Progress Report
Extreme Ultraviolet Imaging Telescope (EIT)
(Contract NAS5-32966)
[for period October 1995 - October 1997]

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SOFTWARE

- Sam Freeland -

Efforts concentrated on development and implementation of the SolarSoft (SSW) data analysis system. From an EIT analysis perspective, this system was designed to facilitate efficient reuse and conversion of software developed for Yohkoh/SXT and to take advantage of a large existing body of software developed by the SDAC, Yohkoh, and SOHO instrument teams. Another strong motivation for this system was to provide an EIT analysis environment which permits coordinated analysis of EIT data in conjunction with data from important supporting instruments, including Yohkoh/SXT and the other SOHO coronal instruments; CDS, SUMER, and LASCO. In addition, the SSW system will support coordinated EIT/TRACE analysis (by design) when TRACE data is available; TRACE launch is currently planned for March 1998. Working with Jeff Newmark, the Chianti software package (K.P.Dere et al) and UV/EUV data base was fully integrated into the SSW system to facilitate EIT temperature and emission analysis.

Detailed documentation of the SolarSoft system is available on the WWW at URL:
http://www.space.lockheed.com/solarsoft/

As an integral part of the SolarSoft system, tools for the the remote distribution and installation of the SSW system were developed. This is an extension of the Yohkoh installation system with new provisions for a simplified WWW interface. A remote user (for example, an EIT CO-I), may select any subset of SSW instruments and libraries (SOHO, Yohkoh, Chianti TRACE...) for installation using a standard WWW FORM to generate a customized installation script. Installation documentation and links to the installation procedure and FORM are available using the SSW URL given above. The SSW installation procedure, which involves an WWW/IDL server, is itself written using software available in the SSW libraries.

Recent developments extend the automatic upgrade capabilities of the SSW system to assure that SSW/EIT CO-I institutes always have the latest EIT software with minimal work. Additional SSW WWW documentation was placed online recently to describe the (nearly effortless) process of keeping SSW current.
http://www.space.lockheed.com/solarsoft/ssw_upgrades.html

Additional specific EIT software was written to support coordinated EIT analysis within the SSW framework. For example, a "fundamental" routine <read_eit> reads and translates EIT reformatted data (multiple FITS files) into IDL structures and data cubes which are consistent with other SSW data sets. This permits direct application of many SSW (Yohkoh, SDAC, etc.) routines to EIT data analysis applications (display, time series, correlation of EIT with other SSW data sets, etc.). Continued working with members of CDS/SUMER (Zarro, Wang) and MDI teams (DeForrest, Morrison) to maximize reuse and inter-instrument use of certain fundamental SSW utilities.

SOFTWARE (continued)

Wrote and installed automatic jobs at the GSFC EAF to run several SSW and EIT software tasks. Tasks include monitoring the SSW system for updates and conflicts and generating the files required by the WWW installation task. An example of an EIT automated task is the one which generates near real time movies at all four EIT wavelengths on the WWW in three different WWW browser compatible formats (mpeg, gif-animate and javascript). The data is automatically selected for quality and cadence, and is processed to improve movie cosmetic quality. The associated EIT movies which include most recent data are available at URL:

http://sohowww.nascom.nasa.gov/sdb/http/eit_fullfov_java.html

A suite of software was developed to allow automated detection of EIT 304 limb features. A description of the software algorithms, intended applications, and current results were presented at the SPD meeting in Bozeman Montana, June 1996. The abstract follows:

Automated He II 304A Limb Feature Detection

S.L.Freeland, G.L.Slater, J.R.Lemen

We describe algorithms and software designed to automatically identify, catalog, and extract the prominence features from cleaned, full disk He II 304A images of the solar atmosphere recorded by the The Extreme Ultraviolet Imaging Telescope (EIT) aboard the Solar and Heliospheric Observatory (SoHO). Sequences of partial frame images extracted in this manner will be presented, together with parameters automatically derived from the data, such as limb location, 'center of mass' location, and apparent radial velocity of the features. It has been observed that limb prominences show up exceptionally well in the 304A images, which therefore provide excellent candidates for automated feature recognition software. Specifically, these 'above the limb' prominence features are highly contrasted with the surrounding pixels in individual 304A images. When assembled into three dimensional data cubes, the growth, shrinkage, and possible eruption of prominences are identifiable with software. Moreover, for events identified as eruptive, the 304A signal might provide a valuable proxy to identify and extract corresponding events in less "well behaved" data sets, including those of EIT at other wavelengths, Yohkoh/SXT, and SOHO/LASCO. The software design permits near real time execution in anticipation that identification of eruptive prominence events will provide some future predictive or automated notification value. To optimize use of existing software capabilities and to facilitate cross reference with other data sets, we use the SolarSoft system as our development environment

SOFTWARE (continued)

- Brian Handy -

Software efforts have concentrated on creating a small suite of software that permit extraction of a "clean" (dark-subtracted, flat-fielded, etc) sub-image from from a set of mixed-resolution EIT full-frame images. The tracking sofware is designed to follow and extract an identified EIT region as it rotates across (with) the solar disk. In the spirit of the SolarSoft system, the routine builds upon previous work by Slater, Metcalf, Morrison, etc., and incorporates suggested SOHO standard "keywords" to facilitate extension to other SOHO instruments (MDI magnetograms, for example). One fundamental routine developed in this area was <ssw_track_fov> which is now incorporated into Jeff Newmark's EIT movie making software.

Worked with Gary Linford (LMMS) discussing how best to archive EIT data to CDrom for use in the LMMS 500-CD Jukebox. The decisions have been made; now it's just a matter of doing the work. Gary has suggested that he would be interested in putting EIT data on-line (in the jukebox) for us.

CALIBRATION

R. Stern, J. Lemen, L. Shing, and R. Catura reviewed the status of the EIT CCD quantum efficiency calibration, and summarized this work in a report dated 9 March 1996. This report was presented by J. Lemen to the EIT team at the subsequent science meeting. The conclusions and proposed actions are summarized as follows (FM #1 is the device flown on EIT, FM #2 is a device from an earlier CCD lot):

Conclusions

(1) The calibrations for FM #1 and FM #2 still differ significantly, especially in the 171-304 A region; however they both exhibit a curiously near flat or slowly decreasing QE toward the shorter wavelengths in this range, where the photon penetration depth in the CCD is actually increasing.

(2) Both devices exhibit a significant temperature dependence of the QE. This suggests an effect due to the electrical properties within the CCD, or associated with the CCD back surface, not an optical transmission or reflection effect.

(3) Assuming nominal parameters for the back surface native oxide of the CCD, the charge collected from each photon event is only ~ 25-45% of that expected. Using the original charge collection model of Stern, Shing, and Blouke (1994), the data cannot be fit. However, using a modified version of this model, where the local charge collection efficiency never reaches unity, even deep in the CCD, an approximate model fit is possible.
The apparent decrease in charge collection efficiency from 256 to 171 A requires an unusually low - and perhaps unbelievable - active thickness of device, i.e. ~ 1 micron. Thus it is not clear whether this represents a reliable way to characterize the EIT CCD.

Proposed Actions

(1) complete existing cross-calibration of uchannelplate at 460, 735, and 1216 A.

(2) Obtain Orsay calibration data from J.F. Hochedez.

(3) Cross-calibrate EIT channels using CDS data for several limited areas on the CCD.

(4) Check calibration using filter ratios based upon expected temperature ranges in quiet and active regions.

(5) Perform a thorough calibration of CCD used for NRL calibration rocket.

- Dick Catura, 4th quarter 1996 -

The major effort during this quarter was preparation for and participation in a LASCO/EIT Science meeting held from 17-21 November 1996 in Aix En Provence, France. He made two presentations at the EIT meeting on Sunday, November 17. The first was on the results of analysis of calibration data. The second presentation was on the latent image problem experienced by the CCD in the Soft X-ray Telescope (SXT) on the Yohkoh mission. This was of interest to EIT because its CCD also suffers from latent images and the discussion was centered on our understanding of the SXT problems and whether there may be similarities with the EIT problem. Three view-graphs presented at the meeting showing the architecture of the SXT CCD and two examples of the SXT latent images are included in this report. The SXT latent images appear only when the CCD is illuminated by diffuse visible light and show features that have received heavy exposure to x-rays in the past as shown in the viewgraph reproductions. However, there are no latent image effects appearing in the SXT x-ray images. This is not the case for EIT where the EUV images of the sun show an apparently lower detection efficiency in regions previously heavily exposed to EUV. This could be from either reduced charge collection efficiency in the CCD or from molecular deposits on the CCD surface that have become polymerized by EUV exposure and absorb the incidence radiation. In both SXT and EIT the latent images can be reduced by warming up the CCD. In both cases the mechanism for forming the latent images is not understood. For EIT it is felt that at least some of the problem is from negative charge generated by photo-electric interactions in the insulating layer of silicon dioxide on the CCD entrance surface. Because of the these insulating properties the charge remains trapped in the silicon dioxide, where it attracts and holds positively charged holes. These holes attract and annihilate electrons generated in the semiconductor. These electrons would normally be collected beneath the CCD gates to become a part of the signal. Their loss thus decreases the available signal in the image and has the effect of decreasing the CCD efficiency.

- Dick Catura, 1st quarter 1997 -

The major effort during this period was to analyze and understand data on filter transmissions acquired at the synchrotron light source by IAS in 1993 and 1994. The data files were transferred from a computer in Orsay, France late in 1996. The filters are identified as follows:

Entrance Filters:	171 A quadrant-filters I1 and I2
	195 A quadrant-filters L1 and L2
	284 A quadrant-filters A1 and A2
	304 A quadrant-filters O1 and O2

Where each filter covers half the entrance aperture for each quadrant.

Filter Wheel Filters:	Al/Cellulose/Al-SQC08
	Al-SQ4,SQ34,SQ35 (Identification with wheel position not presently available)
CCD filter	Al-SQ37

In analyzing these data it was found that the position of zero order shifted for some of the measurements. This causes a shift in the wavelength scale by as much as .6 A, probably within the uncertainties of the measurements, but the corrections were made to the data anyway.

The 171 A and 304 A quadrants were measured with two different gratings. The agreement of the data from the two gratings in the ~170 A to 500 A range of wavelengths is good. In this range we will probably average the two measurements for each filter and fit the results to a model of the filter using optical constants compiled by Henke et. al. These models will then be used to predict the filter transmissions outside the 170-500 A band. The only other filters where measurements were made with both gratings are SQ34 and SQ04.

The transmissions of the entrance filters has also be analyzed. For the 171A and 304A quadrants the transmissions are nearly identical, but not for the 195A and 294A quadrants.

The reflectivities of the primary and secondary witness mirrors have been fit in amplitude to the data obtained in measurements made on the EIT telescope. The multiplicative factors vary between 0.8 and 1.3. The estimates of the reflectivities and the models of the filter transmissions and CCD efficiency will be used to derive new estimates of the EIT response function for each band pass.

SCIENCE

- Robert Stern -

R. Stern visited Laboratoire d'Astronomie Spatiale (LAS) in Marseilles from 26 June to 19 July 1996 to work with EIT co-I Jean Maucherat, and graduate student Fabrice Portier-Fozzani on EIT data. Travel expenses for the visit were reimbursed by LAS. Because the EIT co-I's Open VMS computer system did not have the IDL Solar Software (SSW) Tree for EIT installed, much of the first week of the visit was occupied getting the software up and running. S. Freeland was of great help (even over the 4th of July weekend!) in accomplishing this task, since the procedure for installation of the SSW for Open VMS had not yet been fully established. R. Schwartz of GSFC was also very helpful in this task. Once the software was installed, R. Stern began a study of intensity histograms for a sample of EIT full-disk images. Initial results from this study indicated that the bulk of the intensity distribution could be represented by a log-normal distribution. Because the images were taken from a period of very low solar activity, it remains to be seen whether or not such a distribution can be used to characterize the solar EUV emission at all times. The hope is that the parameters which characterize the log-normal intensity distribution may be used to formulate "Sun-as-a star" models during the activity cycle, which can be related to stellar EUV fluxes. Also during this visit, R. Stern assisted J. Maucherat and F. Portier-Fozzani in writing a contribution for the July COSPAR meeting in Birmingham, UK.

- Brian Handy -

Analysis efforts development have been concentrated on EIT coronal hole analysis. Of particular interest is the large coronal channel that transited the sun several times over a three-month period centered more or less on the middle of September 1996.

> "I want to be able to track the progress of the active region that appears to anchor the southern end of the coronal channel and compare it to the activity of the coronal channel and the development of the CH boundaries. In further pursuit of understanding this I hope to also meld in SXT data to better follow what the high temperature plasma is doing as well in that area."

A proposal was submitted to the EIT team to study this.

SCIENCE (continued)

- Tom Metcalf -

Acted as liason between EIT and Sac Peak for the recent ASP campaign (October 1 through October 12, 1997). The goal of the project ("Separator Models of Coronal Loops" by A.A. Pevtsov and D.W. Longcope) is to study temporal evolution of non-flaring coronal loops and photospheric magnetic fields in conjunction with the separator model of the coronal loops. The ASP vector magnetograms (2 per hour) are used to compute separator field lines and study their time evolution, energy output etc. The computed separators are compared with the coronal loops observed by Yohkoh/SXT and by EIT to test the adequacy of the separator theory.

- Dick Catura -

Attended EIT/LASCO science meeting in Aix, France November 17-22, 1996

Attended the (brief) EIT/LASCO science team meeting on 16 June 1996. Requested that during real time contacts the sequence 171-195-304 be run continuously to allow temperatures of various structures to be estimated from the 195/171 ratios and study of prominences in 304. J.P.DelaboudiniÈre was going to try to get this implemented.

Other work was directed at identifying loop structures suitable for studying temperature gradients in the loops. Data files have been identified for the passage of an active region across the solar disk between 22 November and 2 December 1996.

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OPERATIONS

Jim Lemen served as EIT science planner at GSFC from 10/6/1996 - 10/18/1996
Tom Metcalf served as EIT planner at GSFC from 10/19/1996 through 11/3/1996

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Respectfully submitted,

James Lemen
Samuel Freeland

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