Report on H_α Flatfielding

1) General Comments

- Five frames were provided, three dome flat-fields, HAflat1,2,3 and two twilight-sky exposures, T17471 and T17808, hereinafter referred to as HAflat4,5. Each frame was 3225 pixels square but was rebinned to 645x645 for ease of data handling.
- There are no step-wedges on any of the frames so no investigation of linearity has been possible.
- The numbers appeared to be proportional to the SuperCOSMOS CCD signal (lowest in the centre, smallest at the corners). They were therefore interpreted as transmission values (see page 3, *The SuperCOSMOS data processing guides: Photometry*, hereafter SCP). Harvey McGillivray has confirmed that this is a correct assumption.
- Visual inspection of gray-scale plots shows the three dome flats to be quite similar, with significant departures from radial symmetry in at least two respects:-
  i) there are bars of higher filter transmission above and below centre (see Fig 1). These are also visible in the twilight sky frames, though not as clearly;
  ii) the response is asymmetric to left and right, with a much greater fall-off of filter transmission to the left. This is also apparent in HAflat5, but HAflat4 appears to be reversed, left-right.

2) Data handling
As the photographic-film density D is given by

$$D = log_{10}(T_C/T)$$

where T_C is the transmission through unexposed emulsion, and this density is related to the intensity I through

$$D = \gamma log_{10}(I)$$

on the linear part of the film characteristic, we may obtain intensities I from the transmission numbers provided through

$$I = 10^{N-\gamma^{-1} log_{10}(T)}$$

where N can be chosen to give values in any range required (about 4.5 seems to be used in the H_α data we have already) and $\gamma^{-1} = 0.3$ is recommended by SCP and is consistent with Fig 1 in Phillipps and Parker, MNRAS Vol 265, pp 385-394, 1993. Clearly this expression will only provide useful values for I in areas where the emulsion may be assumed to be on the linear part of the characteristic curve, i.e. not at very low intensities close to unexposed emulsion or at high intensities where saturation may be expected. Assuming that the flat fields had exposures chosen to avoid central saturation, it seems likely that the range in which we are interested – from central transmission to a loss of up to 20 percent – will be contained within the linear part of the characteristic. This assumption could obviously be checked if flat-fields with step-wedges were produced.

The following procedure was used on all the five frames:-

- 3225x3225 frame rebinned to 645x645 and resulting array stored in `/data/hydra2/HA_FLAT` on sol as flat6n.fits, n=1 to 5.
- Intensity array created from T values in flat6n via

$$I = 10^{4.5-0.3log_{10}(T)}$$

  Elements divided by highest value in central region, ignoring spikes, then reciprocal of this array taken to provide a zeroth-order approximation to a correction array. This was stored as corr6n.fits.
- Median filtering seemed to remove the spikes very efficiently, if done with a large enough box. 9x9 seemed adequate, except for corr64 which will probably not be used. Median filtered corr6n.fits, then divided all elements by the lowest value in the new array to provide a correction array with lowest value 1.0. This was stored as corr6nb.fits.
- All following discussion is based on these arrays.

3) Discussion

1. Residuals. Apart from the expected 'pepper and salt' random noise spikes, structure is visible in all the frames when the difference between corr6n and corr6nb is carefully contoured. In each of the dome-flats five concentric circles are seen, with two 'axes' not quite at right-angles intersecting at the centre (see fig 2). This structure does not appear in the twilight-sky frames, but in these, diagonal lines are seen pointing towards the corners of the frame (see fig 3).
2. Dome-flats. These all display the same features and even the contour positions at 1.05, 1.10, 1.15 etc are quite similar. If this were the only data, the use of a mean correction array, probably smoothed to some extent, might seem to be justified (mean stored as corr6mb.fits; see fig 4). Some reservations about this are discussed below.
3. Twilight-sky frames. Corr65b (see fig 5) is topologically similar to corr6mb but there are detailed differences. These differences are displayed and contoured (without smoothing) in fig 6. In the regions we are likely to use, the differences are mostly less than 5 percent, so one might argue that some kind of average might be justified, but with what weighting? Are the dome-flats inherently more or less reliable than the twilight-sky frames?
   Corr64b is only topologically similar to the other frames when reversed in x, and even then the quantitative differences are bigger than those between any of the other frames. Is it possible that the filter could have been put in the wrong way round? If this is so, and its response is asymmetric, as is suggested by all the frames, the consequences are serious for quantitative intensity work if this reversal might also have happened for any H_α exposures.

4. Asymmetry. All data suggests that the filter response droops by about 25 percent to the left-hand, 'high-RA' side of the frame and only 5 percent to the right-hand side. Up/down is also asymmetric, but rather less so, with the response drooping by about 25 percent at 'high-δ' and only 15 percent at 'low-δ'. It would seem sensible to attempt to confirm this asymmetry from earlier measurements on the filter before including it in any form of flat-field correction.

5. Magnitude of corrections needed. A 5.66^0 ($4^0\sqrt{2}$) circle is shown on fig 4. Corrections on this circle are seen to be (in percent, starting at the top and going clockwise in steps of 45^0) 21, 10, 5, 10, 15, 20, 25, 28. However, if corrections greater than 1.15 are thought to be undesirable, it is possible to cover all overlaps, if all the contiguous frames are available, because of the extension to upper and lower right of the 1.15 contour (see fig 7). Obviously this strategy assumes that the asymmetries are real and included in the final flat-field correction.

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