Useful and Useless Cleaning Methods in CCD Imaging

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Astronomical vs Consumer cameras?

Astronomical	Consumer
Cooled	Not cooled
Fixed sensitivity	Adjustable sensitivity (ISO)
No in camera functions	All in camera functions
Fixed optical setup	*Variable* optical setup
Better quality CCD	Poorer quality CCD/CMOS detector

What is a CCD Image?

- Combination signal of
  - photons
  - random electronic noise due to heat
  - amplification noise
  - cosmic rays
- Electronic representation of light reaching the sensor

What happens to the photons?

- Depends on the light path
  - mirrors (reflection/absorption)
  - lenses (refraction/absorption)
  - filters (absorption)
  - dust (absorption/scattering)
  - stray light (addition)

What is electronic noise?

- Due to heat
  - Resistance of material
- Due to amplification
  - Resistance of contact layers in semiconductor material
  - Random noise added to the system by electricity applied
- Bad pixels

Do CCD's deliver unmeasureable images?

- Useful images are obtained if we can
  - subtract the effect of electronic noise
  - compensate for the influence of the dust, reflections and stray light
- Useless images will result if
  - we just apply enhancing techniques
    - averaging/smoothing/noise reductions
    - unsharp masking
    - enhancing of colours etc.

Noise terms

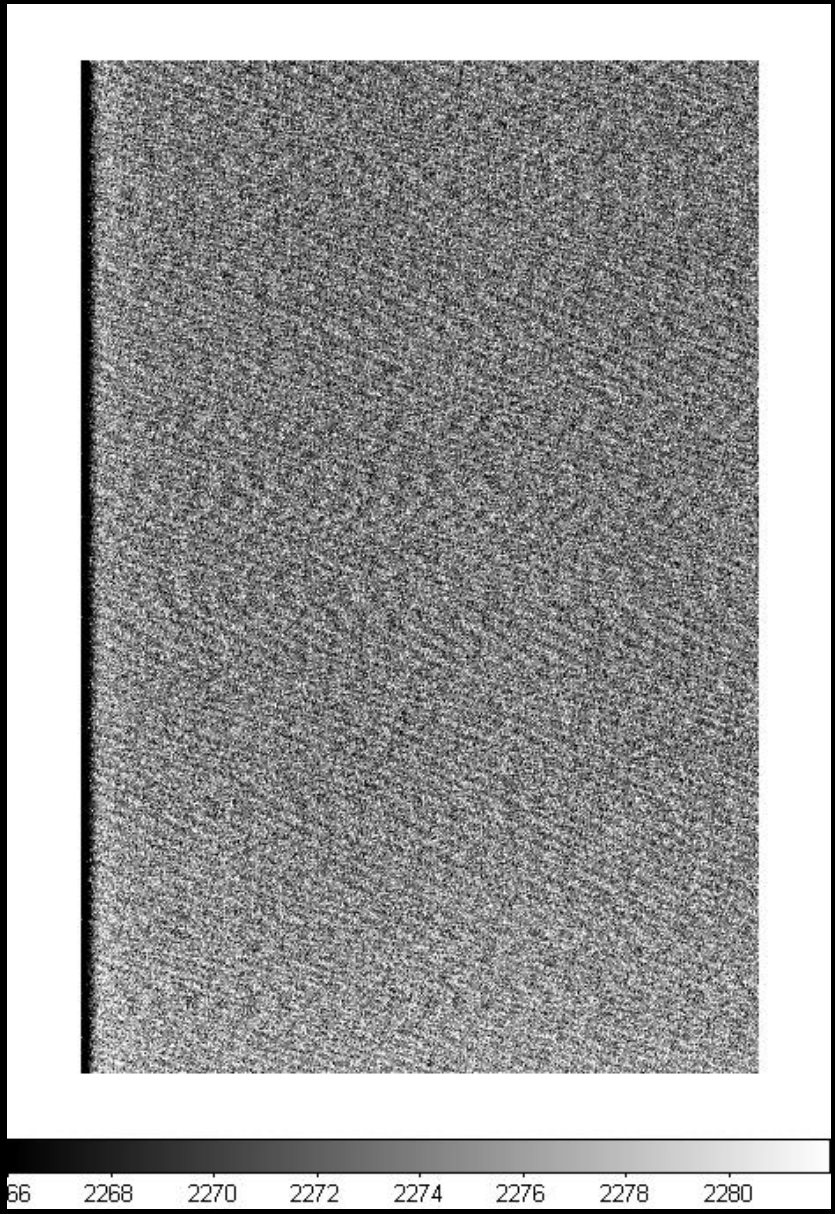
- Electronic noise
  - Bias noise
    - readout process
    - amplification
  - Dark Current
    - buildup of electronic noise over time in keeping the pixels sensitive to light
- Optical Noise
  - Flat frames
    - Image of optical obstacles and readout characteristics of CCD

Requirements for CCD imaging

- Constant temperature of CCD chip

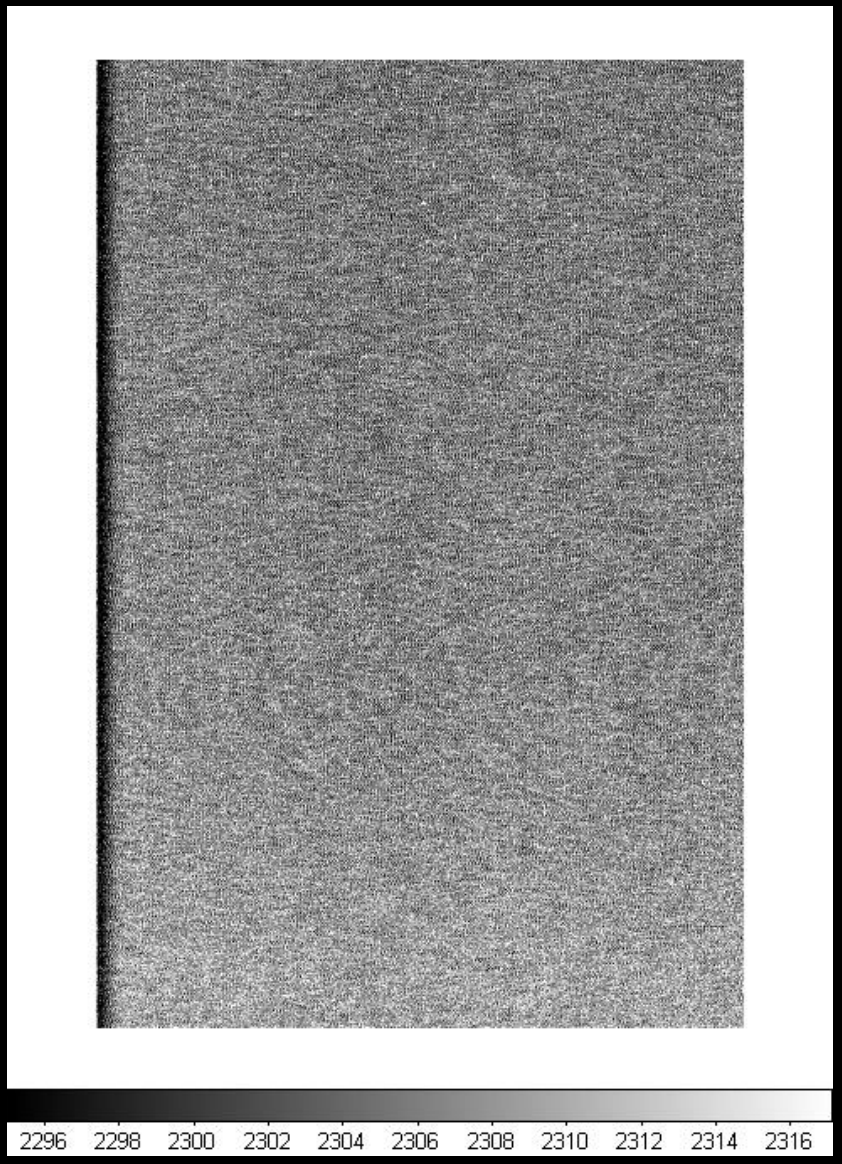
Bias frames

- Image of electronic readout noise alone
- Take with closed shutter and shortest exposure time possible
- Average 20-40 images and combine into a master bias frame



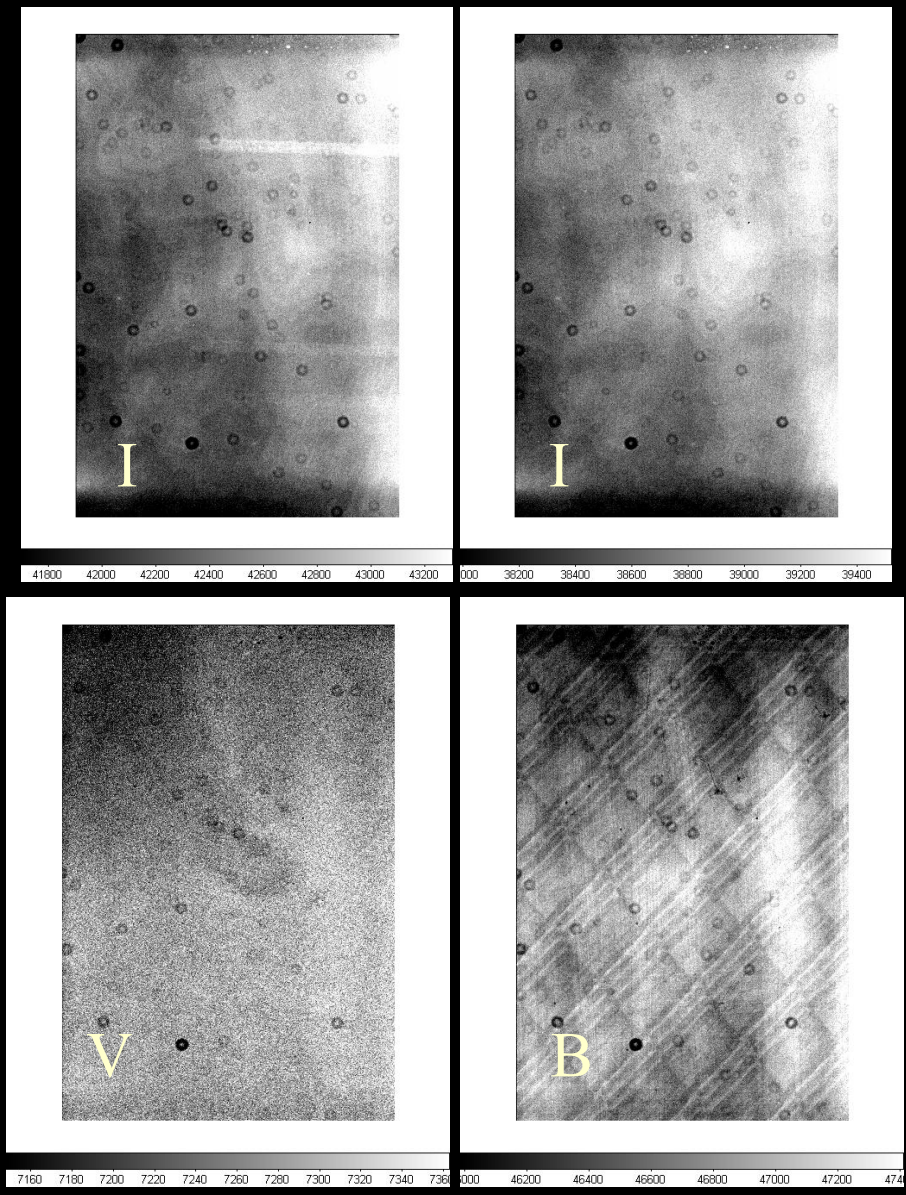
Dark Frames

- Take at same temperature as images
- Use closed shutter and same exposure times as image
- Take around 20 images
- Average and combine into a master dark for that temperature
- Stay constant over a few months time



Flat Images

- Compensate for internal reflections, dust on lenses, filters and mirrors
- Expose 60%-80% of saturation counts
- Expose for each different optical setup
  - Cleaning
  - Filters
  - Baffles
  - Dew shield
  - Aperture change
  - Should be EXACTLY the same setup as when image was taken



Reduction Procedure

Replace BAD PIXELS

RAW Image | FLAT | DARK

Subtract BIAS

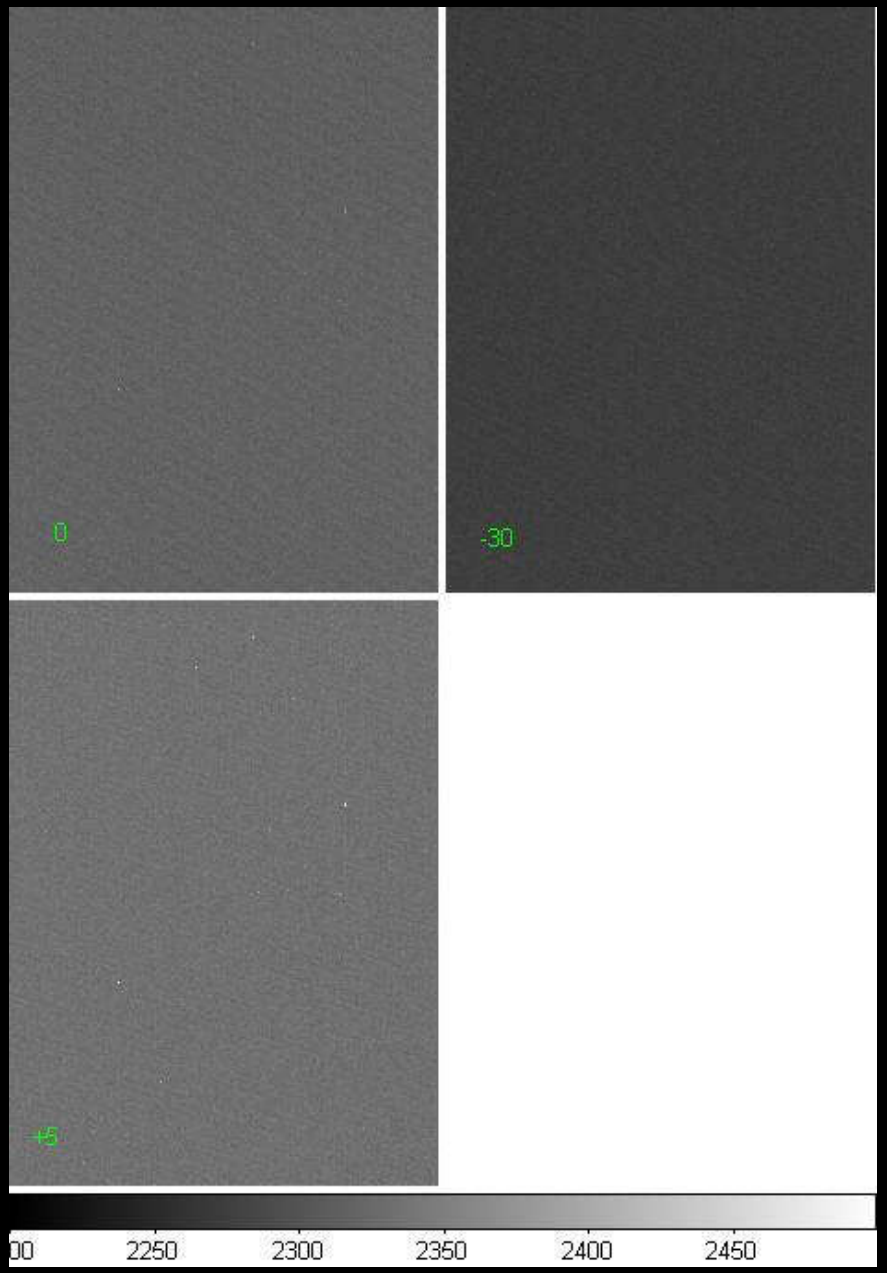
$$\frac{\text{IMAGE} - \text{DARK}}{\text{FLAT}}$$

- read your data from disk or tape,
- convert your data to a format compatible with your software,
- inspect the original images and discard those that are faulty,
- flag all the known faulty pixels as `bad' or replace them with invented, reasonable values,
- create master bias and dark images for subsequent use in removing the dark and bias signal from raw images of target astronomical objects,
- for each filter, create a master flat field frame defining the pixel-to-pixel sensitivity variations and then flat field each of the images,
- for each filter, align and add the individual images of each target astronomical object to produce a master image of the object

Software

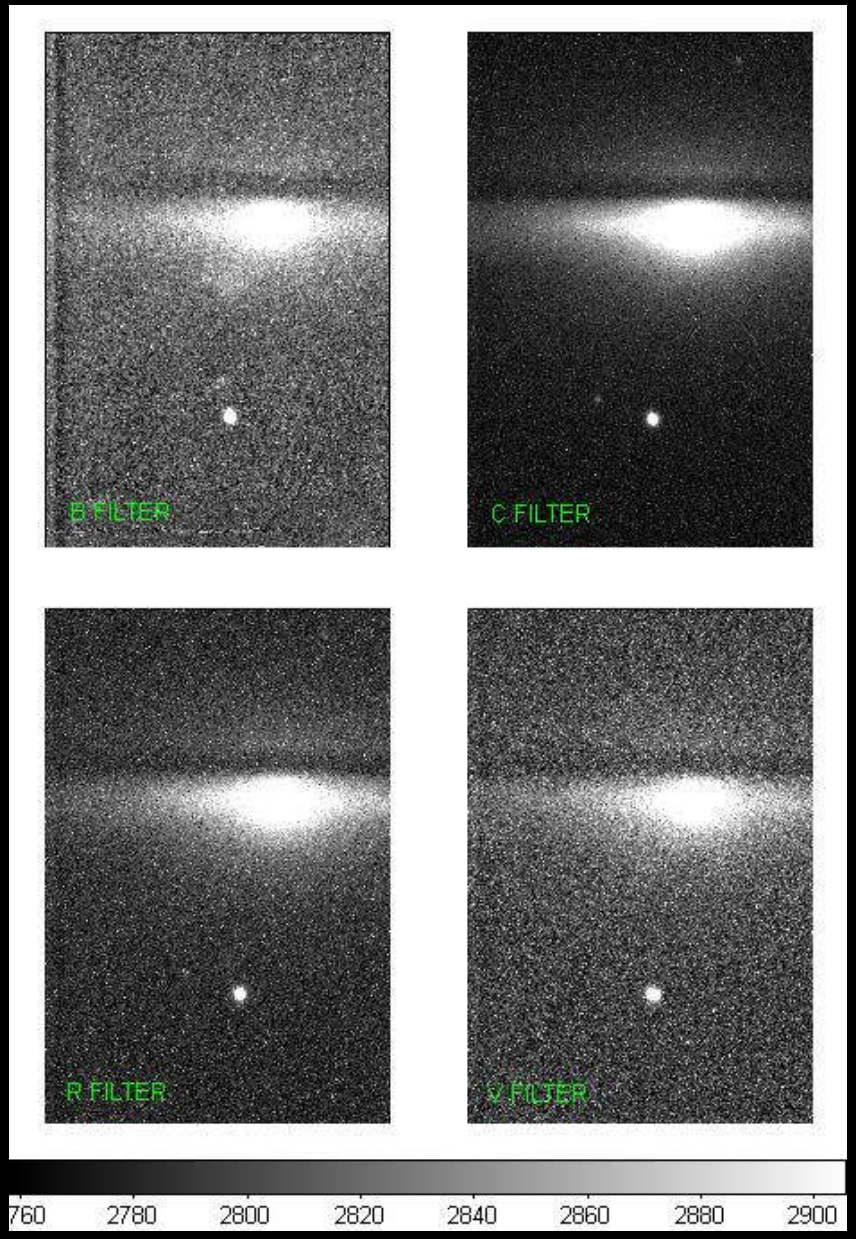
- Linux
  - IRAF
  - Starlink
  - MIDAS
- Windows
  - MaxIm DL
  - CCDSoft

Example : Temperature influence

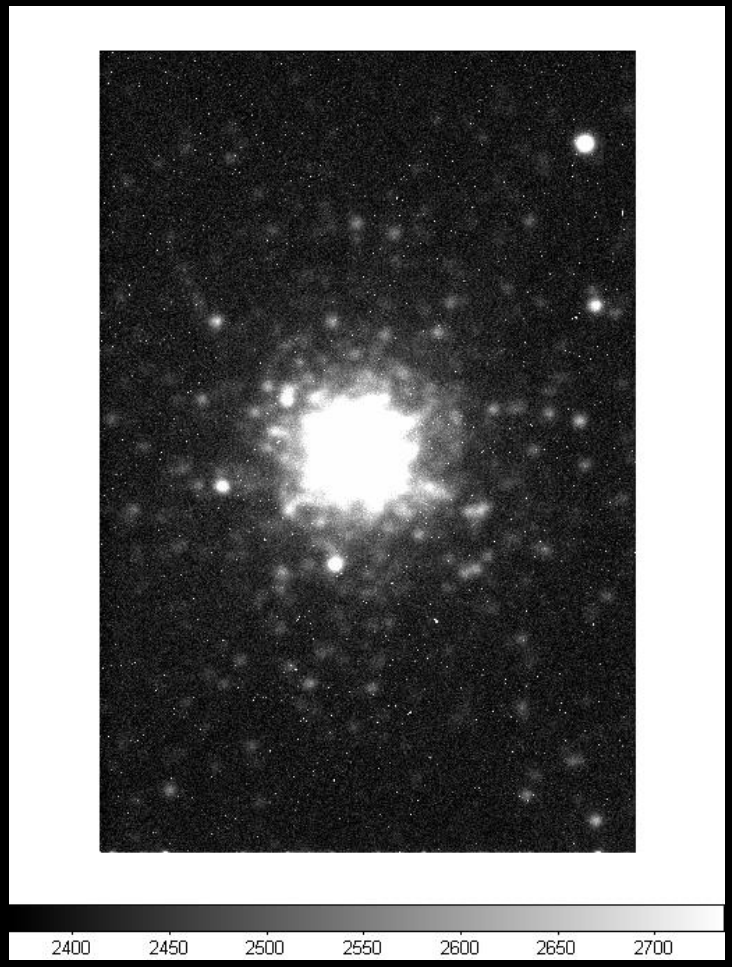


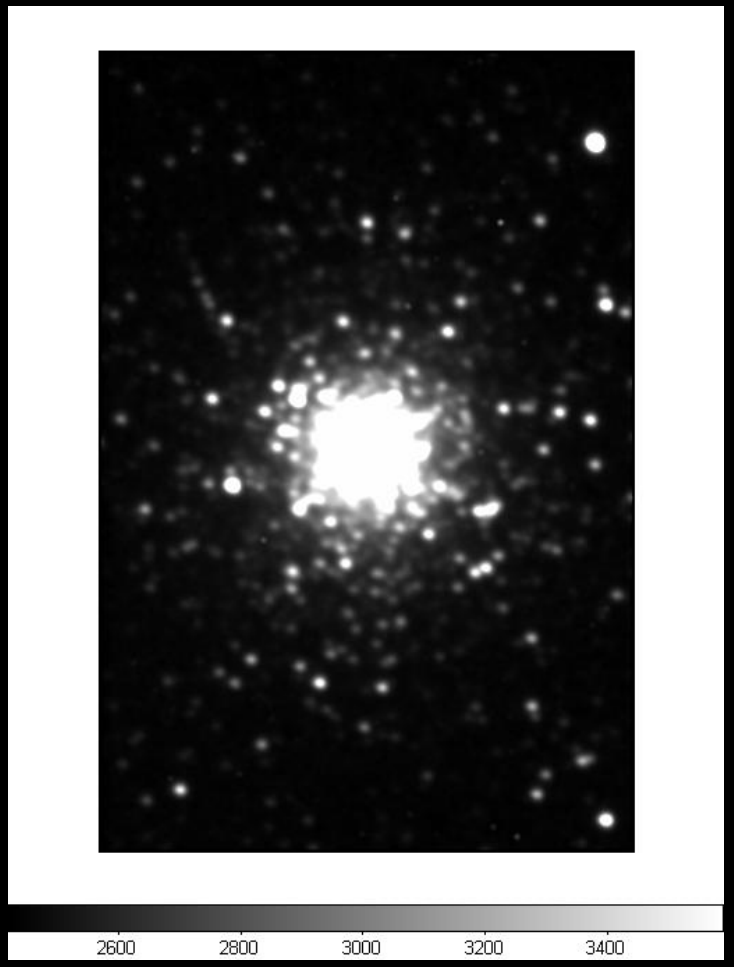
All images scaled between 2100-2300 counts

Example :
Filter influence



Example : Correcting image

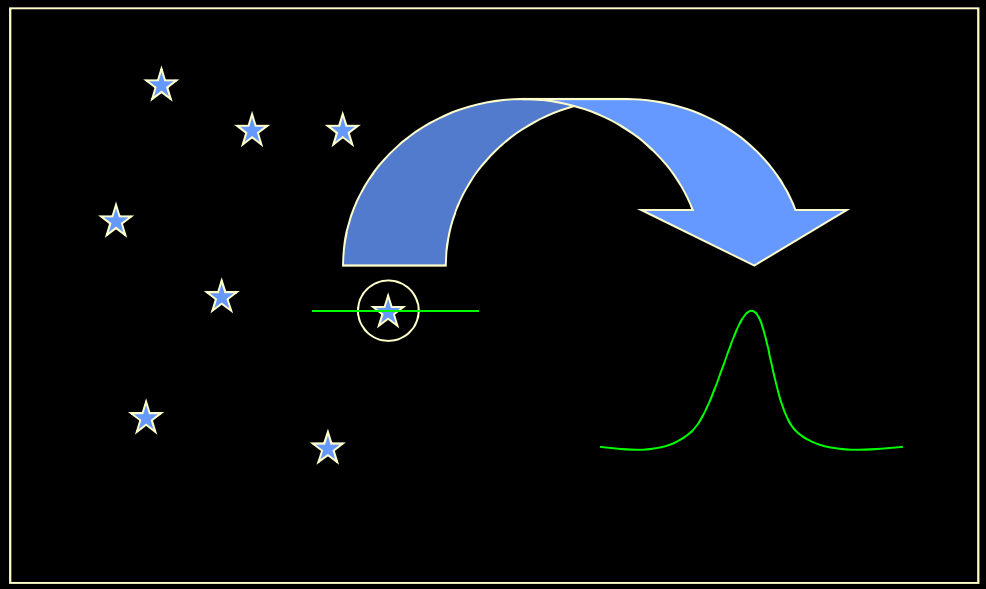




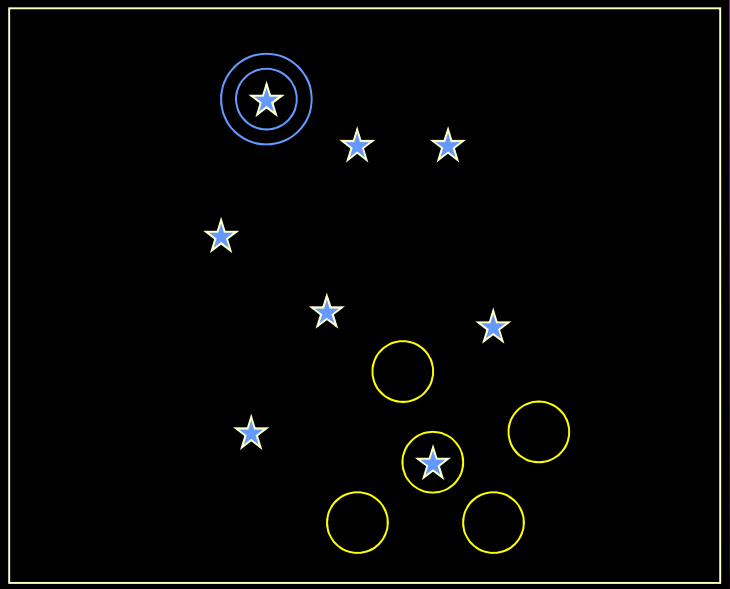
Other CCD Skills

- Measurement of observations

Point spread function



Aperture



Photometry

Differential

Absolute