

# Introduction to HI data

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Facilities Council

# Where to find general information

- Where is STEREO?
  - <http://stereo.gsfc.nasa.gov/where.shtml>
  - <http://stereo-ssc.nascom.nasa.gov/where/>
- get\_stereo\_sep\_angle
- stereo\_coord\_info
  - doesn't work with IDLde

```
solar.bnsc.rl.ac.uk - Solar ssh - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles
% Compiled module: GET_SUN.
% Compiled module: TIM2JD.
% Compiled module: ANYTIM2JD.
% Compiled module: JULDAY.
% Compiled module: RECPOL.
% Compiled module: FILEPATH.

                STEREO-B      Earth      STEREO-A
Heliocentric distance (AU)  1.054133  1.010832  0.960081
Semidiameter (arcsec)      910.348   949.344   999.528
HCI longitude               155.814   158.418   163.734
HCI latitude                -3.270    -2.679    -1.988
Carrington longitude        125.026   127.630   132.946
Carrington rotation number  2056.653  2056.645  2056.631
Heliographic (HEEQ) longitude -2.604     0.000     5.316
Heliographic (HEEQ) latitude -3.270    -2.679    -1.988
Earth Ecliptic (HEE) longitude -2.651     0.000     5.356
Earth Ecliptic (HEE) latitude -0.284    -0.000     0.052
Roll from ecliptic north    -6.122     0.000    -0.556
Roll from solar north      -12.734    0.000    -7.516

Separation angle with Earth      2.666     5.357
Separation angle A with B        8.015

% Program caused arithmetic error: Floating illegal operand
IDL>
```



# Where to find HI data/information...

- RAL STEREO website
  - <http://www.stereo.rl.ac.uk/science/>
    - User guide
    - Event List
    - Gallery
- Daily/Monthly Quicklook Movies
  - <http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES>
- Data
  - <http://www.ukssdc.ac.uk/solar/stereo/data.html>
- Email support
  - [stereo\\_support@ukssdc.ac.uk](mailto:stereo_support@ukssdc.ac.uk)

The top screenshot shows the 'UK Solar System Data Centre' website with the 'UKSSDC - STEREO Archive movie access' page. It features a navigation bar with 'Data', 'Contact Us', 'Register to Retrieve Data', 'Site Index', and 'Search'. Below the navigation bar, there is a breadcrumb trail: 'Home > Solar Archives > STEREO > STEREO data'. The main heading is 'UKSSDC - STEREO Archive movie access'. A sub-heading reads 'The STEREO team have produced various daily movies.' Below this is a table with columns 'Name', 'Last modified', and 'Size'. The table lists various movie files, including directories like 'EARED\_movies' and 'EARED\_movies', and individual movie files with their last modified dates and sizes.

The bottom screenshot shows the 'UK Solar System Data Centre' website with the 'UKSSDC - STEREO Archive data access' page. It features a navigation bar with 'Data', 'Contact Us', 'Register to Retrieve Data', 'Site Index', and 'Search'. Below the navigation bar, there is a breadcrumb trail: 'Home > Solar Archives > STEREO > STEREO data'. The main heading is 'UKSSDC - STEREO Archive data access'. Below the heading is a 'Data Selection form :'. The form includes a 'Select spacecraft, SECCHI instruments and date range and receive those data files zipped for FTP.' section. The 'Spacecraft' section has a checkbox for 'ahead' and a checkbox for 'behind'. The 'Instrument' section has a dropdown menu for 'SECCHI' and checkboxes for 'w1', 'w2', 'euv1', 'hl\_1', and 'hl\_2'. The 'Date/UT Time' section has 'Start Time' and 'End Time' fields, each with a time dropdown (00 to 00) and a date dropdown (1 to 31, Jan to Dec, 2007). Below the form are 'Reset' and 'Submit query' buttons. At the bottom of the page, there is a footer with 'Data | Contact Us | Register to Retrieve Data | Site Index | Search' and 'Page last updated by [Matthew Wild](#) on Friday, 13-Apr-2007 10:29:42 BST'.

# Filename definitions

- 20070503\_001000\_s4h1A.fts
  - 20070503 - date
  - 001000 - UT time
  - s4 - summed image (1024x1024)
  - h1 - HI 1 image (would be h2 for HI 2 image)
  - A - STEREO A image (would be B for STEREO B image)
- 20070503\_000700\_n4h1A.fts
  - n4 - hi res (2048x2048) single exposure
  - Only one taken a day - will be used for calibration
- 20070503\_011900\_s7h1A.fts
  - s7 - beacon mode image (512x512, 2 hrs)

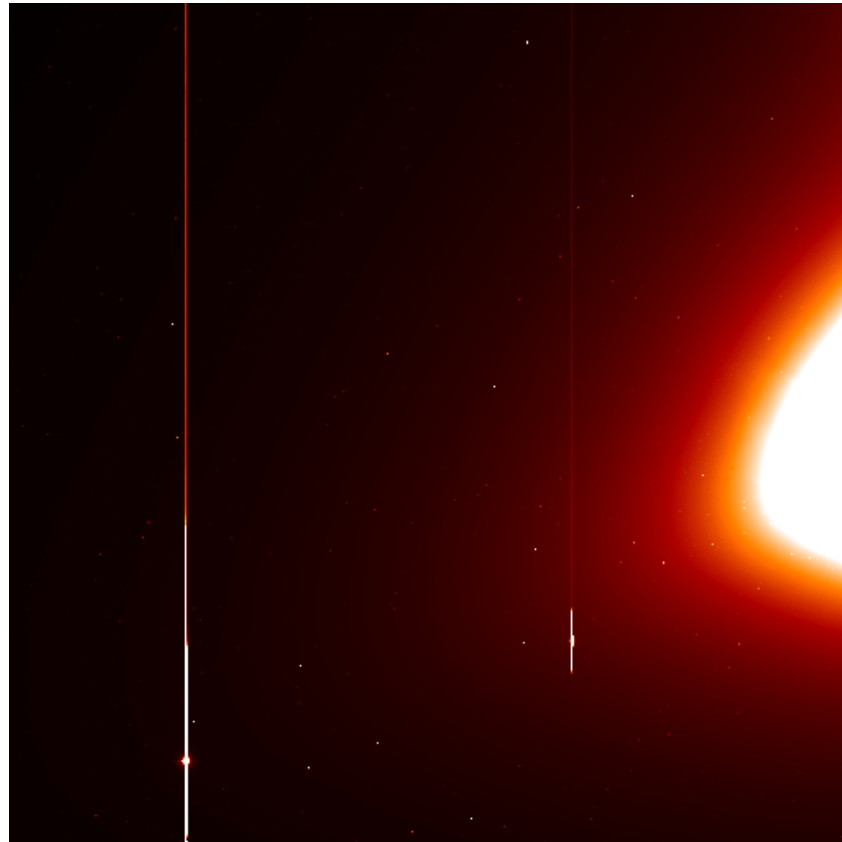


# General HI data information

- Images made up of number of exposures
  - HI 1 (nominal values)
    - # of exposures: 30
    - Exposure time: 40s (1200s total)
    - Cadence: 40 mins
    - Image size: 1024x1024
  - HI 2 (nominal values)
    - # of exposures: 99
    - Exposure time: 50 seconds (4950s total)
    - Cadence: 2 hours
    - Image size: 1024x1024
- Exposures summed on board
- Exposures also scrubbed of cosmic rays on board

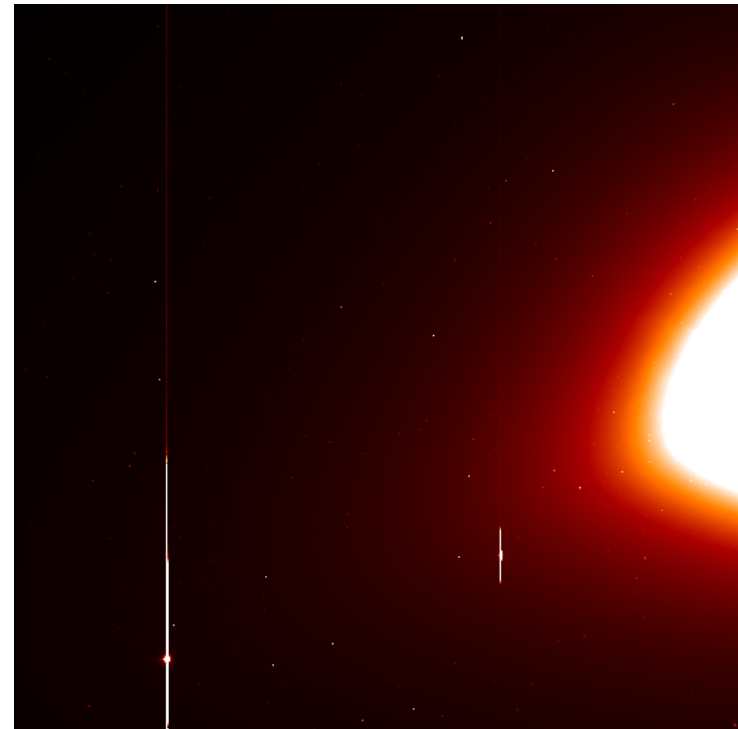


# Raw data



# secchi\_prep

- secchi\_prep,files,index,data
- Files
  - list of all files you want to read
  - Can be mix of EUVI, COR and HI
- Index
  - Header structures
- Data
  - Data cube
  - If images are all different sizes, then can specify size of data cube that you want returned



# secchi\_prep II

- HI data
  - Shutterless correction
    - No shutter
    - Image smeared as readout and CCD cleared out
  - Flatfield
    - Provisional pre-flight flatfield
    - Calibration on going





# secchi\_prep III

- Warning

- Early data does not work with secchi\_prep
- All data from beginning of mission will be re-processed at a date TBD
- Number of files that can be read into secchi\_prep depends on machine memory



# Header keywords

- naxis1/2 – length of 1<sup>st</sup> (columns, x) and 2<sup>nd</sup> (rows, y) axes
- date\_obs – date/time of start of CCD readout
- exptime – exposure time of all exposure that make up image
- summed – combines summing from CCD and IP to get one number for number of rows and columns being summed on CCD, SEB and ground
  - ipsum
  - sumrow, sumcol, ccdsum
- detector – name of telescope within SECCHI
- obsrvtry – name of satellite



# Header keywords II

- ctype1(a)/2(a) – string representing coordinate axis
  - [http://stereo-ssc.nascom.nasa.gov/coordinates\\_explanation.shtml](http://stereo-ssc.nascom.nasa.gov/coordinates_explanation.shtml)
  - Thompson, 2006, A&A, 449, 791
- cunit1(a)/2(a) – units of coordinates
- crval1(a)/2(a) – reference data coordinates corresponding to centre of image
- pci\_j(a) – coordinate transformation matrix: rotation information is included
- cdelt1(a)/2(a) – height/width of pixels
- pv2\_1 – parameter which encodes information about optical properties of telescope



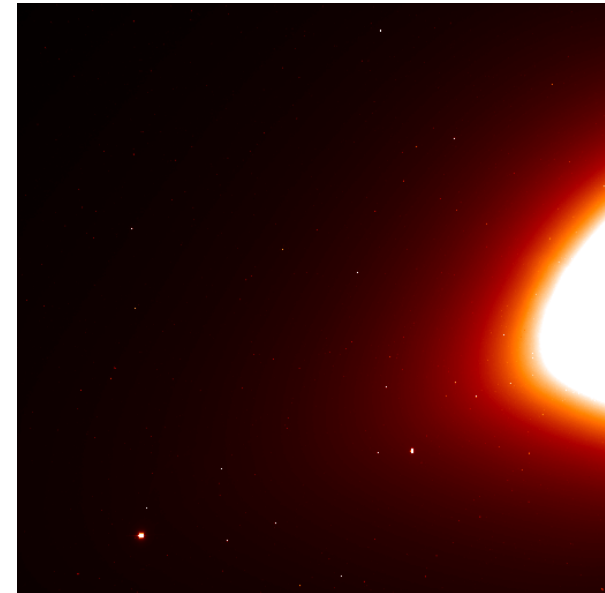
# Header keywords III

- More info on header keywords
  - [ftp://louis14.nrl.navy.mil/pub/secchi/ssw/doc/FITS\\_keywords.pdf](ftp://louis14.nrl.navy.mil/pub/secchi/ssw/doc/FITS_keywords.pdf)
- Warning!
  - Values of header keywords have changed during mission
  - All values will be correct when data is reprocessed
  - Don't hard code header values in to programs until data is reprocessed
  - Need to check that header values are reasonable!

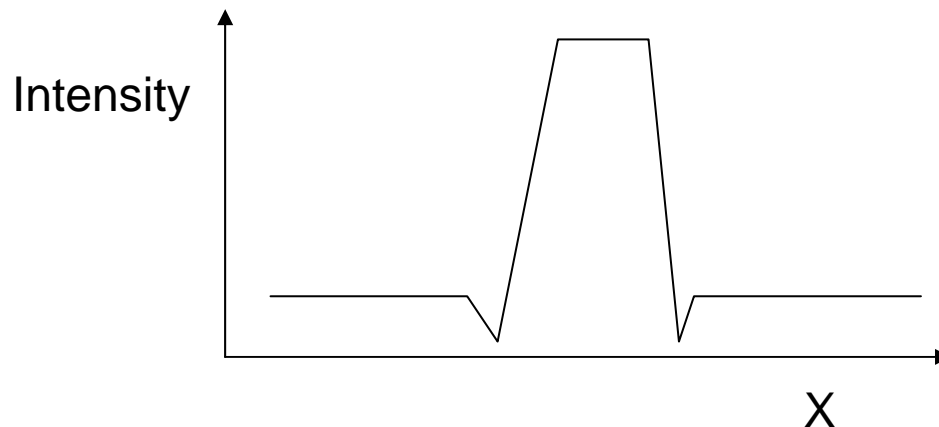
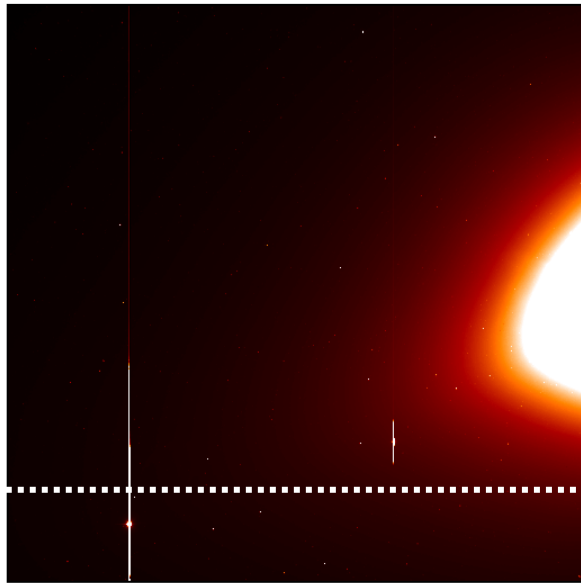


# Saturated Pixels

- Brightest objects (e.g. planets & stars) will saturate
- Blooming
  - Occurs up & down column
  - Not side to side like LASCO
- Can remove blooming



# Saturated Pixels II



- Must deal with saturated columns before doing background subtraction
- Anomalous low values in background
- Anomalous high values in background subtracted data

- Bright stripes in data
- [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200705\\_hi1a.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200705_hi1a.mpg)



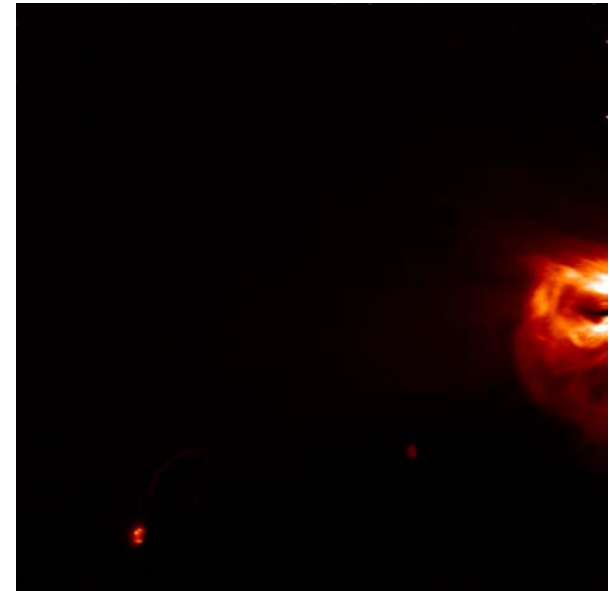
# Background subtraction

- $bg = \min(\text{data}, \text{dimension}=3)$ 
  - Need to also account for missing blocks and saturated columns when using minimum
- $bg = \text{median}(\text{data}, \text{dimension}=3)$ 
  - More robust
  - But not physically meaningful?
- Time scale: several days depending on conditions
- Warning! This will only work if spacecraft is not rolling too much (few degrees) during period of observations
  - [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200702\\_hi2b.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200702_hi2b.mpg)
- Looking into generating monthly backgrounds which could be used for subtraction



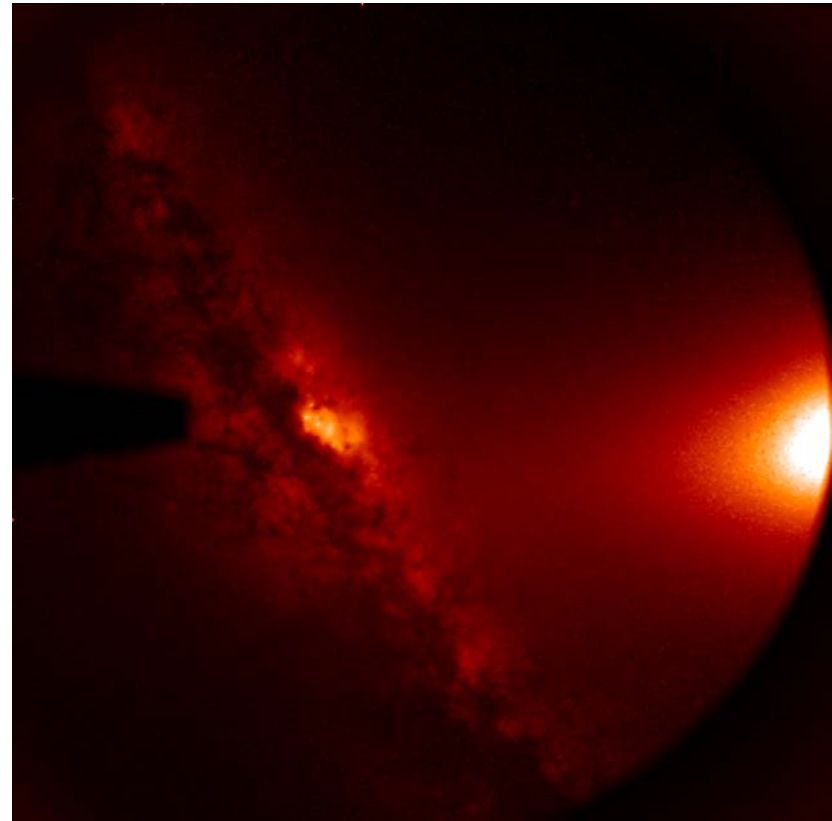
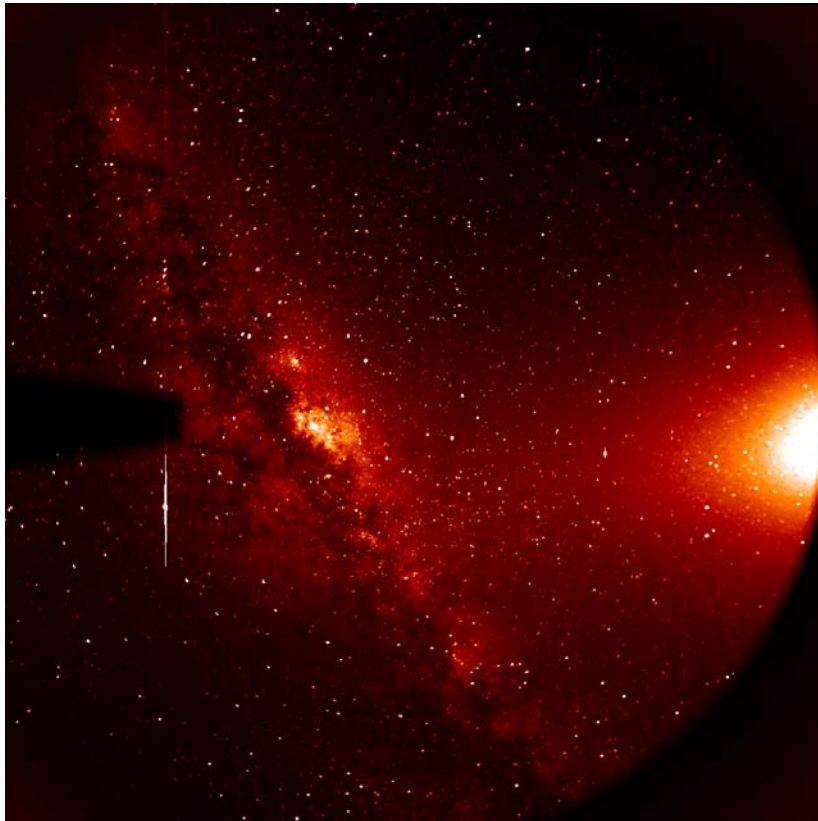
# Star Removal

- Finds peaks in data over a user specified threshold
- Uses successive over relaxation method to fill in stars with values from surrounding pixels

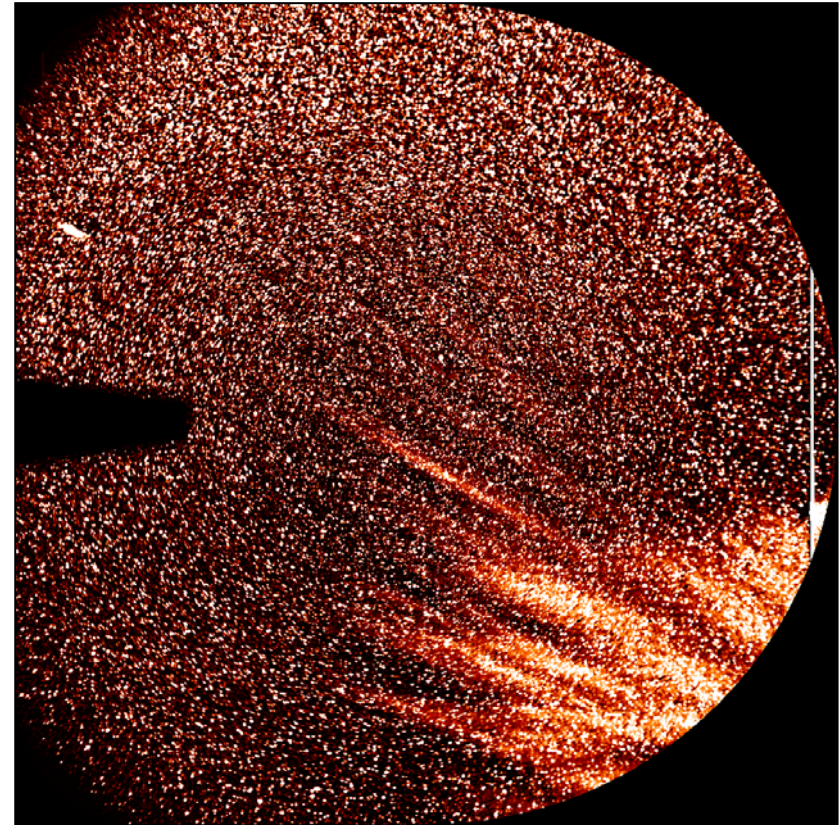
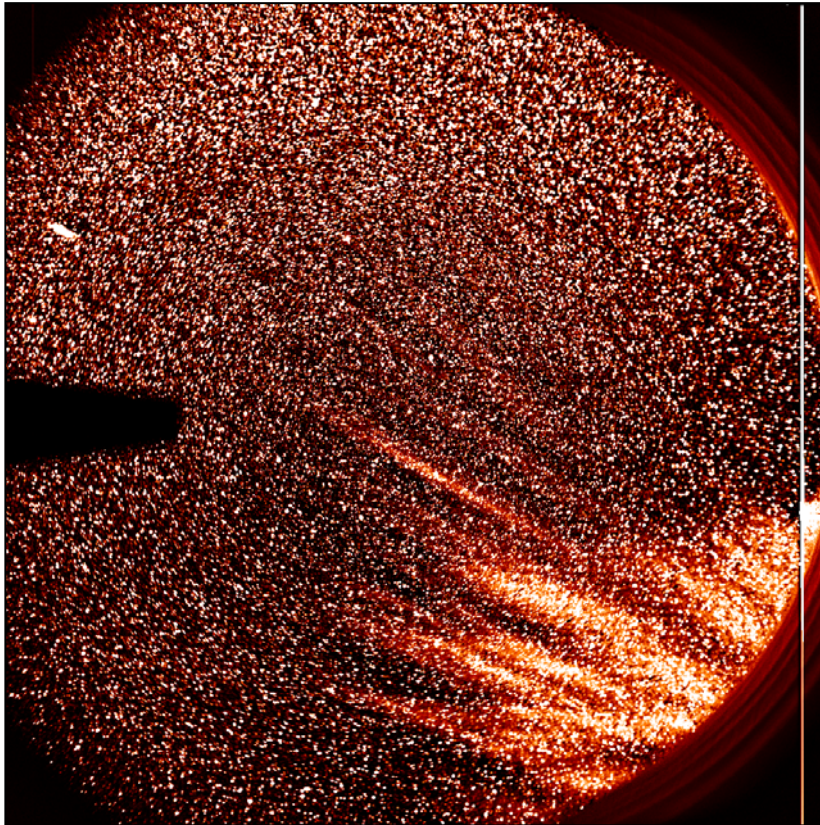




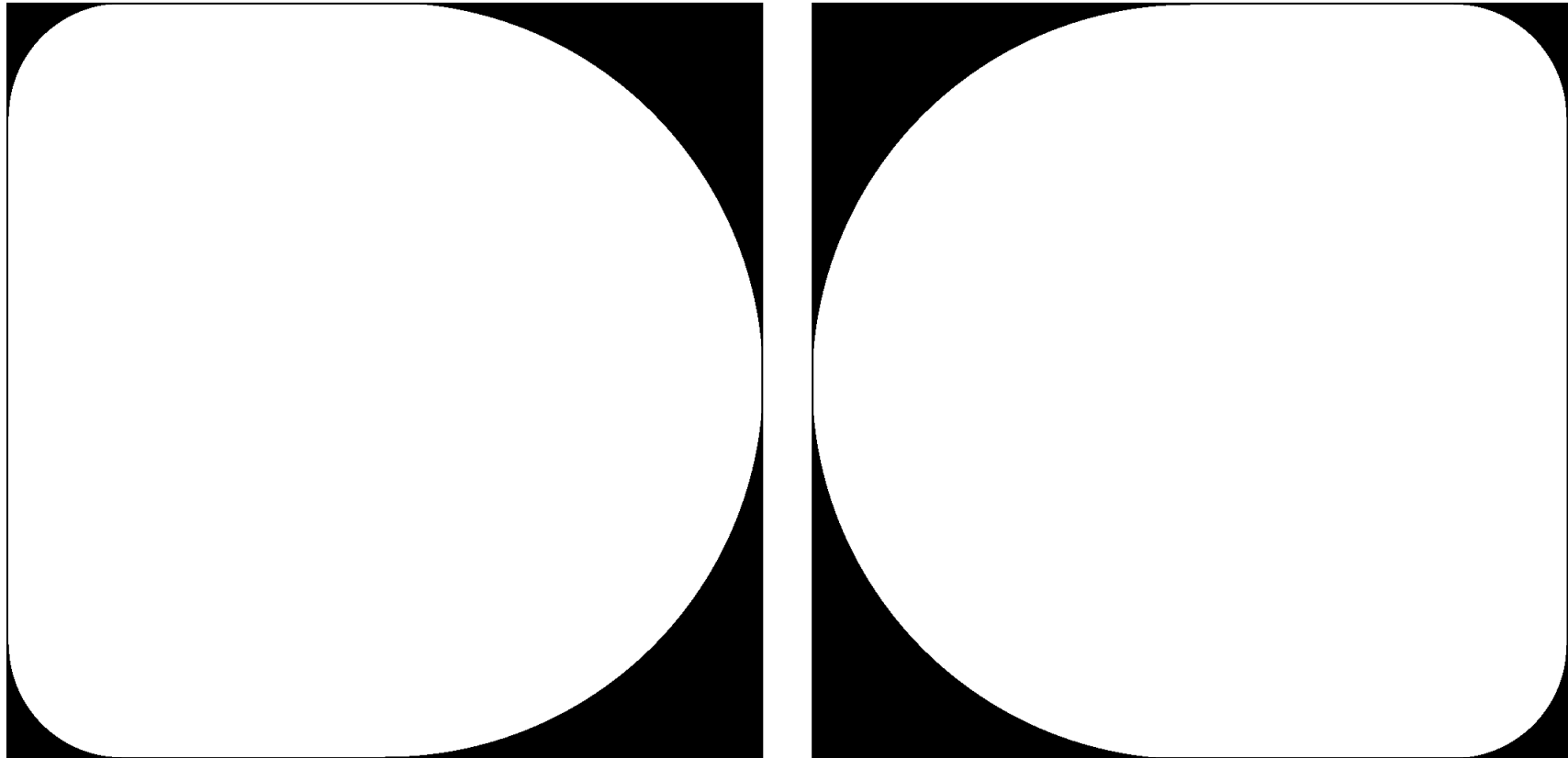
# Star Removal II



# HI 2 Mask

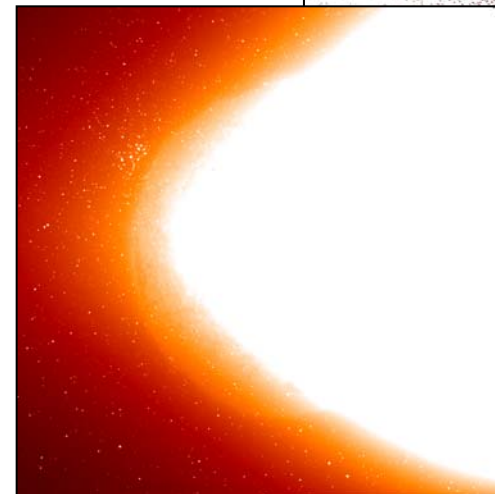
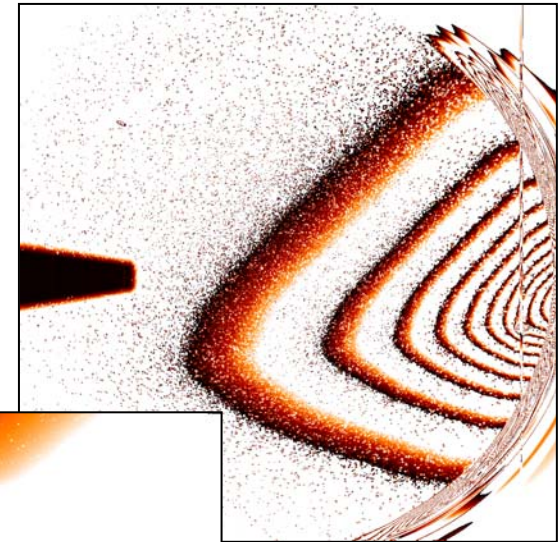


# HI 2 Mask II



# Things to look out for!

- High/low word images
  - [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200702\\_hi2a.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200702_hi2a.mpg)
  - Mucks up background subtraction!
- Mixed images
  - [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200705\\_hi1a.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200705_hi1a.mpg)
  - Mucks up background subtraction!
- Earth and Moon
  - HI B observations only
  - [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200701\\_hi2b.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200701_hi2b.mpg)
- Ghosts
  - [http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200701\\_hi1a.mpg](http://www.ukssdc.ac.uk/solar/stereo/movies/MOVIES/200701_hi1a.mpg)

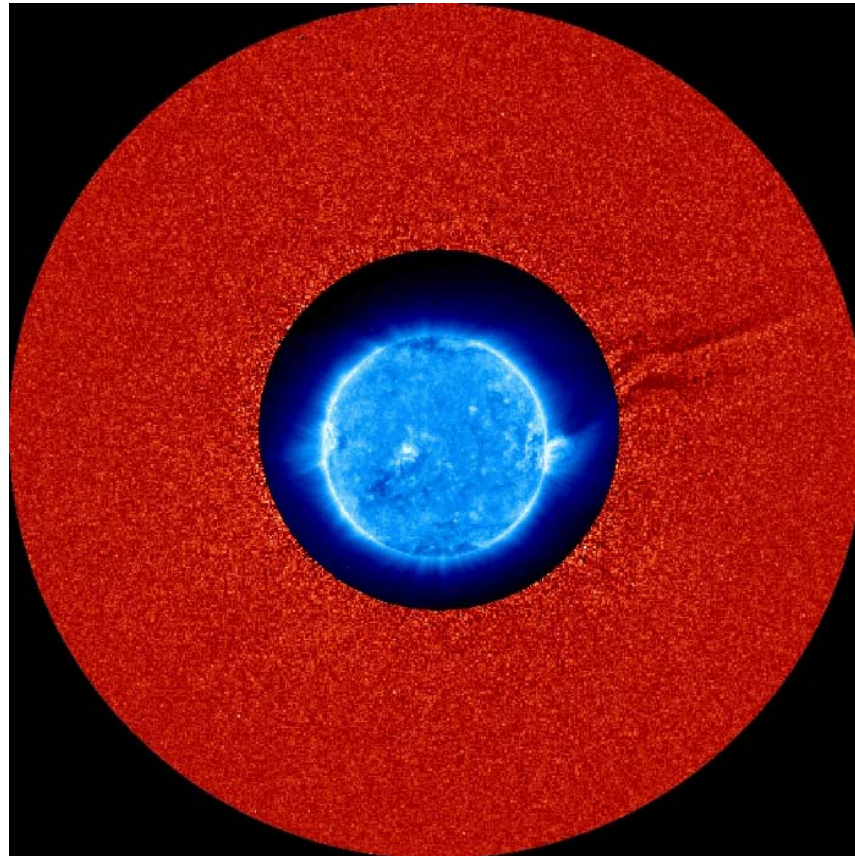


# Image manipulation

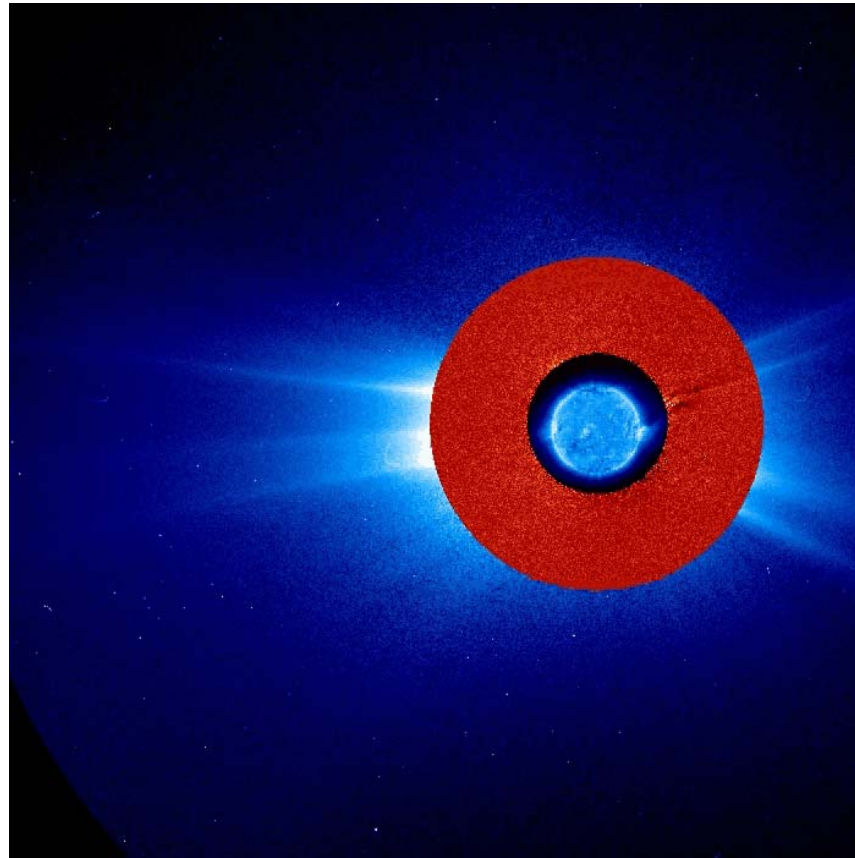
- Festival
  - <http://www.ias.u-psud.fr/stereo/festival/>
- Solarsoft package
- ‘simultaneous, fast and easy manipulation of SECCHI/STEREO, EIT/SOHO and LASCO/SOHO images’



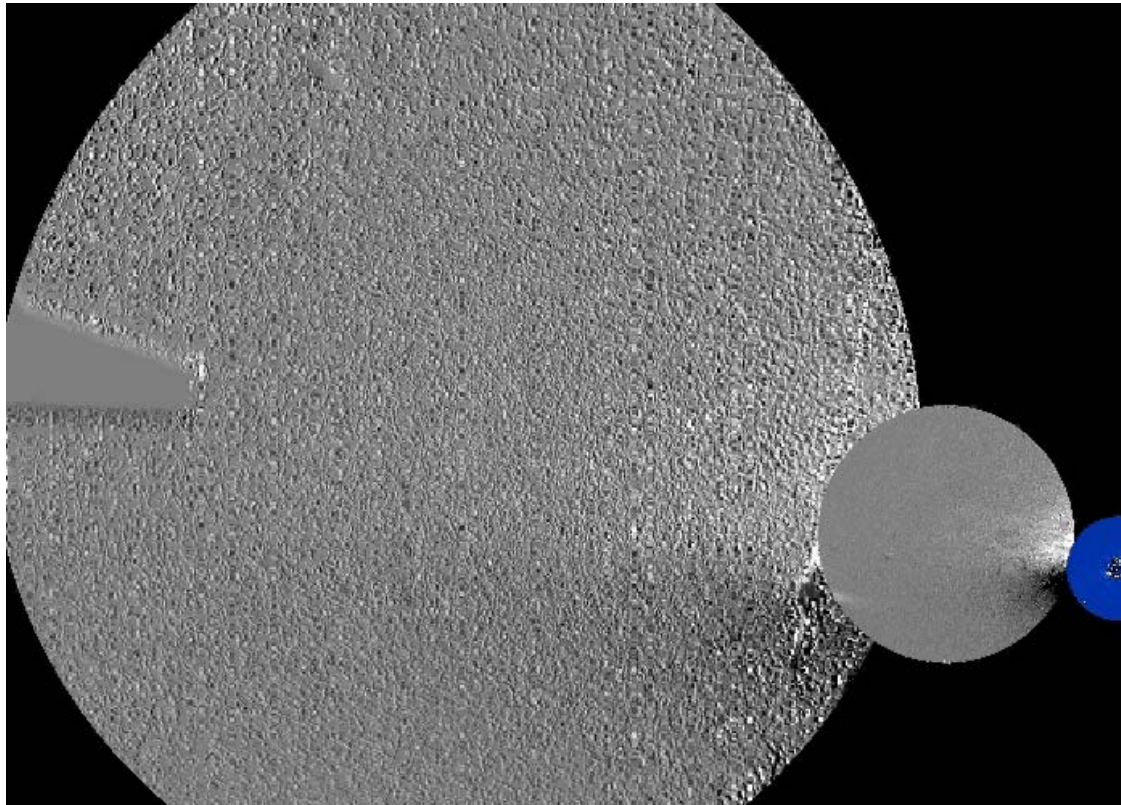
# Festival Movie – EUVI & COR1



# Festival Movie – EUVI, COR1 & COR2

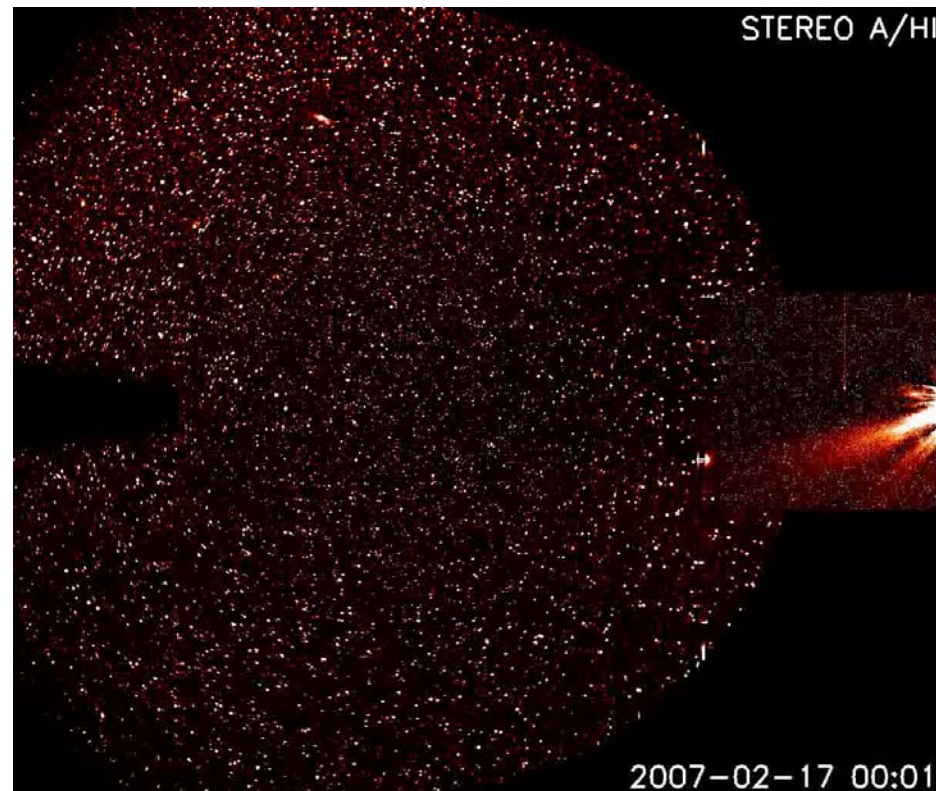


# Festival Movie – All SECCHI

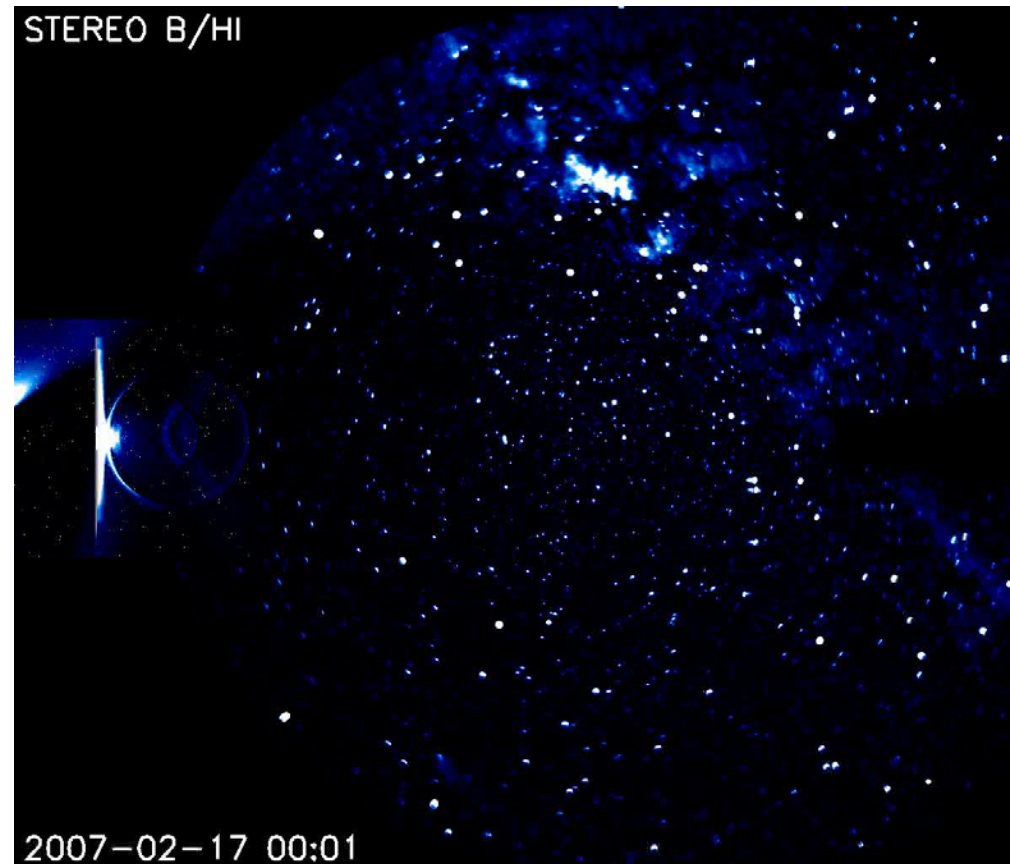




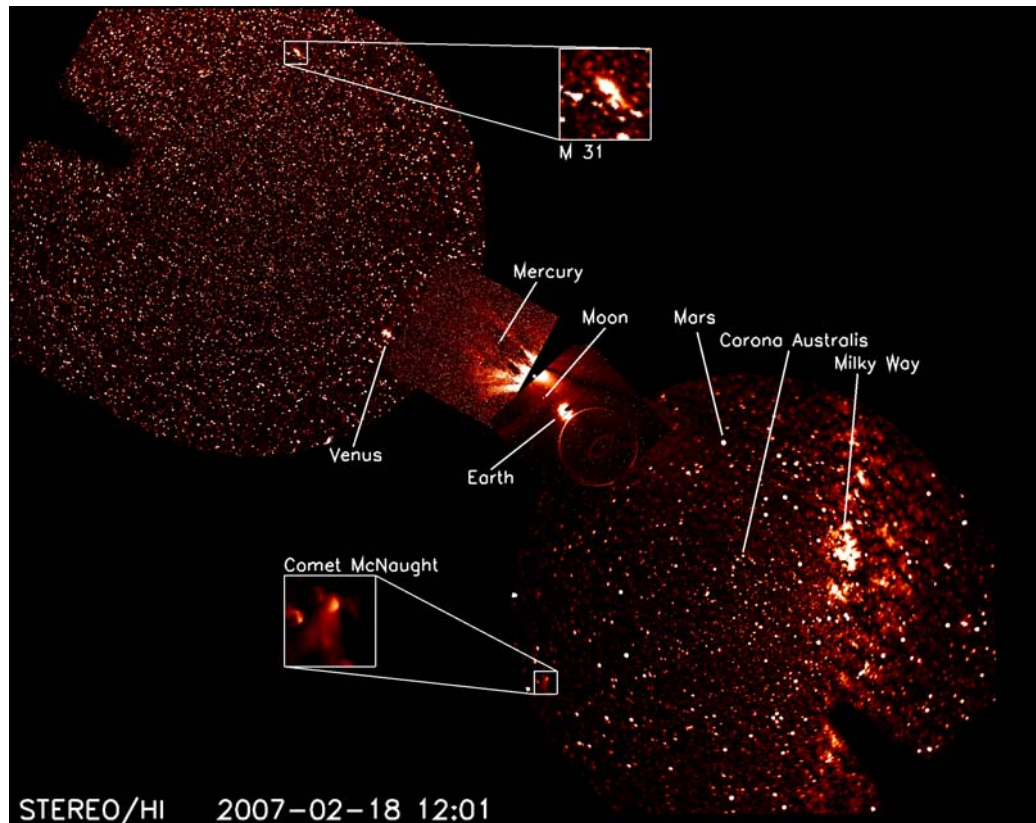
# STEREO A 17/02/07



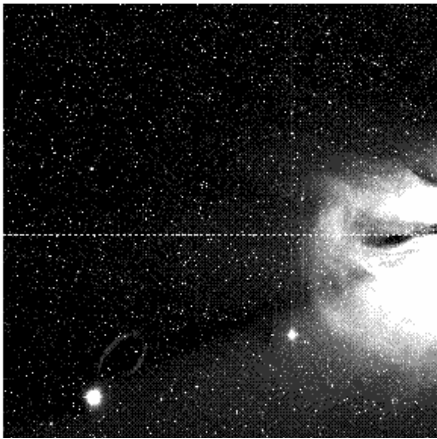
# STEREO B 17/02/07



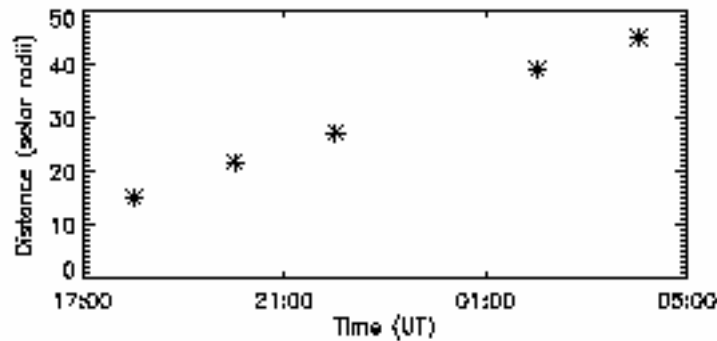
# STEREO A & B 18/02/2007



# CME Velocity



- Example 24/01/07
- RAH manual front detection
- Amount of structure makes it hard to know what to track
- Automatic detection and tracking will be developed



# CME Density

- Calibration ongoing
  - Absolute intensity
- Vourlidas et al. 2000, ApJ, 534, 456
  - Mass calculations from LASCO data
  - Details Thomson scattering assumptions

