Determination of the photometric calibration and the large-scale flatfield of the STEREO Heliospheric Imagers: I. HI-1

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Introduction

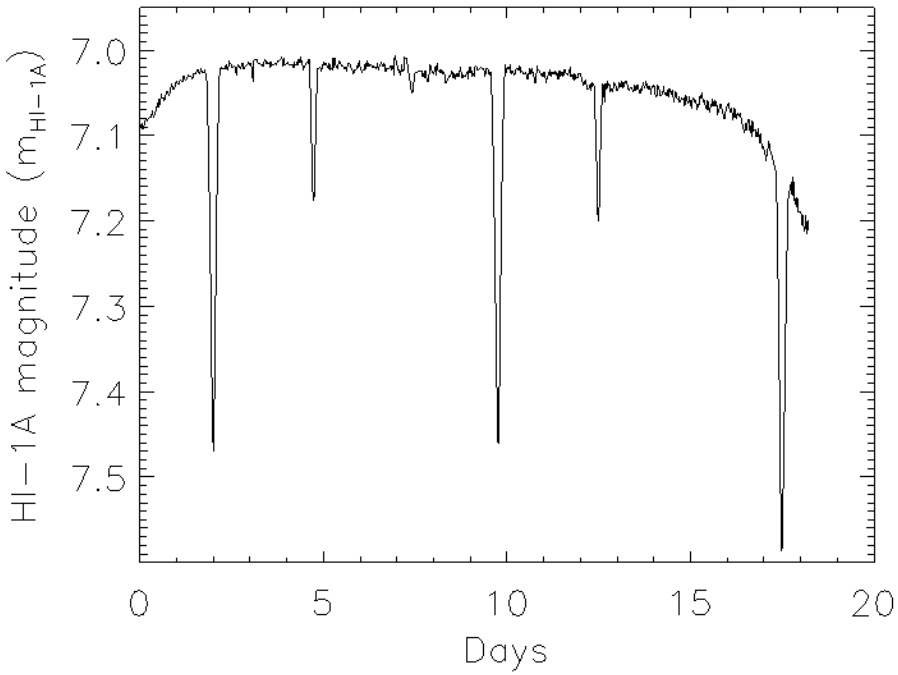
- Nominal HI-1 FOV is circular
  - All pre-flight calibrations optimised for circular FOV
- However, CCDs are square
  - Usable response in corners
  - Not calibrated prior to launch

Pre-launch calibration

- Large-scale flatfield calibrated using response to light source
- Test configuration only permitted calibration source to be scanned along single axis
  - No information about corners
  - Axial symmetry assumed – does it hold?

Why do we need accurate large-scale flatfield?

- Lightcurve of binary system HD22766
  - Passes across upper part of HI-1A FOV
- Variation in intensity due to eclipses of stars in binary system
- Effect of non-optimised flatfield seen as large-scale variation across CCD



Method

- Make prediction for intensity of star
- Compare with measured intensity of star
- Then ratio of 2 values will give correction factor
- Correction factors across CCD give flatfield
- How do we predict intensity of star?

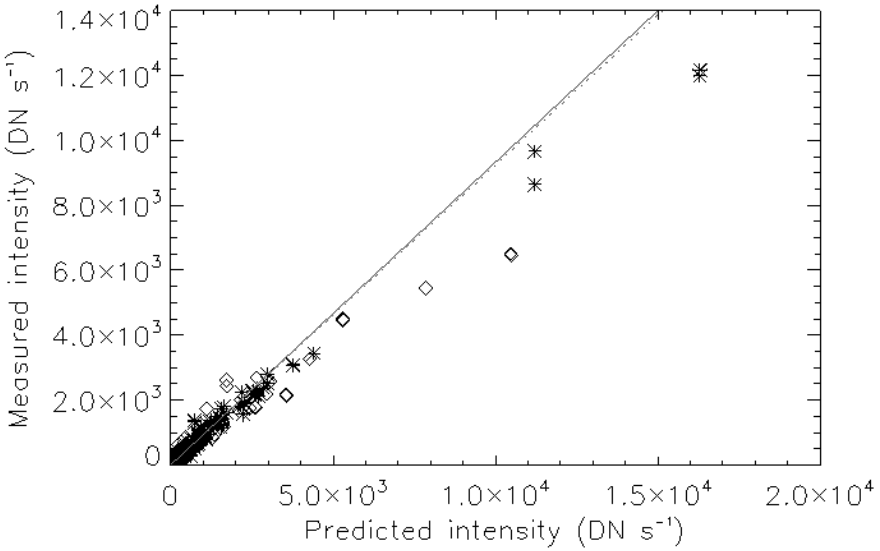
Method – Predicting stellar intensity

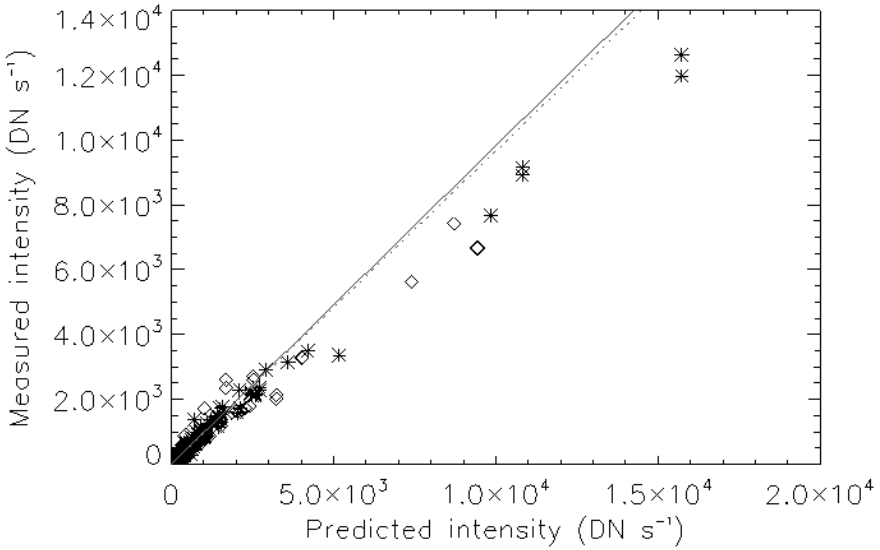
- When star's stellar spectral type known & spectrum available in Pickles (1998), fold spectrum through HI-1 response function
- When spectral type not known or not available, use 'colour mixing' approach
  - Map R-, V-, B-magnitudes to HI-1 magnitude scale defined by spectral folding
- When spectral type is known, but does not have an exact match in Pickles (1998), but has close match, both spectral folding and colour mixing carried out. Use 'best' method

Method: Calculating large-scale flatfield

- All stars in HI-1 FOV used to determine flatfield
- Where multiple stars cross same pixel, resistant mean of ratio values used
- Errors in measured & predicted intensities give a ‘noisy’ initial map
- Further processing eliminates small-scale variation, leaving large-scale flatfield

Results: Predicting stellar intensity – spectrum folding



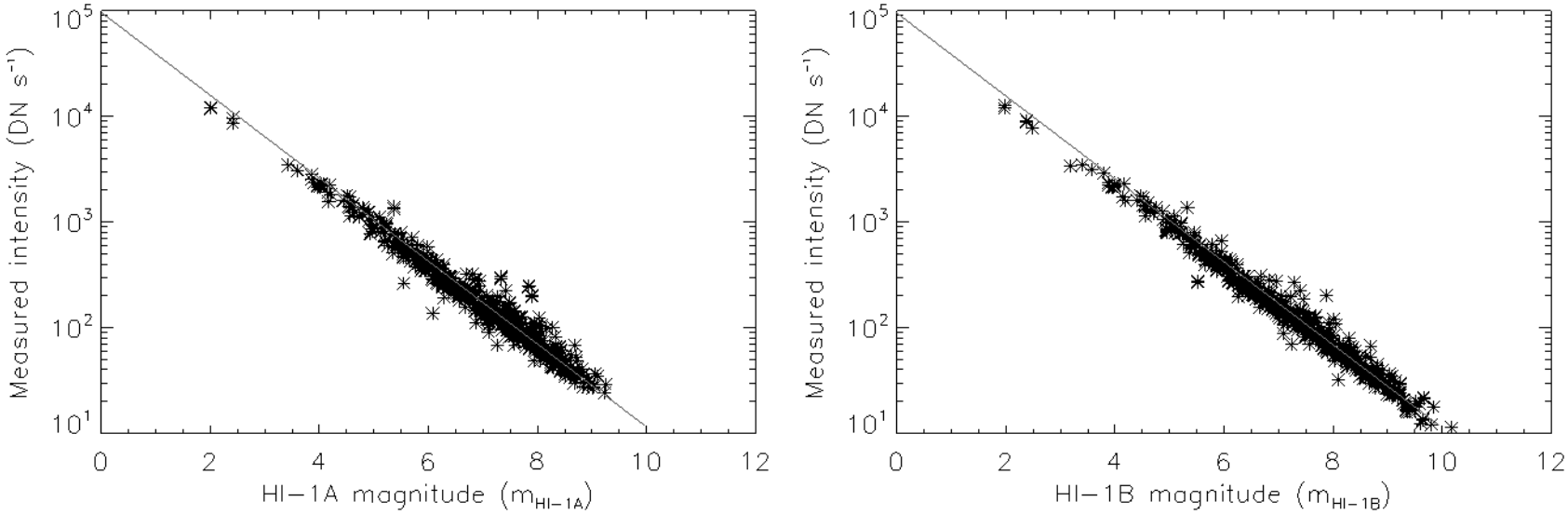


Measured stellar intensity (DN s^{-1}) vs predicted stellar intensity (DN s^{-1}) from spectrum folding for HI-1A (left) and HI-1B (right).

Results: Predicting intensity – spectrum folding

- Ideally predicted and observed intensities should be 1:1
- Reality is close
  - μ = 0.93 for HI-1A
  - μ = 0.98 for HI-1B
- Predicted intensity slightly too high
- Brightest stars may be saturated, hence measured intensity too low

Results: Predicting stellar intensity – spectrum folding



Measured stellar intensity (DN s^{-1}) versus HI magnitude (m_{HI}) for HI-1A (left) and HI-1B (right)

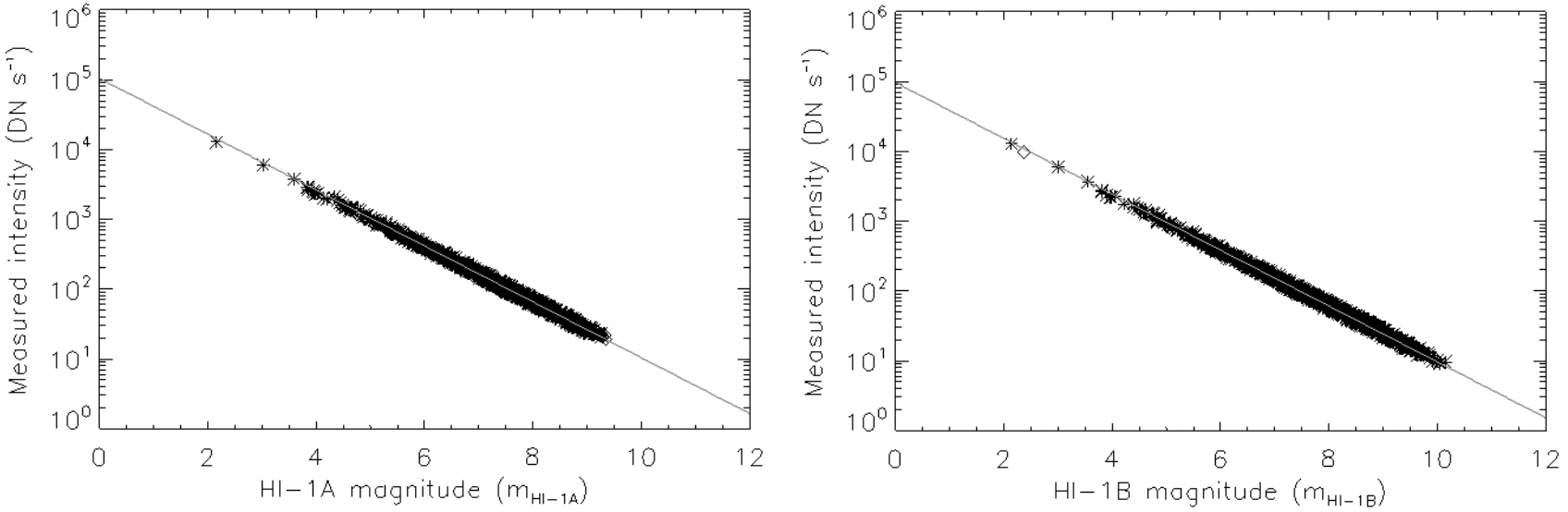
Results: HI magnitude scale

- HI magnitude scale, m_{HI} defined as

$$m_{HI} = -2.5\log_{10}\left(\frac{I}{\mu F_0}\right)$$

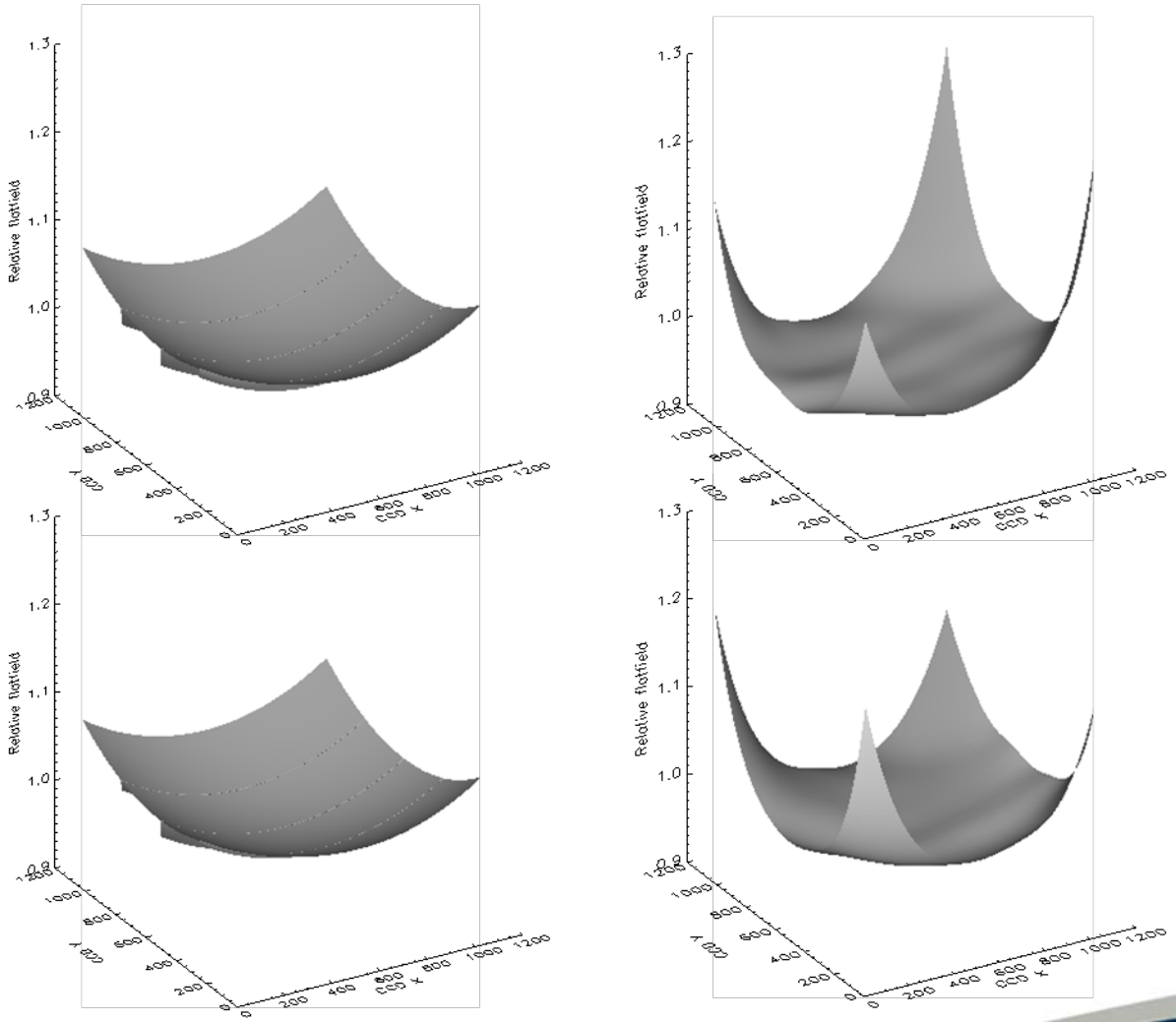
- Where
  - I is the measured intensity
  - μ is the conversion factor between the predicted and measured stellar intensity
  - F_0 is the predicted intensity of a reference star
    - Calculated by folding a Vega-like spectrum through instrument response
    - F_0 = 103968 DN s^{-1} for HI-1A
    - F_0 = 97026 DN s^{-1} for HI-1B

Results: Predicting stellar intensity – colour mixing



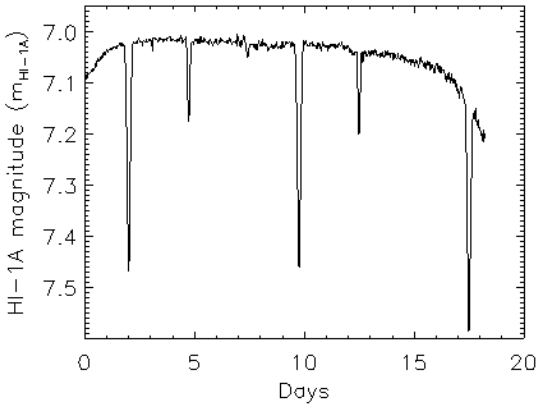
Measured stellar intensity (DN s^{-1}) versus HI magnitude (m_{HI}) from colour mixing for HI-1A (left) and HI-1B (right)

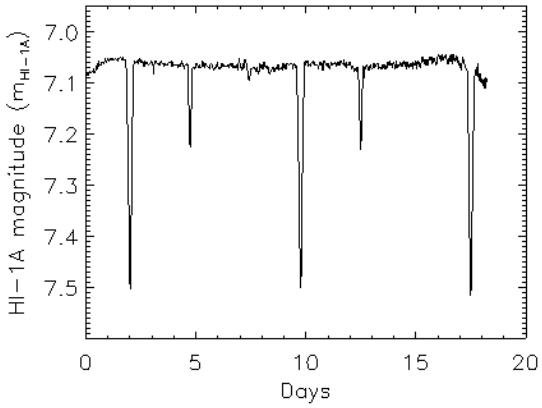
Results: Large-scale flatfield

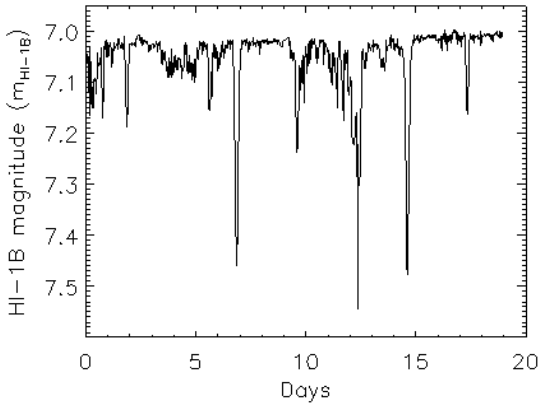


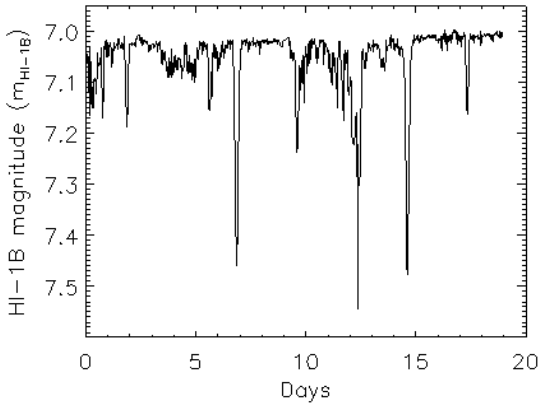
Surface plots of nominal & optimised large-scale flatfield for HI-1A (top left & right) and HI-1B (bottom left & right)

Results: Stellar Lightcurves









Lightcurves of binary system HD22766 with nominal pre-flight & optimised flatfield for HI-1A (top left & right) and HI-1B (bottom left & right)

Conclusions

- Have presented the methodology for determining large-scale flatfield using variation in intensity of background starfield as it tracks across CCD
- Photometric calibration to predict stellar intensities using spectrum folding & colour mixing determined
- Flatfields will be included in secchi_prep