7.1.3 Flat-Fielding Error

Due to the finite number of counts in the flat-field image, a small error is introduced when the flat-field image is divided into the object images. Typically, a flat-field summation of 50,000 to 200,000 counts is used in this division. For a flat-field summation of 50,000 counts, the error in the flux of a stellar source due to the counting statistics error in the flat-field image is less than 0.1% . However, other errors can occur due to (1) the instability of the flat-field image over time, and (2) the difference between the background illumination of the flat-field images and the QSO field images, and (3) the difference in the CCD response to the spectrum of light from the star (or QSO) and from the twilight sky. Since the stars and QSO appear at different parts of the CCD, any relative change in the flat-field across the CCD will cause errors in the final reduction.

The time between the object and flat-field exposures ranges from a few hours to a few days (when bad weather prevents dusk or dawn flat-field exposures). The most noticeable example of changes in the flat-field images are when dust appears in the optical path (e.g. the CCD window), causing unfocused "pin-hole" (ring shaped) images on the CCD. By dividing flat-field summations from adjacent nights and taking means in areas spread across the CCD, we have estimated this error to be on the order of 0.2%, with deviations as large as 1% near the pin-hole images. However, the areas with large (1%) deviations typically cover less than 5% of the CCD.

Case (2) is more difficult to estimate. This might be caused by by reflections of a bright star or the moon within the optical system causing a non-uniform illumination across the CCD. These problems are often difficult or impossible to correct for at reduction time. Light leaks (from outside the beam) during CCD readout of short exposure sky flats from a bright dawn or dusk sky are another possibility.

Case (3) is also rather difficult to estimate. The best test would be to take flat-fields with lamps of various spectral shapes (this has not been done for our system). Given the wavelength range of our filters, the large change in CCD response over this range, and the difference in spectral shape between the twilight sky and the stellar sources, this could be