_install.html.

C. SOT Data Analysis Examples

In this section we illustrate the access, visualization, and analysis of SOT data products from both the FG and the SP instruments. The examples are shown in step-by-step SSW IDL commands that can be used as a tutorial for learning the routines. Text files with the IDL commands and comments from this text are found in the following directory in your SSW distribution: $SSW/hinode/sot/doc/demo.

Example fg_demo01: 09-December-2006 Data Analysis

The following tutorial is found in the SSW distribution in the following file: $SSW/hinode/sot/doc/demo/paris/fg_demo01.pro. In it you will learn how to access FG data files on your local disk as well as from a remote server. You will also learn how to use the fg_prep.pro routine to apply basic photometric corrections to FG images.

Accessing and Analyzing Local FG Data

We want to produce a co-aligned dataset of SOT/FG G-band, Ca II H-line, and Stokes V/I magnetogram images of active region AR 10926 for a period of time on **9-December, 2006**. This date is chosen because both XRT and EIS have good data for this date and one of the goals of the workshop is to work with multiple Hinode data sets.

We assume in this tutorial that all of the data is on a locally accessible disk. To make sure that SSW knows where to locate the data set the SOT_DATA environment variable:

```
IDL> set_logenv, 'SOT_DATA', '/Volumes/data1/hinode/sot/data'
```

The first step is to find all relevant observations for the time interval of interest. We make use of the SSW routines sot_cat.pro and sot_umodes.pro to access the data catalog and identify all unique observational modes that were executed during the time interval:

```
IDL> time0 = '09-Dec-2006T11:30:00'
IDL> time1 = '09-Dec-2006T15:00:00'

IDL> sot_cat, time0, time1, /level0, cat, files
```

Note that there are two versions of the SOT catalog: one is the QuickLook catalog and the other is the Level-0 catalog. By default sot_cat searches the QuickLook catalog. However data is purged form the QuickLook database after a nominal period of a few months. If the data of interest is older than a few months, you need to include the "/level0" keyword in your call to sot_cat. In general it is advised to use QuickLook data only for cursory data exploration. Always use the /level0 flag for data that you intend to analyze for scientific content.

Sot_cat returns two variables: "cat" which is the SOT catalog structure for the time range indicated, and "files" which are the filenames of all SOT files found in the local database for the time range given. The filenames are referenced to the local source of SOT FITS files on your system. This location is set by the environment variable "SOT_DATA". If you do not have SOT data locally on your machine, you can request that sot_cat return URLs to the nearest database center, as illustrated below.

```
IDL> help, cat, files
     CAT             STRUCT    = -> <Anonymous> Array[2994]
     FILES           STRING    = Array[2994]
```

For the date/time period specified, a total of 2994 SOT observations are found[1]. This includes FG, SP, correlation tracker reference frames, and other images not necessarily of interest to our example. In order to winnow this down to the particular type of observations we are interested in, we use sot_umodes.pro to identify all "unique modes" that were observed during the time interval:

```
IDL> modes = sot_umodes(cat, mcount=mc, info=info)
```

You can print out the unique modes found to see what is available using the SSW string printing routine "prstr":

[1] Your results may differ – this example was composed using a subset of the SOT database.

```
IDL> prstr, modes
          FG (simple)          G band 4305       2048      1024
          FG (simple)          Ca II H line      2048      1024
          SP IQUV 4D array     6302A              112       512
          CT reference frame                       49        50
          FG shuttered I and V  TF Fe I 6302      2048      1024
```

We wish to select only the FG (simple) Ca H-line mode for further analysis in this example. There are two options to accomplish this selection. One, you can call sot_cat.pro again, this time using the 'search_array' input parameter to return only the 2048 x 1024 magnetogram images :

```
IDL> sot_cat, time0, time1, cat, files, /level0, $
        search_array=['wave= Ca*II*H*line','naxis1=2048','naxis2=1024']

IDL> help, cat, files
     CAT               STRUCT    = -> <Anonymous> Array[103]
     FILES             STRING    = Array[103]
```

The second option is to use the interactive feature of the sot_umodes function as follows:

```
IDL> ss = sot_umodes(cat, /interactive)
```

In the widget that opens, choose the observation type that you would like to analyze. In this case, we choose the line with Ca H-Line to select the data:

```
IDL> cfiles = files[ss]
IDL> help,cfiles
     CFILES            STRING    = Array[103]
```

Take a look at the filenames contained in CFILES to see that they are pointing to the correct data location:

```
IDL> print, cfiles
IDL> nc = N_elements(cfiles)
```

Keep in mind that nothing has been read yet - there are no images in your SSW session yet. In order to read a data file and take a look at the contents, we use the read_sot routine:

```
IDL> read_sot,cfiles[0],index,data
```

The "INDEX" variable contains the FITS header data in a structure format. You can look at the data in the header as follows:

```
IDL>help,index,/str
```

Note that the keywords "CAMSSUM" and "CAMPSUM" are both 2. This indicates that the images are summed in both the Serial and Parallel directions on the camera. Thus the images are 2x2 summed pixel images that were originally 4096x2048 full resolution pixels.

Similarly, you can examine the images in the data file as follows.

```
IDL> WINDOW,xs=1024,ys=512
IDL> TVSCL,REBIN(data,1024,512)
```

At this point we have identified the set of 103 files we wish to analyze. We next calibrate the full set of images, using FG_PREP.PRO. There are several ways to do this:

1. Handing the entire block of pre-read index and data variables to fg_prep:

```
IDL> read_sot,cfiles, index, data
IDL> fg_prep,index, data, index_out, data_out, /despike
```

2. Reading the files from within fg_prep:

```
IDL>fg_prep, cfiles, -1, index_out, data_out, /despike
```

3. Handing individual images to fg_prep from within a loop:

```
IDL> outpath='/Volumes/data1/SOT/2006/12/09/FG/'
IDL> mkdir,outpath
IDL> .run
for i=0,nc-1 do begin
   read_sot,cfiles[i],index,data
   fg_prep,index,data,index_out,data_out, /despike
   mwritefits,struct2ssw(index_out),data_out,$
     outfile=STRING(outpath+'20061209_caH_level1.',i,'.fits',$
     format='(a,i05,a)'), /flat_fits
end
end
```

The methods are listed in order of decreasing memory useage in IDL. Note that the first methods results in full 3D data cubes for both the level-0 and level-1 data. This can rapidly overwhelm the available RAM for laptops or small workstations. The second method reads in one level-0 file at a time but returns a full 3-D level-1 data cube. The third method reads in one file at a time and writes out one file at a time and thus minimizes memory load.

Next, examine the calibrated data as a movie: if you used method 3 above, you won't have a calibrated data_out cube. Make an abbreviated one:

```
IDL> fg_prep,cfiles[0:19],-1,sindex_out,sdata_out,/despike
IDL> xstepper,bytscl(congrid(sdata_out,1024,512,20,/int))
```

Occasionally an image will be corrupted in the download process from the spacecraft. These images will typically have large sections of the FOV with 0 pixel values. We can remove instances of incomplete images using a simple filter:

```
IDL> percent_zero = dblarr(nc)
IDL> for i=0,nc-1 do percent_zero[i] = $
     (n_elements(where(data_out[*,*,i] eq 0)) / (2048.0*1024)) * 100
IDL> ss_good = where(percent_zero lt 5, n_good)
IDL> index_cah = index_out[ss_good]
IDL> data_cah = reform(data_out[*,*,ss_good])
```

We next search for and process the Magnetogram images using the same steps, but simply specifying the appropriate FGIV mode:

```
IDL> sot_cat, time0, time1, mcat, mfiles, /level0, $
     search_array=['wave=TF*Fe*I*6302','naxis1=2048','naxis2=1024']
IDL>help, mcat
     MCAT                 STRUCT    = -> <Anonymous> Array[103]
```

We again 'prep' the images, using FG_PREP.PRO:

```
IDL> fg_prep, mfiles[0:19], -1, index_out, data_out, /despike
IDL> help, index_out, data_out
     INDEX_OUT           STRUCT    = -> <Anonymous> Array[20]
     DATA_OUT            FLOAT     = Array[2048, 1024, 2, 20]
```

I (intensity) and V(circular polarization) images are stored in data_out[*,*,0,*] and data_out[*,*,1,*], respectively. V/I magnetrograms can be created as follows:

```
IDL> mag = reform(data_out[*,*,1,*])/(data_out[*,*,0,*]>100) $
     * (data_out[*,*,0,*] gt 100)
```

This time we can take a look at the output files using "sodasurf", a new image and movie viewer in SSW:

```
IDL> launch_sodasurf, data=mag>(-0.3)<0.3
```

For very large datasets that you want to briefly explore, you can use the timegrid.pro routine to sub-sample the catalog:

```
IDL> sot_cat,time0,time1,/level0,cat
```

Sample only 3 images from the whole time series. The files are evenly spaced throughout the dataset:

```
IDL> n_samp = 3
IDL> n_rec = n_elements(cat)
IDL> t_grid = timegrid(cat[0].date_obs, cat[n_rec-1].date_obs, $
              nsamp=n_samp)
IDL> ss_samp = tim2dset(anytim(cat.date_obs,/ints), $
               anytim(t_grid,/ints))
IDL> cat_samp = cat[ss_samp]
IDL> files_samp = files[ss_samp]
```

You can also select a subset of the magnetograms that are closest in in time to the caH set.

```
IDL> sot_cat, time0, time1, cat, files, /level0, $
        search_array=['wave=TF*Fe*6302','naxis1=2048','naxis2=1024']
IDL> ss_samp_mag = tim2dset(anytim(cat.date_obs,/ints), $
        anytim(index_cah.date_obs,/ints))
IDL> cat_samp_mag = cat[ss_samp_mag]
IDL> files_samp_mag = files[ss_samp_mag]
```

Accessing remote FG data using SSW sock_copy

Although the SOT catalog is online locally (if the hinode branch of the SolarSoft Database tree has been installed), the actual FITS data files may not be available locally. In this case one can remotely access the FITS files from one of the online database centers. To specify the desired institution, the routine hinode_server_select just sets the environmental which points to desired sot/xrt http server. In the following demonstration we use the Oslo as our remote server site.

First, set the hinode_server_select variable to the nearest data center. Here we use the Oslo data center:

```
IDL> hinode_server_select,/oslo ; or /lmsal or /darts
```

Then we use sot_cat again, but this time with the /URLS keyword set:

```
IDL> time0 = '09-Dec-2006T11:30:00'
IDL> time1 = '09-Dec-2006T15:00:00'
IDL> sot_cat, time0, time1, /level0, cat, urls, /URLS
IDL> help, urls
     URLS            STRING    = Array[2994]
```

Now we use sot_umodes to narrow down the selection:

```
IDL> ss = sot_umodes(cat,/int)
```

Selecting the G-band data this time, we narrow our dataset down and then use sock_copy to get the data:

```
IDL> gurls = urls[ss]
IDL> dir_local = './demo'
IDL> if file_exist(dir_local) eq 0 then spawn, 'mkdir ' + dir_local
```

Now use the sock_copy routine to fetch the files and write them to the specified directory. This takes a while, depending on your internet environment.

```
IDL> sock_copy, gurls, out_dir=dir_local
IDL> gfiles = file_list(dir_local, '*.fits*')
```

Example sp_demo01: accessing and displaying remote Level-1 SP data

In addition to the FG data for this date, there are many SP data files. Each Level-0 SP data file is a single 4-D data object: [x,y,Stokes vector, orthogonal component]. These files comprise three Fast Map of the full SP FOV. To calibrate and assemble these files into maps of the magnetic field requires huge amount of disk space and processor power. Since most people using this tutorial for the workshop are using laptops, this is impractical. Instead we will now show how to retrieve pre-assembled Level-1 SP maps.

The following tutorial is found in the SSW distribution in the following file: $SSW/hinode/sot/doc/demo/paris/sp_demo01.pro. In it you will learn how to access SP Level-1 files from remote databases and display the maps on a solar heliographic grid.

The maps we will retrieve are co-temporal to the FG images from 9-December, 2006 which were produced in fg_demo01.pro.

First we specify the time span for which we want SP maps.

```
IDL> time0 = '09-dec-2006 11:30'
IDL> time1 = '09-dec-2006 15:00'
```

Recall that the SP data files in the database are single slit images. We need to know which slit images belong to a single scan set in order to create a unified 2-d "map" of the magnetic field. We use the sotsp_time2scan function to return a "scan" structure with information on which SP files in the database correspond to a given single scan set.

```
IDL> scn=sotsp_time2scan(time0,time1,/span)
IDL> help,scn & more,get_infox(scn,'date_obs,nrecs,ssstart,ssstop')
SCN             STRUCT    = -> <Anonymous> Array[3]
2006-12-09T11:30:01.543       843         0        842
2006-12-09T12:40:05.354      1000       843       1842
2006-12-09T14:00:05.393       842      1843       2684
```

NRECS is the number of slit images in a given scan set. The SSSTART and SSSTOP values indicate which files belong to the scan.

The time2file function returns the unique identifier for each of the three scans found in the time period.

```
IDL> scanids=time2file(scn.date_obs,/sec)
```

Next we use the SOTSP_STKS2INDEX function to fetch a particular scan from the database. Each Level-1 scan set contains maps of continuum' intensity, longitudinal flux density, and transverse flux density. The flux density maps are in units of Mx/cm^2.

```
IDL> sotsp_stks2index,scanids[1], index, data
IDL> help,index,data
     INDEX      STRUCT    = -> MS_248917823009 Array[3]
```

```
     DATA       FLOAT     = Array[1000, 512, 3]

IDL> info=get_infox(index,'date_obs,wave,cunit1,xcen,ycen')
IDL> more,info
2006-12-09T12:40:05.354  6302A Continuum Intensity   -420.4725   -100.8778
2006-12-09T12:40:05.354  6302A Longitudinal Flux Density, Mx cm^-2   -420.4725   -
100.8778
2006-12-09T12:40:05.354  6302A Transverse Flux Density, Mx cm^-2   -420.4725   -
100.8778
```

Finally we use the SSW mapping software to place the maps on a solar grid:

```
IDL> index2map,index,data,maps
IDL> wdef,xx,1024,/ur
IDL> plot_map,maps[1],fov=6,grid=5,/limb, $
     drange=[-1000,1000],title=info(1),margin=.05
```

Example sp_demo02: Analyzing SP Data using sp_prep

The previous example sp_demo01 showed how to retrieve pre-compiled Level-1 scans from the SOT database. In this example we go through how to create these maps from a group of Level-0 4-D slit data files.

The following tutorial is found in the SSW distribution in the following file:

$SSW/hinode/sot/doc/demo/paris/sp_demo02.pro.

In it you will learn how to produce SP Level-1 maps from slit images. The slit images must be accessible from a local Level-0 SOT data directory.
First, if necessary, set your SOT_DATA environment variable to point to the local database tree:

```
IDL> set_logenv,'SOT_DATA','/Volumes/data1/hinode/sot/data'
```

Now find and group SP level0 images by map via sotsp_time2scan.pro /span_day keyword links slit images for a map across "next UTDay". The function sotsp_time2scan returns one structure per map-group and includes tags required to subscript 'catalog' and 'files' (or 'urls') output parameters for calibration and map generation.

```
IDL> scninfo=sotsp_time2scan('27-aug-2007 19:25', $
     '27-aug-2007 20:45',/span_day,cat,files)
IDL>help, scninfo, cat, file
     SCNINFO        STRUCT    = -> <Anonymous> Array[92]
     CAT            STRUCT    = -> <Anonymous> Array[548]
     FILES          STRING    = Array[548]

IDL> more,get_infox(scninfo[0:9],'date_obs,nrecs,ssstart,ssstop,macroid')
2007-08-27T19:32:07.505        6         0         5       6174
2007-08-27T19:32:53.839        6         6        11       6175
2007-08-27T19:33:40.155        6        12        17       6176
```

```
2007-08-27T19:34:26.092         6        18        23       6177
2007-08-27T19:35:11.010         6        24        29       6178
2007-08-27T19:35:57.148         6        30        35       6179
2007-08-27T19:36:42.067         6        36        41       6180
2007-08-27T19:37:28.692         6        42        47       6181
2007-08-27T19:38:14.825         6        48        53       6182
2007-08-27T19:39:01.139         6        54        59       6183
```

Show 1st & last Level0 file names (1 slit scan per file) for each map

```
IDL> fnames = ssw_strsplit(files,'/',/tail)  ; 'files' output full path
IDL> more, fnames(scninfo[0:9].ssstart) + ' - ' + $
     fnames(scninfo[0:9].ssstop)
SP4D20070827_193207.5.fits - SP4D20070827_193239.7.fits
SP4D20070827_193253.8.fits - SP4D20070827_193325.8.fits
SP4D20070827_193340.1.fits - SP4D20070827_193412.1.fits
SP4D20070827_193426.0.fits - SP4D20070827_193457.1.fits
SP4D20070827_193511.0.fits - SP4D20070827_193543.2.fits
SP4D20070827_193557.1.fits - SP4D20070827_193628.2.fits
SP4D20070827_193642.0.fits - SP4D20070827_193714.6.fits
SP4D20070827_193728.6.fits - SP4D20070827_193800.8.fits
SP4D20070827_193814.8.fits - SP4D20070827_193846.9.fits
SP4D20070827_193901.1.fits - SP4D20070827_193933.2.fits
```

Sub-Demo 1.2 - Example: using above <scninfo>, <cat>, & <files> output, calibrate the set of slit scan images which for the 2nd map above, e.g.

```
IDL> scan=scninfo(1) & spname=time2file(scan.date_obs,/sec)
IDL> more, spname
20070827_193253 << Uniq SP Map identifier = <spname> for this demo.

IDL> mk_dir, spname ; name by 1st scan image & make empty directory
```

Sp_prep.pro is now called to calibrate the Level-0 images. This combines the orthogonal polarization slit images to create a 3-D [x,y,Stokes vector] slit array. Alternately, the ssw-client call to sp_prep call is:

```
IDL> sp_prep,files[scan.ssstart:scan.ssstop],outdir=spname, /quiet
```

Depending on the number of slit images in your scan, the sp_prep calls will take a few to many tens of minutes to complete. This is one reason why it is probably worth it to check for pre-calibrated Level-1 maps in the database, as shown in the previous tutorial. The SOT team intends to produce Level-1 SP maps for the entire mission. Currently the processing to accomplish this is ongoing.

Next we generate the 2-D maps from the calibrated spectra. The Stokes component maps are sometimes referred to as “Level-1.5” data.

```
IDL> stksimages_sbsp,spname,outstokes,outdir=spname
IDL> help, outstokes, /str
```

You can restore the Stokes component maps from an IDL save file stored in the output directory:

```
IDL> stks_struct_local = ssw_save2struct(concat_dir(spname, $
     'stksimg.save'))
```

As in the FG tutorial above, we now show how to retrieve Level-0 slit data files from a remote database. Aside from fetching the data, the process is very similar to the process shown above. We will use the optional /URLS switch so that the 'files' output of sotsp_time2scan are urls rather than nfs file paths.

```
IDL> hinode_server_select, /oslo  ; or /lmsal or /darts
IDL> scninfo=sotsp_time2scan('27-aug-2007 19:25', $
     '27-aug-2007 20:45', /span_day, cat, files, /urls)

IDL> help,scninfo,cat,files
     SCNINFO          STRUCT    = -> <Anonymous> Array[92]
     CAT              STRUCT    = -> <Anonymous> Array[548]
     FILES            STRING    = Array[548]
```

Choose the second scan in the scan structure:

```
IDL> scan=scninfo[1]
IDL> spname=time2file(scan.date_obs,/sec)
IDL> more,spname
    20070827_193253
```

This is the unique SP scan identifier. We now make a subdirectory with this unique identifier to contain the Level-1 slit data:

```
IDL> mk_dir,spname
IDL> l0dir = spname + '_l0'
IDL> mk_dir,l0dir  ; create target directory for L0 files
```

Now fetch the data from the remote database:

```
IDL> sock_copy,files(scan.ssstart:scan.ssstop),out_dir=l0dir
```

And call sp_prep to calibrate the spectra:

```
IDL> l0dir = l0dir[0]
IDL> sp_prep, file_search(l0dir,'*fits*'), outdir=spname, /quiet
```

Finally, create the Level-1.5 Stokes maps from the calibrated spectra:

```
IDL> stksimages_sbsp, spname, outstokes, outdir=spname
IDL> stks_struct_remote = ssw_save2struct(concat_dir(spname, $
     'stksimg.save'))
```

Data Policy

All Hinode QuickLook and Level-0 data are freely available to anyone. Level-1, Level-1.5, and Level-2 data that exist on the databases listed above are also considered public data with no restrictions on their access.

There are several rules which publishers of Hinode data are expected to follow in order to avoid conflicts with other users.

1. When you write a paper, please include the standard acknowledgment sentences to Hinode:

Hinode is a Japanese mission developed and launched by ISAS/JAXA, with NAOJ as domestic partner and NASA and STFC (UK) as international partners. It is operated by these agencies in co-operation with ESA and NSC (Norway).

We would be grateful if you could place more detailed acknowledgement.

Hinode is a Japanese mission developed and launched by ISAS/JAXA, collaborating with NAOJ as a domestic partner, NASA and STFC (UK) as international partners. Scientific operation of the Hinode mission is conducted by the Hinode science team organized at ISAS/JAXA. This team mainly consists of scientists from institutes in the partner countries. Support for the post-launch operation is provided by JAXA and NAOJ (Japan), STFC (U.K.), NASA, ESA, and NSC (Norway).

2. Please also refer to the following relevant instrumentation papers:

THE HINODE (SOLAR-B) MISSION: AN OVERVIEW
Kosugi, T., Matsuzaki, K., Sakao, T., Shimizu, T., Sone, Y., Tachikawa, S., Hashimoto, T., Minesugi, K., Ohnishi, A., Yamada, T., Tsuneta, S., Hara, H., Ichimoto, K., Suematsu, Y., Shimojo, M., Watanabe, T., Davis, J.M., Hill, L.D., Owens, J.K., Title, A.M., Culhane, J.L., Harra, L., Doschek, G.A., and Golub, L.
2007, *Solar Physics*, **243**, pp. 3-17

THE SOLAR OPTICAL TELESCOPE (SOT) FOR THE SOLAR-B MISSION
Tsuneta, S., Suematsu, Y., Ichimoto, K., Shimizu, T., Otsubo, M., Nagata, S., Katsukawa, Y., Title, A., Tarbell, T., Shine, R., Rosenberg, B., Hoffmann, C., Jurcevich, B., Levay, M., Lites, B., Elmore, D., Matsushita, T., Kawaguchi, N., Mikami, I., Shimada, S., Hill, L., and Owens, J.
2007, *Solar Physics*, submitted.

THE SOLAR OPTICAL TELESCOPE OF SOLAR-B: THE OPTICAL TELESCOPE ASSEMBLY
Suematsu, Y., Tsuneta, S., Ichimoto, K., Shimizu, T., Otsubo, M., Katsukawa, Y., Nakagiri, M., Noguchi, M., Tamura, T., Kato, Y., Hara, H., Mikami, I., Saito, H., Matsushita, T., Kawaguchi, N., Nakaoji, T., Nagae, K., Shimada, S., Takeyama, N., and Yamamuro, T.
2007, *Solar Physics*, submitted.

POLARIZATION CALIBRATION OF THE SOLAR OPTICAL TELESCOPE ONBOARD HINODE
Ichimoto, K., Lites, B., Elmore, D., Suematsu, Y., Tsuneta, S., Katsukawa, Y., Shimizu, T., Shine, R., Tarbell, T., Title, A., Kiyohara, J., Shinoda, K., Card, G., Lecinski, A., Streander, K., Nakagiri, M., Miyashita, M., Noguchi, M., Hoffmann, C., and Cruz, T.
2007, *Solar Physics*, submitted.

IMAGE STABILIZATION SYSTEM FOR HINODE (SOLAR-B) SOLAR OPTICAL TELESCOPE
Shimizu, T., Nagata, S., Tsuneta, S., Tarbell, T., Edwards, C., Shine, R., Hoffmann, C., Thomas, E., Sour, S., Rehse, R., Ito, O., Kashiwagi, Y., Tabata, M., Kodeki, K., Nagase, M., Matsuzaki, K., Kobayashi, K., Ichimoto, K., and Suematsu, Y.
2007, *Solar Physics*, in press .

3. When your paper is accepted, or when you make a presentation at a conference, or hold a press conference on your result, please let us know by sending email to publ_hinode@solar-b.nao.ac.jp.

In addition, when you use Hinode data we would very much like you to:

1. Tell relevant instrument PI(s) what you are working on.

2. We have set up a website so that you can tell us about your project through the site rather than contacting PI(s) directly. The URL is http://hinode.nao.ac.jp/hsc_e/OnGoing_top.shtml

This is partly to our benefit, particularly in protecting existing and potential Ph.D. thesis projects. Also, if your project coincides with one that core team members are working on, that can lead to a fruitful collaboration. This will also work as a way for you to gain better insights into Hinode data.

Other Useful Routines

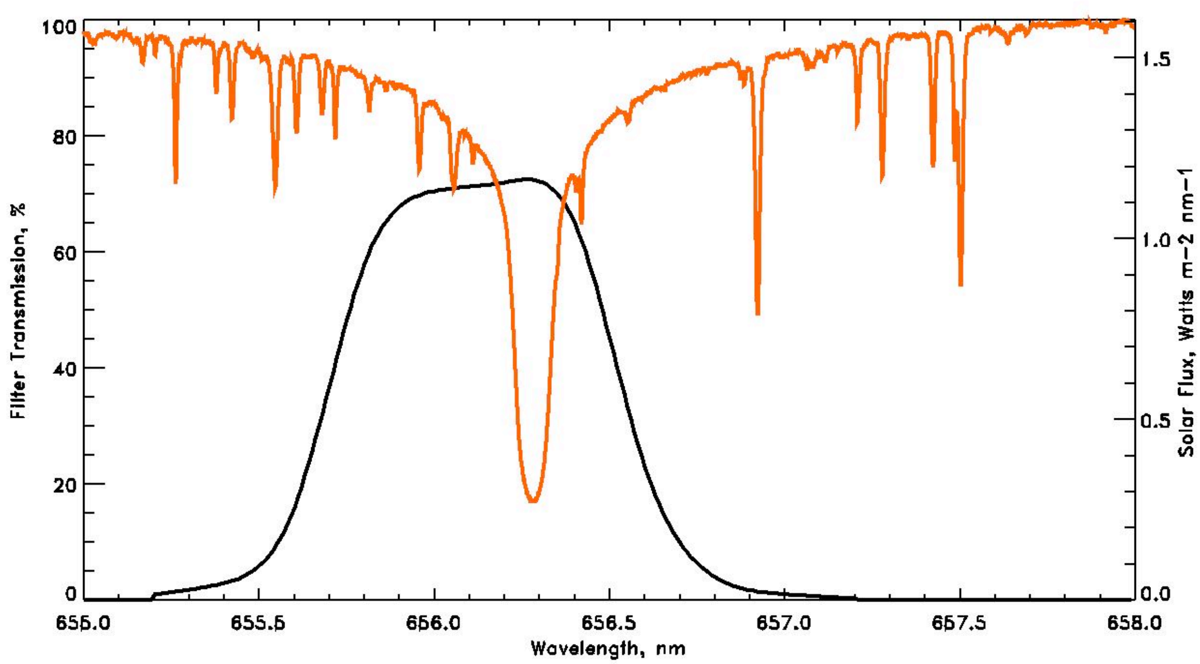
fg_bfi_filter.pro and fg_nfi_filter.pro

PURPOSE:
Return the BFI and NFI blocking filter transmission profiles. These profiles were measured on the ground at the vendor. Two sets of measurements were made: one at 18C and one at 24C temperatures. Some example calls are shown below. To re-create them in an active IDL session, cut and paste the given call to do_demo.pro

This example demonstrates the basic usage of fg_nfi_filter.pro

```
IDL> fg_nfi_filter, '6563', wave, trans, /plot, temp=18, /solar
```

The following plot is produced:



sot_umodes.pro
http://sohowww.nascom.nasa.gov/solarsoft/hinode/sot/idl/util/sot_umodes.pro aka SSW_SOT/idl/util/sot_umodes.pro

Returns string array of uniq SOT instr. "modes" for input time range or input catalog records - optionally, interactive selection & display cadence graphic

```
;   IDL>modes=sot_umodes(time0,time1,mcount=mc, info=info)
;   IDL>modes=sot_umodes(time0,time1,mcount=mc, /interactive)
;   IDL> sot_cat,'15-feb-2007','17-feb-2007',catalog
;   IDL> um=sot_umodes(catalog,/display) ; catalog in and display
graphic
```

(Calls ssw-gen routine ssw_uniq_modes.pro)

all_vals.pro
Returns all uniq vales of any array

hinode_make_wwwmovies.pro
http://sohowww.nascom.nasa.gov/solarsoft/hinode/sot/idl/util/hinode_make_wwwmovies.pro aka
SSW_SOT/idl/util/hinode_make_wwwmovies.pro

Generates www summary movies/thumbs/context/voevents ala sot.lmsal.com (extensive doc header; parameters for maximum frame size, max frames per movie, etc - calls many lower level sot and ssw-gen routines)

hinode_credits.pro
Function returns "approved" sot,xrt,eis, or hinode credits as text or html

See also:
http://orpheus.nascom.nasa.gov/~zarro/xdoc/xdoc
Browse/search SolarSoft utilies&doc headers, including SOT & XRT trees

http://orpheus.nascom.nasa.gov/~zarro/idl/maps/maps.html
Describe overlays, registration, mapping software; directly applicable to SOT/XRT

Appendix A. SOT SSW Routine List

Routine Name	Description
analyzer	-
aperture	-
bapp_sbsp	-
calib_sbsp	generate calibrated, merged Stokes spectra from 4D SP IQUV
centertlb	This is a utility routine to position a widget program\\on the display at an arbitrary location. By default the\\widget is centered on the display.
check_reg2	Check the registration coefficients for a specified time and two specified\\wave bands;\\SAMPLE CALLING SEQUENCE:
cormax_sbsp	find the maximum of a cross correlation function
correlate_tab__define	This defines the correlate_tab plugin module for the GUI tool.
corshft_sbsp	find the shift between line 1 and line 2 by correlation\\sub-pixel accuracy with polynomial interpolation\\adapted to do cross-correlation, not just difference
data_properties_tab__define	This is a template for plugin modules of the MURAM GUI tool.\\Plugin modules are visible as tab widgets in a Display Window.
data_set__define	The purpose of this routine is to implement a data_set Object class\\as part of the Main Module. The Main Module is a component\\of the MHD analysis Software as specified in
display_Window_TBL_Events	-
display_window__define	The purpose of this routine is to implement a Display Window\\for the Solar Data Surfer (SoDaSurf) package within Solarsoft.
error_message	The purpose of this function is to have a device-independent\\error messaging function. The error message is reported\\to the user by using DIALOG_MESSAGE if widgets are
event_movie3	form a 3D plot movie from UT events (via evt_grid)
export_cube_events	-
extend_sbsp	smoothly extend data to make it periodic over its\\dimensioned extent
fftrp_sbsp	Obtain Fourier transform of data. Make smooth transition\\from beginning to end, remove mean, and kill frequencies with\\rgb variation.
fg_bad_pix	Correct the FG CCD camera fix pattern defects. Including:\\removed rows in partial readout frames, dead pixels, hot\\pixels, fixed flaws on the chip such as dust.
fg_bfi_filter	Return the BFI wide-band interference filter transmission\\profiles. These profiles were measured on the ground during\\pre-launch testing in 2006.
fg_bin_image	-

fg_dark_catalog	-
fg_dark_sub	Subtract ADC offset and dark currents from SOT/FG images on\\each half of CCD. ADC offset is temperature dependent and\\different for left and right halves of CCD.
fg_extract	Extract a sub-image from each image in the DATA array.
fg_flatfield	Divide SOT/FG images by an appropriate flat field image.
fg_genid	-
fg_get_flat	Return an FG flat field image appropriate for the index\\structure. This routine is called from FG_FLATFIELD by default\\when a user-provided flat image is not available.
fg_noise	Estimate the photometric noise of a BFI or NFI filtergram.
fg_polar_cal	-
fg_prep	Process an SOT BFI or NFI filtergram, magnetogram, dopplergram, or Stokes set.
fg_rigidalign	Calculates and applies 2-D shifts to a series of images to bring\\them into relative alignment with the first image in the series.
fg_shift_pix	Correct the FG CCD camera readout defects.\\This is the first step in the calibration procedure of FG_PREP.
fg_sum_image	-
fg_waveid	Returns a string with the wavelength in Angstroms\\corresponding to the header keyword WAVEID.
flatgen_sbsp	Generate flat-field data including flat images, variation of the\\intensity along the slit, spectral curvature, skew, spectral offsets, etc\\from the average spectra of a sequence of quiet Sun maps
fsc_droplist	The purpose of this compound widget is to provide an alternative\\to the DROPLIST widget offered in the IDL distribution. What has\\always annoyed me about a droplist is that you can't get the current
fsc_field	The purpose of this compound widget is to provide an alternative\\to the CW_FIELD widget offered in the IDL distribution. One weakness\\of the CW_FIELD compound widget is that the text widgets do not
fsc_fileselect	The purpose of this compound widget is to provide a means\\by which the user can type or select a file name. The\\program is written as an "object widget", meaning that
fsc_plotwindow	The purpose of this compound widget is to create a resizeable\\"plot window" inside a larger "page window". I'm not sure it\\has any value except as a utility routine for the PostScript
fsc_psconfig__define	The purpose of this program is to implement an object that\\can keep track of--and allow the user to change--the current\\configuration of the PostScript device.
fshft_sbsp	shift array line by non-integer pixel shift sh by fourier\\or linear interpolation; uses wraparound for ends\\notes: 1/95, lites@ncar (& rob@ncar) -
gapsmth_sbsp	-

genflt_sbsp	Generate gaintable for HINODE SP data.
get_custom_cube_ptr	-
get_fg_reg_coeff	Return FG registration coefficients for a specified time and two specified wave bands
get_voevent_blorch	-
getdark_sbsp	-
getgain_sbsp	-
go_vomovies	-
gt2exe2	convert gt function shorthand to valid calls (for use w/execute)
hinode_credits	return web/pub credits for Hinode instruments, opt. as html
hinode_fov_context	sot/xrt wrapper for ssw_fov_context (see that routine...)
hinode_gev2movie	-
hinode_make_wwwmovies	make Hinode SOT/XRT movies for given time range
hinode_time2level1	generate Level1 from QuickLook or final Leve0; parallel tree
icrossqu_sbsp	Determine residual i -> Q,U crosstalk from the continuum spectral region, then apply the inverse of that crosstalk to the data. Crosstalk determined and applied on a row-by-row basis.
kb_tab__define	-
launch_sodasurf	-
lmbdrk_sbsp	-
load_addon_plugins	-
load_event	-
main_menu_events	-
mean_sbsp	Calculate mean (float) value of an array.
medfilt_sbsp	Apply a median filter to an input array.\\n gives the size of the box for the filter: 2*n+1.\\sr gives the average range to apply the filter.
mk_voe_obs	Create an OBSERVATION VOEvent XML file from catalog data.
movie_player	-
movie_player_events	-
parabofit	-
pdf_tab__define	This defines the pdf_tab plugin module for the GUI tool.
plugin__define	This object class defines what a plugin is.\\It is the superclass of object classes such as pixel_tab etc.
plugin_template__define	This is a template for plugin modules of the MURAM GUI tool.\\Plugin modules are visible as tab widgets in a Display Window.
pswindow	This function is used to calculate the size of a PostScript\\window that has the same aspect ratio (ratio of height to\\width) as the current display graphics window. It creates
pvpvcomp_sbsp	-
read_sot	read sot FITS files -> "index,data" w/header-index tweaks if

	any
readl1_sbsp	-
residcross_sbsp	-
ruffazm_sbsp	-
sac_peak_atlas	-
sfftrp_sbsp	Obtain Fourier transform of data. Make smooth transition from beginning to end, remove mean, and kill frequencies with
sizeof_sbsp	return information from the SIZE function
slitshft_sbsp	-
slsh_sbsp	-
slshi_sbsp	-
solareph_sbsp	-
sot_cat	read sot (or xrt) catalog for time/time-range; optionally search
sot_cat2files	map from sot catalog entry to files -or- urls
sot_ctmovie	-
sot_filelist	extract file list from level-0/1 data tree
sot_focus_scan	calculate statistics and estimate best focus position for SOT scand
sot_get_dark	return dark frames implied by input 'index'
sot_index2fileinfo	return implied file prefix, subdirectory and tbd for input index
sot_iquv_3d	convert non simple SOT modes (SP, FG-stokes etc) -> "movies"
sot_list	The event handler for sot_list
sot_list	The event handler for sot_list1
sot_make_genxcat	generate genx catalog for SolarB FPP(SOT) & XRT
sot_nospike	Despike an image using a median filter / dilation\\This is a modified version of "nospike.pro" for SOT data
sot_plan2struct	SOT *pln files -> idl structure vector
sot_profiles_menu_ events	-
sot_select	The event handler for sot_select
sot_tab__define	-
sot_time2files	return fpp filenames or ursl for input time range & observable
sot_time2planfiles	return plan info (stucture vector) for input time/structure
sot_time2planinfo	return plan info (stucture vector) for input time/structure
sot_umodes	return string array of uniq ssot "modes"
sot_zoom_tab__defi ne	-
sotsp_time2scan	return SP scan managment info for all scans in time range
sp_prep	Generate SOT/SP Level1 from Level0. Makes two passes through the data: the first pass determines the thermal shifts in the spectral and slit dimensions, and the second pass calibrates, merges the two CCD sides, and applies the drift corrections.
spacecraft_pointing	Given a Solar-B instrument pointing file and a reference time, this routine will calculate the heliocentric coordinates in arc-seconds.

specross_sbsp	-
specshft_sbsp	-
ssw_modeinfo	return some mode/movie statistics
stksimages_sbsp	-
struct_where2	filter a structure array; return SubScripts which satisfy
tab_switch_events	-
terp_xmat_sbsp	-
thermd_sbsp	Compute the thermal drift of image along the slit from Stokes I\\only. This will be smoothed over the duration of the measurements\\before executing the final full calibration pass. This routine does
tim2fg_synop	-
variable_type__define	This object class defines what a variable type is. It is the super-class of object classes such as temperature_type etc.
vigshift_sbsp	-
write_sot	save input sot index and data into files. Default file type is flat.
xshift_sbsp	FFT frequency space shift theorem. For example for vector xxxx0: dx = 5.

Appendix B: Miscellaneous Useful Software

Data Access	
sot_select	
Data Viewing	
sodasurf	
ssw_panorama	
ana browser	
Data Calibration	
Diagnostics and Modelling	
Utilities	

Appendix C: SOT Catalog Structure Tags

Tag Name	Values
NAXIS	-
NAXIS1	-
NAXIS2	-
NAXIS3	-
XCEN	-
YCEN	-
OBS_TYPE	'FG (simple)', 'FG focus scan', 'FG shuttered I and V', 'FG shutterless I and V', 'FG shutterless I and V with 0.2s intervals', 'FG shutterless Stokes', 'SP IQUV 4D array'
CDELT1	-
CROTA1	-
EXPTIME	-
WAVE	'6302A', 'BFI no move', 'CN bandhead 3883', 'Ca II H line', 'G band 4305', 'NFI no move', 'TF Fe I 6302', 'TF Mg I 5172', 'TF Na I 5896', 'blue cont 4504', 'green cont 5550', 'red cont 6684'
SLIT	-
FOCUS	-
DATE_OBS	-
FOVX	-
FOVY	-
TARGET	-
JOP_ID	-
OBSERVER	-
PLANNER	-
OBSTITLE	-
HOUR	-
OBSDIR	-
WAVEID	-
DARKFLAG	-
CAMPSUM	-
CAMSSUM	-
PROG_NO	-
PROG_VER	-
VER_RF0	-
SPNINT	-
SLITPOS	-
SCN_SUM	-
SLITINDX	-
MACROID	-
FPREFIX	-
ANYTIM_DOBS	-
LEVEL0	-

Appendix D: SOT FITS Header Tags

FG

Keyword	Type	Sample	Unit/Option	Description
SIMPLE	Log	T	T, F	Indicates whether the FITS file is standard or not.
BITPIX	Int	16		Number of bits per pixel.
NAXIS	Int	2		Number of data array dimensions.
NAXIS1	Int	2048		Number of pixels (data points) in the first axis of the data array.
NAXIS2	Int	1024		Number of pixels (data points) in the second axis of the data array.
NAXIS3	Int	2		Number of pixels (data points) in the third axis of the data array.
EXTEND	Log	T	T, F	FITS extension indicator.
DATE	Str	2006-12-02T13:10:11.100	UTC	Date that a particular file was reformatted or created (YYYY-MM-DDThh:mm:ss.sss).
DATE_RF0	Str	2006-12-02T13:10:11.100	UTC	Indicates when the Level-0 reformatting was done (YYYY-MM-DDThh:mm:ss.sss).
TELESCOP	Str	HINODE		Name of the satellite.
MDP_CLK	Int	2133925449	1/512sec	TI (spacecraft) clock delivered by MDP at the exposure start.
FILEORIG	Str	2007_0904_063717.sci		Indicates which sci files were used at creation.
MDPCTREF	Int	2133923951	1/512sec	TI (spacecraft) clock delivered by MDP at the nearest CT reference.
CTREF	Int	2961279384	1/584sec	FPP CT clock at the nearest CT reference.
CTRATE	Flt	584.0	Hz	FPP CT clock speed.
TIMEERR	Flt	0.0	sec	Time error between TI clock and CT clock.
EXP0	Flt	0.051296	sec	Measured exposure duration
OBT_TIME	Int	2133924539	1/512sec	Start time of the exposure in TI spacecraft clock
OBT_END	Int	2133924565	1/512sec	End time of the exposures in TI spacecraft clock
DATE_OBS	Str	2007-08-27T05:59:45.785	UTC	The date and time at the start time of the expsosure (YYYY-MM-DDThh:mm:ss.sss).
TIME-OBS	Str	05:59:45.785	UTC	Start time of the exposure in UTC (hh:mm:ss.sss).
CTIME	Str	Mon Aug 27 05:59:45 2007	UTC	The date and time at the start time of the expsosure in the calendar format (WkD MMM DD hh:mm:ss YYYY).
DATE_END	Str	2007-08-27T05:59:45.83	UTC	End time of the exposure (YYYY-MM-DDThh:mm:ss.sss).
TIMESPAN	Flt	0.051296	sec	Time span to get the image
TIMESYS	Str	UTC		Indicates the time system of the data
INSTRUME	Str	SOT/WB		Name of the instrument used to acquire the data (SOT/WB, SOT/NB, SOT/SP,SOT/CT).
ORIGIN	Str	JAXA/ISAS, SIRIUS		Indicates where the reformatted file was created
DATA_LEV	Int	0	0,1,2	The level of the data
ORIG_RF0	Str	JAXA/ISAS, SIRIUS		Indicates where the Level-0 reformatting was done. Same as ORIGIN keyword for Level-0 FITS.
VER_RF0	Str	1.41		Indicates the version of the reformatting program used to create Level-0 data.
PROG_VER	Int	273		Version number of the program table in use.
SEQN_VER	Int	205		Version number of the sequence table in use
PARM_VER	Int	123		Version number of the parameter table in use
PROG_NO	Int	8	1-20	Program slot number.
SUBR_NO	Int	1	1-4	Subroutine slot number.
SEQN_NO	Int	84	1-100	Sequence slot numer.
MAIN_CNT	Int	238	0-255	Current repeat count of the main routine.

MAIN_RPT	Int	0	0-255	Repeat number of the main routine. 1-255 for repeat count, and 0 means infinite repeat
MAIN_POS	Int	1	1-8	Current position in the main routine.
SUBR_CNT	Int	1	1-255	Current repeat count of the subroutine.
SUBR_RPT	Int	1	1-255	Repeat number of the subroutine.
SUBR_POS	Int	1	1-8	Current position in the subroutine.
SEQN_CNT	Int	1	1-255	Current repeat count of the sequence.
SEQN_RPT	Int	1	1-255	Repeat number of the sequence.
SEQN_POS	Int	1	1-8	Current position in the sequence.
OBSTITLE	Str			Title of the observation
TARGET	Str			Description of the target region
SCI_OBJ	Str			A few sentences on the scientific objective of the observation
SCI_OBS	Str			A few sentences on the scientific objective of the observation
OBS_DEC	Str			A few sentences describing the properties of the observation
JOIN_SB	Str	ESX		Indicates the HINODE instruments involved in the observation (S: SOT, X: XRT, E: EIS).
OBS_NUM	Int	100		HINODE observation number
JOP_ID	Int	123		Joint observations between HINODE and other instruments will be sequentially numbered
NOAA_NUM	Int	11345		The NOAA Active Region number for AR observations
OBSERVER	Str		L F, M	Name of the Chief Observer
PLANNER	Str		L F, M	Name of the Chief Planner
TOHBANS	Str		L F, M	Names of the Real-Time Tohbans
DATATYPE	Str	SCI	SCI, ENG	Indicates whether data is science or engineering test related
FLFLG	Str	FLR	FLR, NON	Flare flag: indicates observations made during FLARE mode
SAA	Str	OUT	IN, OUT	Indicates whether the satellite is in the South Atlantic Anomoly at the time of observation
HLZ	Str	IN	IN, OUT	Indicates whether the satellite is in the High Latitude Zone of auroral precipitation at the time of observation
OBS_ID	Int	23		Numerical identifier that correlates to OBS_TYPE. There is many-to-one correlation to OBS_TYPE
GEN_ID	Int	1		Numerical identifier with one-to-one correspondence to OBS_TYPE
FRM_ID	Int	2		Numerical identifier of frame definition block
WAVEID	Int	12		Numerical identifier of observable wavelength
OBS_TYPE	Str	FG (simple)		A single Str code idenitifying the type of observation.
MACROID	Int	9436		Sequential number of the macro-command delivered by MDP.
XSCALE	Flt	0.10896	asec/pix	Pixel scale in the X-direction.
YSCALE	Flt	0.10896	asec/pix	Pixel scale in the Y-direction.
FGXOFF	Int	10	asec	FG X offset for ROI definition.
FGYOFF	Int	20	asec	FG Y offset for ROI definition.
FGCCDIX0	Int	0	pix	Index of the 1st pixel in the CCD X-direction.
FGCCDIX1	Int	4095	pix	Index of the last pixel in the CCD X-direction.
FGCCDIY0	Int	0	pix	Index of the 1st pixel in the CCD Y-direction.
FGCCDIY1	Int	2047	pix	Index of the last pixel in the CCD Y-direction.
CRPIX1	Flt	1024.5	pix	Coordinates (X) of the reference pixel in the data. The reference pixel is usually the center of the CCD.
CRPIX2	Flt	512.5	pix	Coordinates (Y) of the reference pixel in the data. The reference pixel is usually the center of the CCD.
SC_ATTX	Flt	-43.3359	asec	Heliocentric coordinate (X) of AOCS pointing.

SC_ATTY	Flt	-216.525	asec	Heliocentric coordinate (Y) of AOCS pointing.
CRVAL1	Flt	-43.3359	asec	Coordinates (X) of the reference pixel in heliocentric reference frame.
CRVAL2	Flt	-216.525	asec	Coordinates (Y) of the reference pixel in heliocentric reference frame.
CDELT1	Flt	0.10896	asec/pix	Pixel scale in the X-direction
CDELT2	Flt	0.10896	asec/pix	Pixel scale in the Y-direction
CUNIT1	Str	arcsec		Unit of CRVAL1
CUNIT2	Str	arcsec		Unit of CRVAL2
CTYPE1	Str	Solar-X		Label of the first dimension of the data
CTYPE2	Str	Solar-Y		Label of the second dimension of the data
SAT_ROT	Flt	0.12	deg	Difference between Solar North and the Y-axis of the satellite
INST_ROT	Flt	0.412	deg	Difference between the Y-axis of the satellite and the images
CROTA1	Flt	0.412043	deg	SAT_ROT + INST_ROT. Difference between Solar North and Y-axis of the image.
CROTA2	Flt	0.412043	deg	SAT_ROT + INST_ROT. Difference between Solar North and the X-axis of the image.
XCEN	Flt	-43.3359	asec	The heliocentric coordinate (X) at the center of the image
YCEN	Flt	-216.525	asec	The heliocentric coordinate (Y) at the center of the image
FOVX	Flt	223.15	asec	The width of the field-of-view in the X-coordinate
FOVY	Flt	111.575	asec	The width of the field-of-view in the Y-coordinate
TR_MODE	Str	TR1	TR1-TR4, FIX	AOCS tracking mode (TR1--TR4) or Fixed (FIX). The number after TR indicates the number of the tracking curve.
FGBINX	Int	1	1, 2	On-board s/w summing in the CCD X-direction
FGBINY	Int	1	1, 2	On-board s/w summing in the CCD Y-direction
EXPTIME	Flt	0.0512	sec	Exposure time requested by the command
WAVE	Str	G band 4305		Description of observable ion and wavelength
DARKFLAG	Int	1	0, 1	Flag to indicate the shutter is opend (0) or closed (1)
BITCOMP1	Int	6		Bit-compression parameter for unsigned data (0:none, 1:16U->12, 2:14U->12, 6:12U low)
IMGCOMP1	Int	7		Imaga-compression parameter for unsigned data (0: none, 3:12bit DPCM, 7:12bit JPEG)
QTABLE1	Int	2		Q-table number for unsigned data (0:98, 1:90, 2:75, 3:50, 4:95, 5:92, 6:85, 7:65)
BITCOMP2	Int	3		Bit-compression parameter for signed data (0:none, 3: 16S->12, 4:14.5S->12, 5:13S->12)
IMGCOMP2	Int	7		Imaga-compression parameter for signed data (0: none, 3:12bit DPCM, 7:12bit JPEG)
QTABLE2	Int	4		Q-table number for signed data (0:98, 1:90, 2:75, 3:50, 4:95, 5:92, 6:85, 7:65)
PCK_SN0	Int	18615462		Serial number of the first packet of the image.
PCK_SN1	Int	18615494		Serial number of the last packet of the image.
NUM_PCKS	Int	33		Number of image packets used to construct the FITS file.
FGMODE	Str	shuttered		String indicating the FG camera mode (shuttered or shutterless)
FGNINT	Int	1		Number indicating how many images are integrated
ROILOOP	Int	0	0, 1	Flag indicating ROI loop is used or not in the shutterless mode
NROILOOP	Int	0		Number of ROI loop in the shutterless mode
CTSERVO	Int	1	0, 1	CT servo on (1) or off (0)
CTMESTAT	Int	36864		CTM-E status bit field

CTMEX	Int	20421	0.0005 asec	CTM tip-tilt mirror X-tilt (CTM 2nd word).
CTMEY	Int	-704	0.0005 asec	CTM tip-tilt mirror Y-tilt (CTM 3rd word).
CTMODE	Int	33		Correlation tracker mode bit field.
T_SPCCD	Flt	-10	deg C	Temperature of the SP CCD at the camera head.
T_FGCCD	Flt	-10	deg C	Temperature of the FG CCD at the camera head.
T_CTCCD	Flt	-10	deg C	Temperature of the CT CCD at the camera head.
T_SPCEB	Flt	20	deg C	Temperature of the SP camera electronics box.
T_FGCEB	Flt	20	deg C	Temperature of the FG camera electronics box.
T_CTCEB	Flt	20	deg C	Temperature of the CT camera electronics box.
MASK	Int	22	steps	Position of NFI mask wheel
WBFW	Int	118	steps	Position of BFI filterwheel
WEDGE	Int	22	steps	Position of CT wedge filter
NBFW	Int	38	steps	Position of NFI filter wheel
TF1	Int	2	steps	Position of TF motor 1
TF2	Int	40	steps	Position of TF motor 2
TF3	Int	6	steps	Position of TF motor 3
TF4	Int	6	steps	Position of TF motor 4
TF5	Int	28	steps	Position of TF motor 5
TF6	Int	41	steps	Position of TF motor 6
TF7	Int	67	steps	Position of TF motor 7
TF8	Int	21	steps	Position of TF motor 8
SLITENC	Int	2048	steps	Encoder position of SP scan mechanism.
FOCUS	Int	2048	steps	Position of FPP focusing lens.
WBEXP	Int	53	msec	BFI last requested exposure time.
NBEXP	Int	99	msec	NFI last requested exposure time.
WAVEOFF	Int	350	mA	Offset from baseline wavelength of observable given in WAVE.
ROISTART	Int	0		Camera read-out parameter of ROI start.
ROISTOP	Int	1025		Camera read-out parameter of ROI stop.
DOPVUSED	Int	-1024	m/s	Doppler shift compensation applied to the FG data.
CAMGAIN	Int	2	0-3	Numerical ID of Camera gain.
CAMDACA	Int	8	0-15	Numerical ID of DAC offset A.
CAMDACB	Int	8	0-15	Numerical ID of DAC offset B.
CAMPSUM	Int	2	1, 2, 4	Cameras parallel summing (X-direction).
CAMSSUM	Int	2	1, 2, 4	Cameras serial summing (Y-direction).
CAMAMP	Int	0	0, 1	Numerical ID of camera amplifier.
CAMSCLK	Int	0	0, 1	Numerical ID of camera serial clock direction.
PMUDELAY	Int	128		Phase offset between the PMU signal and the signal sent to the camera.
BITCVER1	Int	45094		Version number of the bit compression table
DCHFVER1	Int	40961		Version number of the JPEG Huffman-DC table
ACHFVER1	Int	53249		Version number of the JPEG Huffman-AC table
QTABVER1	Int	57365		Version number of the Q table for JPEG comp
BITCVER2	Int	45094		Version number of the bit compression table
DCHFVER2	Int	40961		Version number of the JPEG Huffman-DC table
ACHFVER2	Int	53249		Version number of the JPEG Huffman-AC table
QTABVER2	Int	57365		Version number of the Q table for JPEG comp
BYTECNTI	Int	929560	bytes	Total number of bytes of the compressed unsigned data.
PIXCNTI	Int	2097152	pix	Total number of pixels of the compressed unsigned data.
BITSPPI	Flt	3.54599	bits/pix	Average bit/pixel of the unsigned data

BYTECNTQ	Int	68974	bytes	Total number of bytes of the compressed signed data
PIXCNTQ	Int	287232	pix	Total number of pixels of the compressed signed data
BITSPPQ	Flt	1.92107	bits/pix	Average bit/pixel of the signed data.
COMMENT	Str			General comment. Allowed throughout header.
END	(blank)			Marks the end of the FITS header

SP

Keyword	Type	Sample	Unit/Option	Description
SIMPLE	Log	T	T, F	Indicates whether the FITS file is standard or not.
BITPIX	Int	16		Number of bits per pixel.
NAXIS	Int	2		Number of data array dimensions.
NAXIS1	Int	112		Number of pixels (data points) in the first axis of the data array.
NAXIS2	Int	384		Number of pixels (data points) in the second axis of the data array.
NAXIS3	Int	2		Number of pixels (data points) in the third axis of the data array.
NAXIS4	Int	4		Number of pixels (data points) in the fourth axis of the data array.
EXTEND	Log	T	T, F	FITS extension indicator.
DATE	Str	2006-12-02T13:10:11.100	UTC	Date that a particular file was reformatted or created (YYYY-MM-DDThh:mm:ss.sss).
DATE_RF0	Str	2006-12-02T13:10:11.100	UTC	Indicates when the Level-0 reformatting was done (YYYY-MM-DDThh:mm:ss.sss).
TELESCOP	Str	HINODE		Name of the satellite.
INSTRUME	Str	SOT/SP		Name of the instrument used to acquire the data (SOT/WB, SOT/NB, SOT/SP,SOT/CT).
MDP_CLK	Int	2133925449	1/512sec	TI (spacecraft) clock delivered by MDP at the exposure start.
ORIGIN	Str	JAXA/ISAS, SIRIUS		Indicates where the reformatted file was created
DATA_LEV	Int	0	0,1,2	The level of the data
ORIG_RF0	Str	JAXA/ISAS, SIRIUS		Indicates where the Level-0 reformatting was done. Same as ORIGIN keyword for Level-0 FITS.
VER_RF0	Str	1.41		Indicates the version of the reformatting program used to create Level-0 data.
PROG_VER	Int	273		Version number of the program table in use.
SEQN_VER	Int	205		Version number of the sequence table in use
PARM_VER	Int	123		Version number of the parameter table in use
PROG_NO	Int	8	1-20	Program slot number.
SUBR_NO	Int	1	1-4	Subroutine slot number.
SEQN_NO	Int	84	1-100	Sequence slot numer.
MAIN_CNT	Int	238	0-255	Current repeat count of the main routine.
MAIN_RPT	Int	0	0-255	Repeat number of the main routine. 1-255 for repeat count, and 0 means infinite repeat
MAIN_POS	Int	1	1-8	Current position in the main routine.
SUBR_CNT	Int	1	1-255	Current repeat count of the subroutine.
SUBR_RPT	Int	1	1-255	Repeat number of the subroutine.
SUBR_POS	Int	1	1-8	Current position in the subroutine.
SEQN_CNT	Int	1	1-255	Current repeat count of the sequence.
SEQN_RPT	Int	1	1-255	Repeat number of the sequence.
SEQN_POS	Int	1	1-8	Current position in the sequence.
OBSTITLE	Str			Title of the observation
TARGET	Str			Description of the target region

SCI_OBJ	Str			A few sentences on the scientific objective of the observation
SCI_OBS	Str			A few sentences on the scientific objective of the observation
OBS_DEC	Str			A few sentences describing the properties of the observation
JOIN_SB	Str	ESX		Indicates the HINODE instruments involved in the observation (S: SOT, X: XRT, E: EIS).
OBS_NUM	Int	100		HINODE observation number
JOP_ID	Int	123		Joint observations between HINODE and other instruments will be sequentially numbered
NOAA_NUM	Int	11345		The NOAA Active Region number for AR observations
OBSERVER	Str		L F, M	Name of the Chief Observer
PLANNER	Str		L F, M	Name of the Chief Planner
TOHBANS	Str		L F, M	Names of the Real-Time Tohbans
DATATYPE	Str	SCI	SCI, ENG	Indicates whether data is science or engineering test related
FLFLG	Str	FLR	FLR, NON	Flare flag: indicates observations made during FLARE mode
FILEORIG	Str	2007_0904_063717.sci		Indicates which sci files were used at creation.
MDPCTREF	Int	2133923951	1/512sec	TI (spacecraft) clock delivered by MDP at the nearest CT reference.
CTREF	Int	2961279384	1/584sec	FPP CT clock at the nearest CT reference.
CTRATE	Flt	584.0	Hz	FPP CT clock speed.
TIMEERR	Flt	0.0	sec	Time error between TI clock and CT clock.
OBT_TIME	Int	2133924539	1/512sec	Start time of the exposure in TI spacecraft clock
OBT_END	Int	2133924565	1/512sec	End time of the exposures in TI spacecraft clock
DATE_OBS	Str	2007-08-27T05:59:45.785	UTC	The date and time at the start time of the expsosure (YYYY-MM-DDThh:mm:ss.sss).
TIME-OBS	Str	05:59:45.785	UTC	Start time of the exposure in UTC (hh:mm:ss.sss).
CTIME	Str	Mon Aug 27 05:59:45 2007	UTC	The date and time at the start time of the expsosure in the calendar format (WkD MMM DD hh:mm:ss YYYY).
DATE_END	Str	2007-08-27T05:59:45.83	UTC	End time of the exposure (YYYY-MM-DDThh:mm:ss.sss).
SAA	Str	OUT	IN, OUT	Indicates whether the satellite is in the South Atlantic Anomoly at the time of observation
HLZ	Str	IN	IN, OUT	Indicates whether the satellite is in the High Latitude Zone of auroral precipitation at the time of observation
CRPIX1	Flt	56.5	pix	Horizontal position of the reference pixel in the data. The reference pixel is usually the center of the CCD.
CRPIX2	Flt	192.5	pix	Vertical position of the reference pixel in the data. The reference pixel is usually the center of the CCD.
CRVAL1	Flt	6302.0	Ang	The wavelength at the reference pixel specified by CRPIX1.
SC_ATTX	Flt	-43.3359	asec	Heliocentric coordinate (X) of AOCS pointing.
SC_ATTY	Flt	-216.525	asec	Heliocentric coordinate (Y) of AOCS pointing.
CRVAL2	Flt	-216.525	asec	Coordinates (Y) of the reference pixel in heliocentric reference frame.
CDELT1	Flt	-0.021549	Ang/pix	Pixel scale in the dispersion direction.
CDELT2	Flt	0.317	asec/pix	Pixel scale in the slit direction.
CUNIT1	Str	Angstrom		Unit of CRVAL1
CUNIT2	Str	arcsec		Unit of CRVAL2
CTYPE1	Str	Wavelength		Label of the first dimension of the data
CTYPE2	Str	Solar-Y		Label of the second dimension of the data
CTYPE1	Str	CCD side		Label of the third dimension of the data
CTYPE2	Str	Stokes component		Label of the fourth dimension of the data

SAT_ROT	Flt	-0.000128	deg	Difference between Solar North and the Y-axis of the satellite
INST_ROT	Flt	0.412	deg	Difference between the Y-axis of the satellite and the images
CROTA1	Flt	0.411871	deg	SAT_ROT + INST_ROT. Difference between Solar North and Y-axis of the image.
CROTA2	Flt	0.411871	deg	SAT_ROT + INST_ROT. Difference between Solar North and the X-axis of the image.
YSCALE	Flt	0.317000	asec/pix	Pixel scale in the Y-direction.
XSCALE	Flt	0.295200	asec/step	Step size of slit scanning.
FOVX	Flt	0.295200	asec	The width of the field-of-view in X(EW), which means the slit width.
FOVY	Flt	121.728	asec	The width of the field-of-view in the Y(NS).
TR_MODE	Str	TR1	TR1-TR4, FIX	AOCS tracking mode (TR1-TR4) or Fixed (FIX). The number after TR indicates the number of the tracking curve.
XCEN	Flt	-43.3359	asec	The heliocentric coordinate (X) at the slit position.
YCEN	Flt	-216.525	asec	The heliocentric coordinate (Y) at the center of the slit.
SPMAPCTR	Flt	0	steps	Center position of slit scan with respect to scan mechanism center.
SPCCDIX0	Int	128	pix	Index of the 1st pixel in the CCD X-direction.
SPCCDIX1	Int	895	pix	Index of the last pixel in the CCD X-direction.
SPCCDIY0	Int	56	pix	Index of the 1st pixel in the CCD Y-direction.
SPCCDIY1	Int	167	pix	Index of the last pixel in the CCD Y-direction.
MACROID	Int	55		Sequential number of the macro-command delivered by MDP.
PCK_SN0	Int	16088917		Serial number of the first packet of the image.
PCK_SN1	Int	16088925		Serial number of the last packet of the image.
NUM_PCKS	Int	9		Number of image packets used to construct the FITS file.
NSLITPOS	Int	1024	steps	Number of slit positions in an SP map.
SLITINDX	Int	513	steps	Index number of slit position in map. Range from 0 to NSLITPOS-1.
NUM_SIDE	Int	2	1, 2	Number of the CCD sides in use (1: only LHS, 2: both LHS and RHS).
WAVE	Str	6302A		Description of wavelength
SPNINT	Int	4	1-16	Number of intengration cycles. 1 cycle corresponds to 0.8sec integration (half rotation of PMU).
SP_EXTID	Int	10	0-15	SP Extract ID, determines ROI in spatial direction.
SCN_STEP	Int	1	steps	Scan steps, number of slit scan mechanism steps between positions at which data is collected.
SCN_SUM	Int	1	steps	Scan summing, number os slit positions to sum before sending data to MDP.
SCN_RPT	Int	1	0, 1	Repeat flag. Repeat map ad infinitum if set.
SPBSHFT	Int	1	0-3	Scaling (bit-shift) options (0:no scaling, 1:I down by a factor of 2, 2:I and V down, 3: I, Q, U, and V down).
BITCOMP1	Int	6		Bit-compression parameter for unsigned data (0:none, 1:16U->12, 2:14U->12, 6:12U low)
IMGCOMP1	Int	7		Imaga-compression parameter for unsigned data (0: none, 3:12bit DPCM, 7:12bit JPEG)
QTABLE1	Int	2		Q-table number for unsigned data (0:98, 1:90, 2:75, 3:50, 4:95, 5:92, 6:85, 7:65)
BITCOMP2	Int	3		Bit-compression parameter for signed data (0:none, 3: 16S->12, 4:14.5S->12, 5:13S->12)
IMGCOMP2	Int	7		Imaga-compression parameter for signed data (0: none, 3:12bit DPCM, 7:12bit JPEG)
QTABLE2	Int	4		Q-table number for signed data (0:98, 1:90, 2:75, 3:50, 4:95, 5:92, 6:85, 7:65)

ROISTART	Int	56		Camera read-out parameter of ROI start.
ROISTOP	Int	168		Camera read-out parameter of ROI stop.
DOPVUSED	Int	-1024	m/s	Doppler shift compensation applied to the last FG data.
CAMGAIN	Int	2	0-3	Numerical ID of Camera gain.
CAMDACA	Int	7	0-15	Numerical ID of DAC offset A.
CAMDACB	Int	7	0-15	Numerical ID of DAC offset B.
CAMPSUM	Int	1	1, 2, 4	Cameras parallel summing (X-direction).
CAMSSUM	Int	2	1, 2, 4	Cameras serial summing (Y-direction).
CAMAMP	Int	1	0, 1	Numerical ID of camera amplifier.
CAMSCLK	Int	1	0, 1	Numerical ID of camera serial clock direction.
SLITPOS	Int	464	steps	Position of slit with respect to slit scan mechanism center, software best estimate.
SLITENC	Int	2513	steps	Slit position encoder reading, center is 2048.
SPMAPINX	Int	570992		Cumulative number of SP maps completed.
CTSERVO	Int	1	0, 1	CT servo on (1) or off (0)
CTMESTAT	Int	36864		CTM-E status bit field
CTMEX	Int	20421	0.0005 asec	CTM tip-tilt mirror X-tilt (CTM 2nd word).
CTMEY	Int	-704	0.0005 asec	CTM tip-tilt mirror Y-tilt (CTM 3rd word).
CTMODE	Int	33		Correlation tracker mode bit field.
DOP_RCV	Int	254	m/s	Doppler shift compensation provided by MDP.
WEDGE	Int	22	steps	Position of CT wedge filter
FOCUS	Int	2048	steps	Position of FPP focusing lens.
T_SPCCD	Flt	-10	deg C	Temperature of the SP CCD at the camera head.
T_FGCCD	Flt	-10	deg C	Temperature of the FG CCD at the camera head.
T_CTCCD	Flt	-10	deg C	Temperature of the CT CCD at the camera head.
T_SPCEB	Flt	20	deg C	Temperature of the SP camera electronics box.
T_FGCEB	Flt	20	deg C	Temperature of the FG camera electronics box.
T_CTCEB	Flt	20	deg C	Temperature of the CT camera electronics box.
PMUDELAY	Int	128		Phase offset between the PMU signal and the signal sent to the camera.
TIMESYS	Str	UTC		Indicates the time system of the data.
EXPTIME	Flt	3.2	sec	Exposure time requested by the command.
BITCVER1	Int	45094		Version number of the bit compression table
DCHFVER1	Int	40961		Version number of the JPEG Huffman-DC table
ACHFVER1	Int	53249		Version number of the JPEG Huffman-AC table
QTABVER1	Int	57365		Version number of the Q table for JPEG comp
BITCVER2	Int	45094		Version number of the bit compression table
DCHFVER2	Int	40961		Version number of the JPEG Huffman-DC table
ACHFVER2	Int	53249		Version number of the JPEG Huffman-AC table
QTABVER2	Int	57365		Version number of the Q table for JPEG comp
BYTECNTI	Int	929560	bytes	Total number of bytes of the compressed unsigned data.
PIXCNTI	Int	2097152	pix	Total number of pixels of the compressed unsigned data.
BITSPPI	Flt	3.54599	bits/pix	Average bit/pixel of the unsigned data
BYTECNTQ	Int	68974	bytes	Total number of bytes of the compressed signed data
PIXCNTQ	Int	287232	pix	Total number of pixels of the compressed signed data
BITSPPQ	Flt	1.92107	bits/pix	Average bit/pixel of the signed data.
OBS_TYPE	Str	SP IQUV 4D array		A single Str code idenitifying the type of observation.
COMMENT	Str			General comment. Allowed throughout header.
END	(blank)			Marks the end of the FITS header

Appendix E: Relevant Web links to Instrument and Data Sites

Data archive search interfaces

- Hinode DARTS (Japan)
- Hinode SDC Europe (Norway)
- Hinode SOT & XRT Archive (LMSAL, USA)
- SOT Search Catalog direct link (LMSAL, USA)
- Hinode XRT Archive (CfA, USA)
- Hinode EIS Archive (MSSL, UK)

Hinode images/movies

- Hinode Latest Images (NAOJ, Japan)
- Hinode QL movies (NAOJ, Japan)
- XRT Picture of the Week (CfA, USA)
- Hinode picture archive (NASA, USA)
- Hinode movie archive (NASA, USA)
- Hinode movies (NASA MSFC, USA)

Hinode mission sites

- National Astronomical Observatory of Japan (NAOJ, Japan)
- National Aeronautics and Space Administration (NASA, USA)
- Marshall Space Flight Centre (NASA MSFC, USA)
- European Space Agency (ESA, Europe)
- Hinode Europe (IAA, Spain)

Institutions

- Lockheed Martin Solar and Astrophysics Laboratory
- Institute of Theoretical Astrophysics (ITA, Norway)
- University of Oslo (UiO, Norway)
- Norwegian Space Centre (NSC, Norway)
- Japan Aerospace Exploration Agency (JAXA, Japan)
- National Astronomical Observatory of Japan (NAOJ, Japan)
- European Space Agency (ESA, Europe)
- National Aeronautics and Space Administration (NASA, USA)