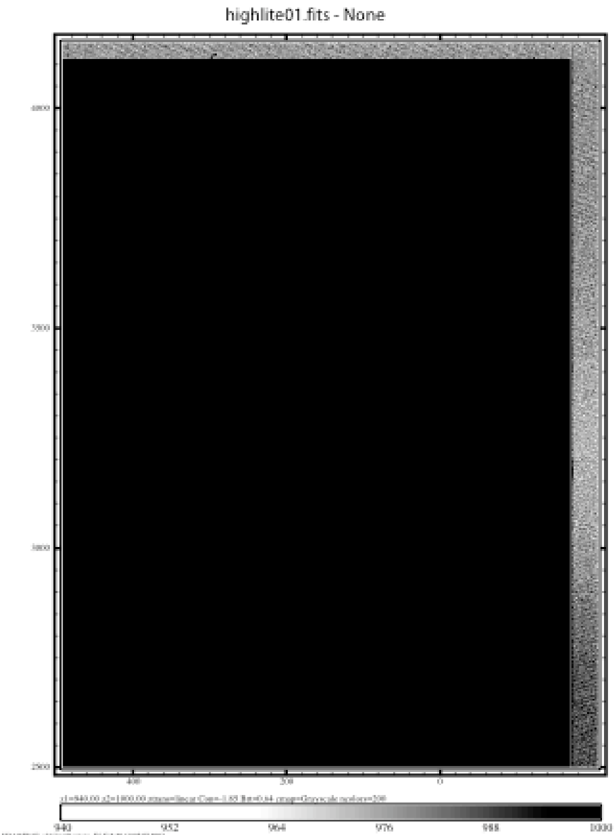
Rudimentary CCD Data Reduction

Supernova Photometry Lecture 2

Bias Correction



Find overscan region on CCD (**BIASSEC** in header)

Examine behavior - constant/sloped/rolling/jagged

Select region away from CTE residuals

Determine overscan independently for all frames:

- Constant - use median of **BIASSEC**
- Sloped - **colbias** in IRAF / Buie IDL
- Rolling - **colbias** in IRAF / Buie IDL
- Jagged - median of each overscan row

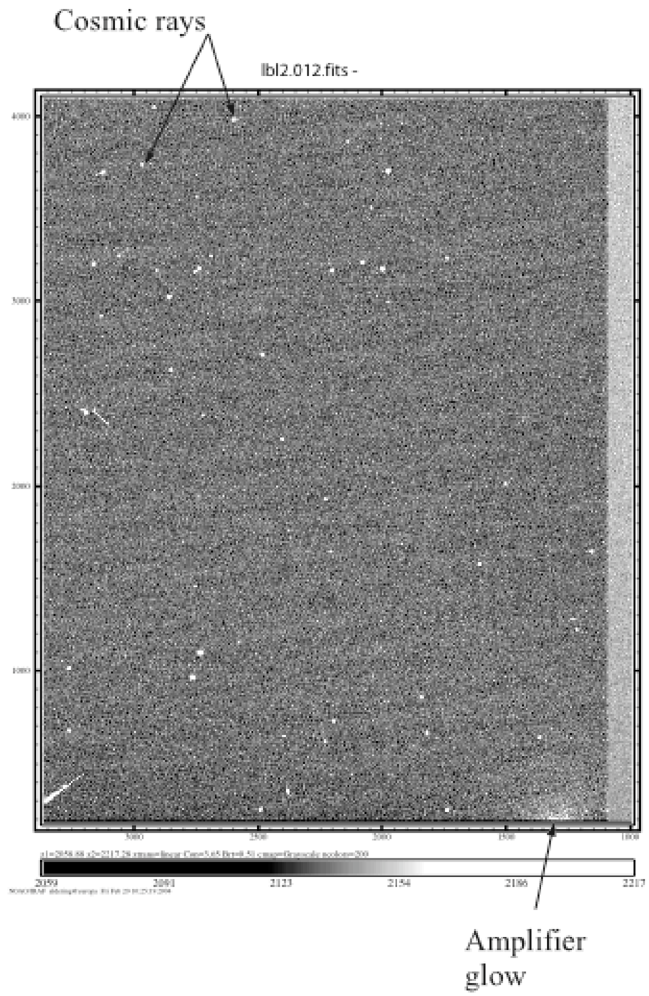
Combine all overscan-subtracted bias images (e.g. using **imcombine** in IRAF with median and no scaling) to make superbias.

If structure in the superbias, subtract from all images

Otherwise, subtract superbias from all bias images

If there is substantial noise reduction, subtract superbias from all images.

Dark Subtraction



Thermal dark current is present:

$C = 120\, C_o T^3 \exp[-6400/T]$

Suppressed by inverting clock voltages during integration (MPP)

Look for **DARKTIME** header keyword

CTE can lead to incorrect dark estimate; examine leading rows for "ramp up".

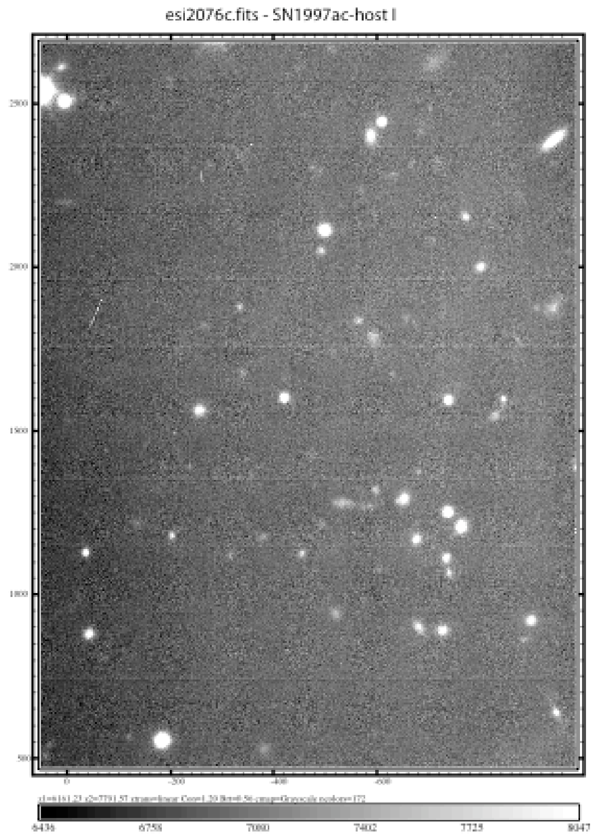
Take long (1 hr) exposure to get decent signal

Long darks have many cosmic rays, so obtain as many as you can (limited by dark dome time)

Median darks together, using **DARKTIME** (e.g. using **imcombine** in IRAF with exposure scaling), to make superdark.

Subtract **DARKTIME**-scaled superdark from all images.

Flat field Correction



Non-uniform response due to:

CCD QE variations (λ dependent)

Dust on filters, dewar window, or detector

Telescope or instrument optics

Uniform illumination used to measure:

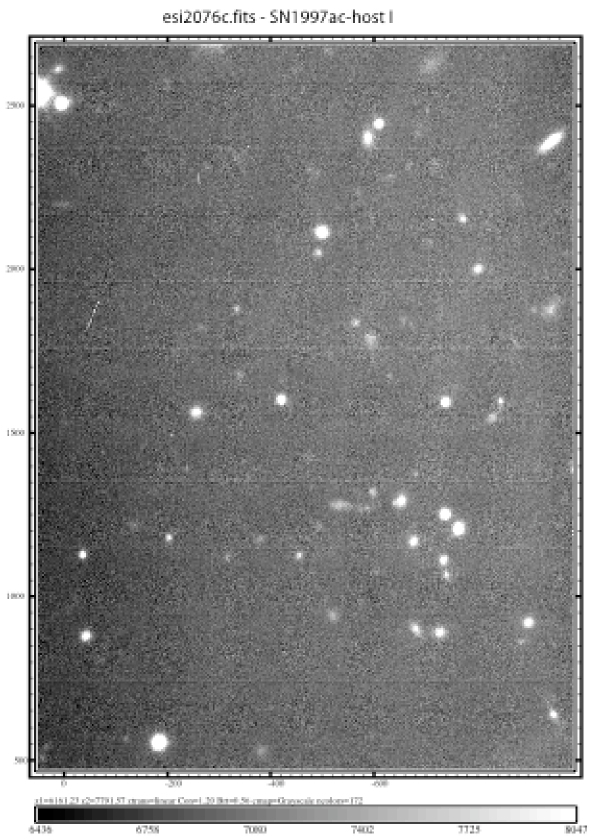
Dome flats (illumination & spectral mismatch)

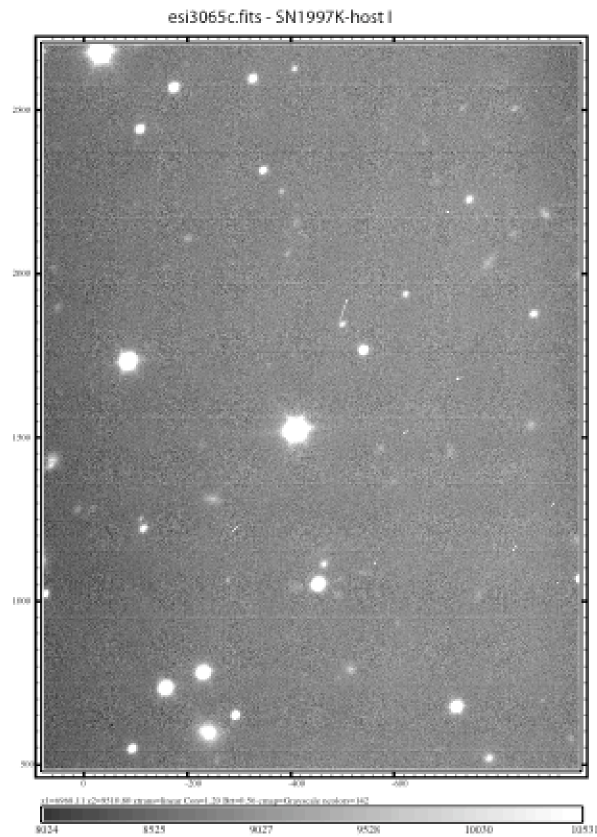
Twilight sky (spectral mismatch/timing)

Sky flats (object removal/Moonlight)

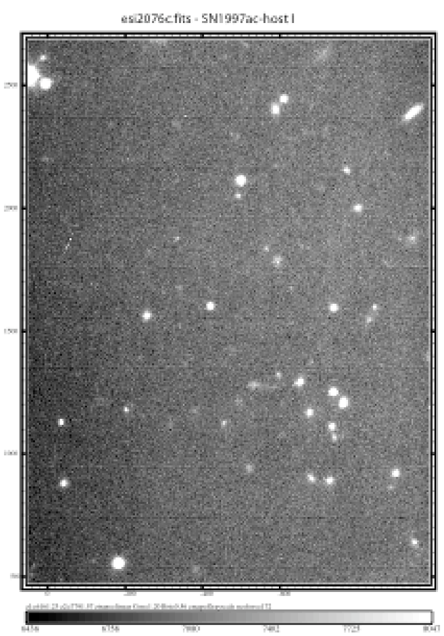
Sky flats are usually best, but require many spatially-dithered exposures.

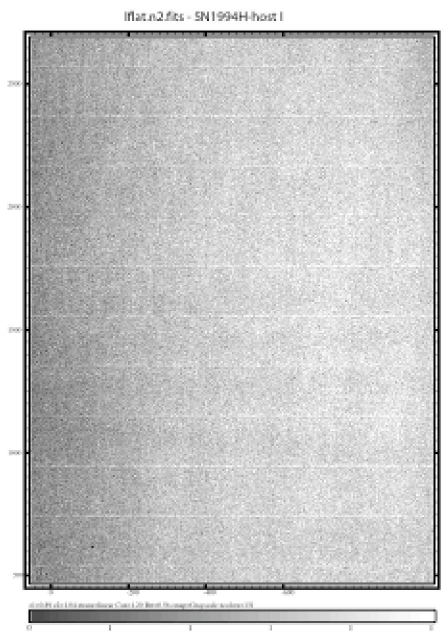
Flat field Correction - Dither Example

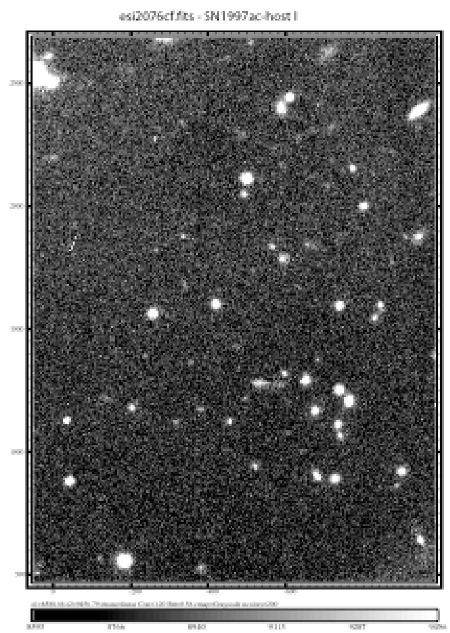




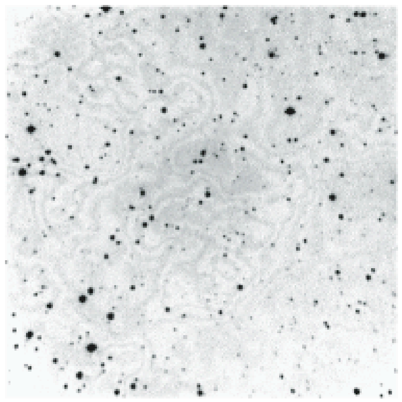
Flat field Correction - results

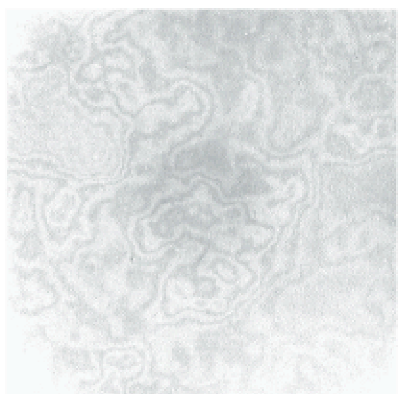






Fringe Correction





At longer wavelengths Si becomes translucent.

Light can bounce off back of CCD in interfer with incoming light.

If CCD were uniformly thick no 2D structure would result.

However, thinned CCDs have both less Si to absorb light and tend to have non-uniform thickness from thinning process.

Still, with broadband light falling on CCD, the interference pattern would be strongly smeared since different wavelengths interfer for different thicknesses. Objects with smooth spectra are still OK.

Night has strong OH lines at red wavelengths, so pattern remains.

So, at red wavelengths and little moonlight, fringe pattern results which must be **subtracted** to obtain uniform background.

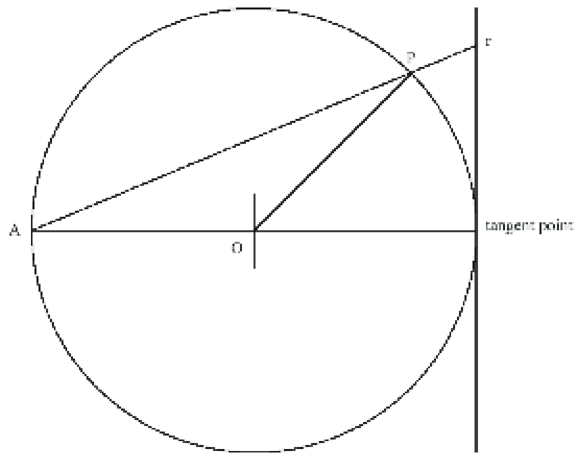
Sky flat will contain fringe pattern, but will **divide** it out.

Thus, when fringing is strong, one needs to first flat field using a dome or twilight flat, and then use sky flat for fringe correction.

Intensity of OH lines varies, so fringe amplitude changes.

Try different scaling of fringe frame to find best subtraction.

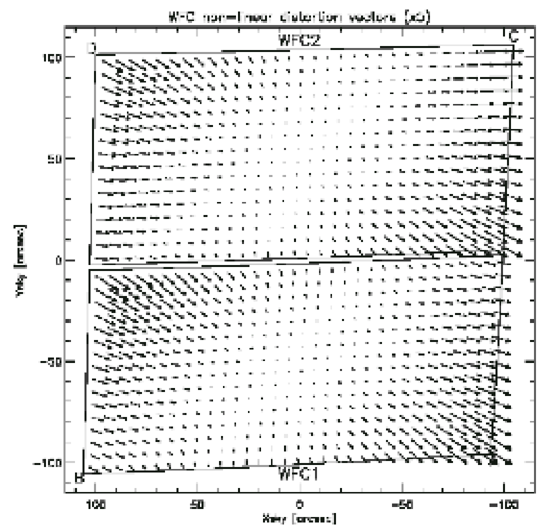
Spatial Distortion



Projection of sky onto detector is non-linear

Thus, uniform sky illumination results in radial illumination gradient on detector

This means that flat fielding has over-corrected brightness at edges relative to center.



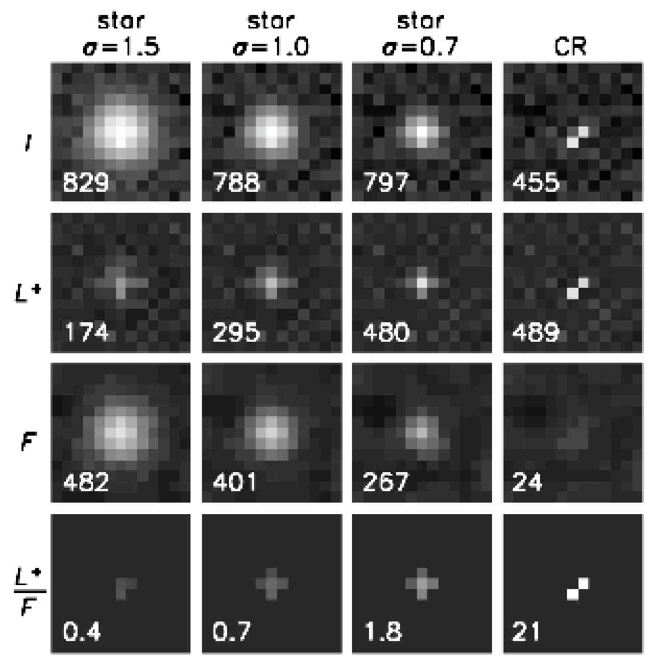
In addition, detector optics may cause distortion

The correction amounts to the normalized Jacobian [dS/dx] between the sky coordinates and the detector.

The correction is often small (~2%), and SCP has always ignored it.

Be alert for when using wide-field or distorting optics!

Cosmic Rays



star σ=1.5
star σ=1.0
star σ=0.7
CR
I
L+
F
L+/F
829
788
797
455
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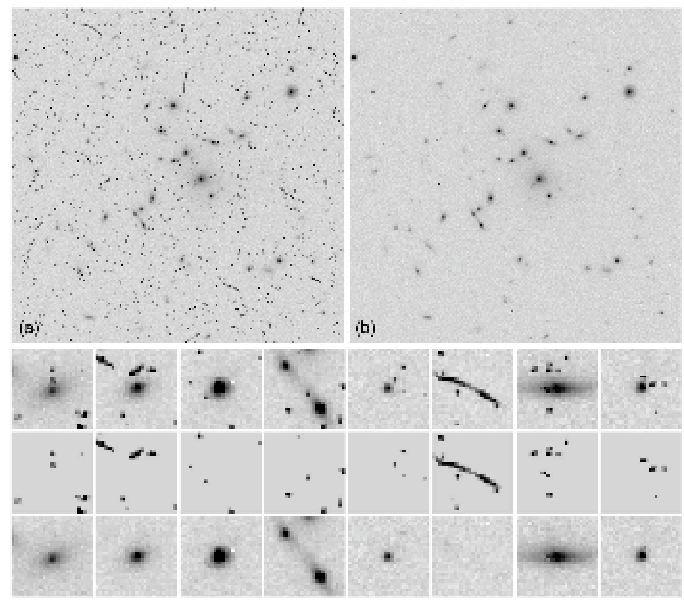
295
480
489
482
401
267
24
0.4
0.7
1.8
21



(a)
(b)