

Producing Quality Optical Images --- short lecture

PHYS 3154

Observational Astrophysics



CCDs can produce high quality images



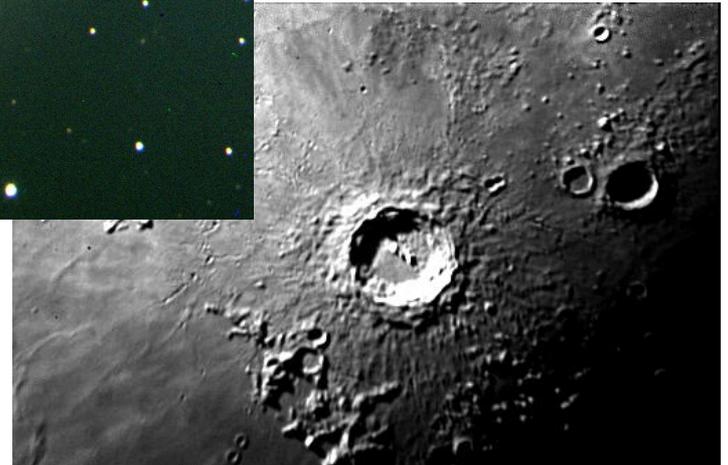
Artifacts minimized



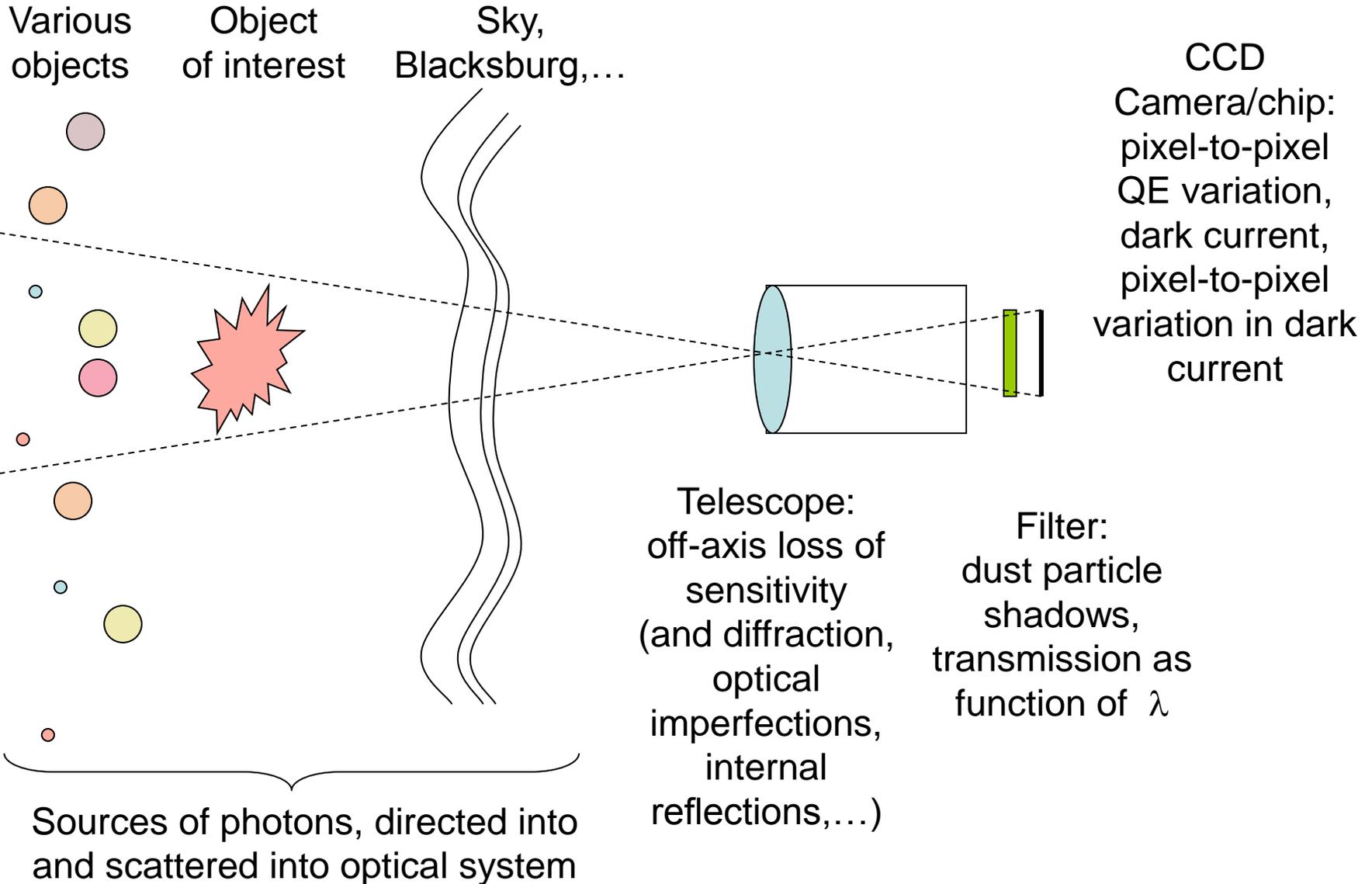
Corrected for
imaging
imperfections



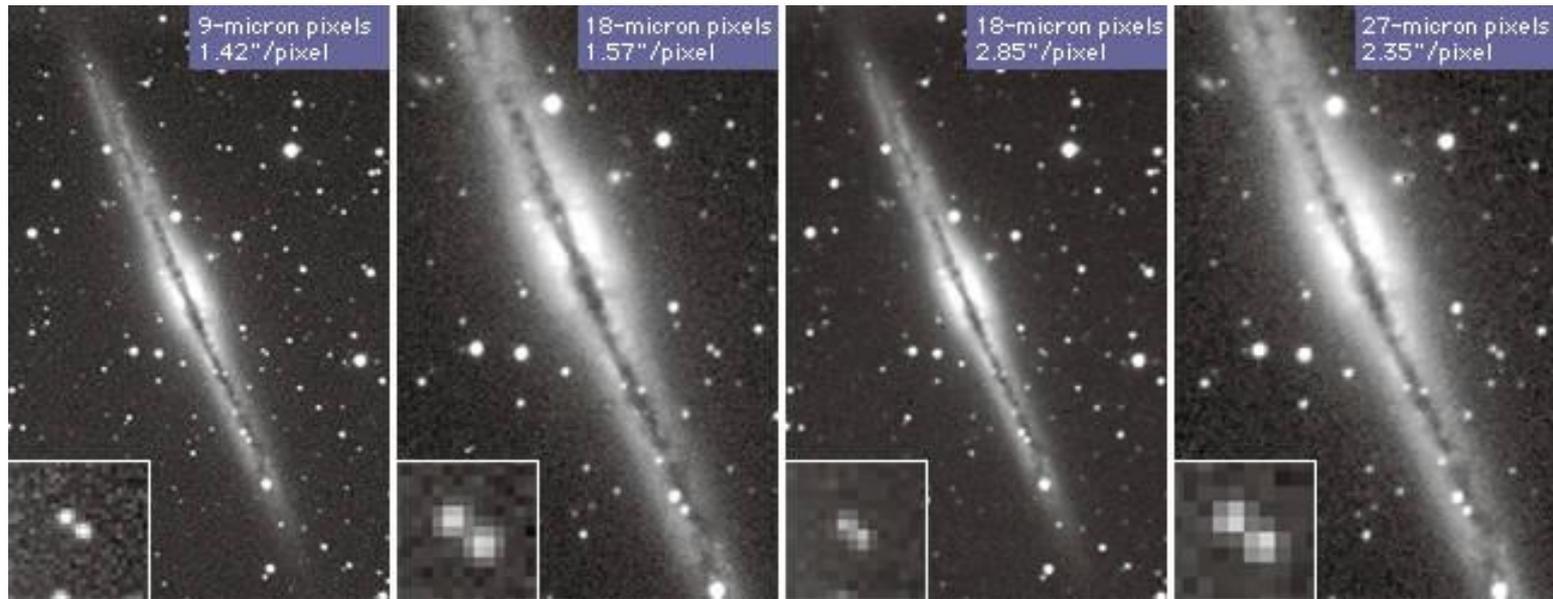
High signal-to-noise
ratio



A CCD image is a digital, but imperfect "record" of an astrophysical object + ...



Finite pixel sizes affect CCD image "record"

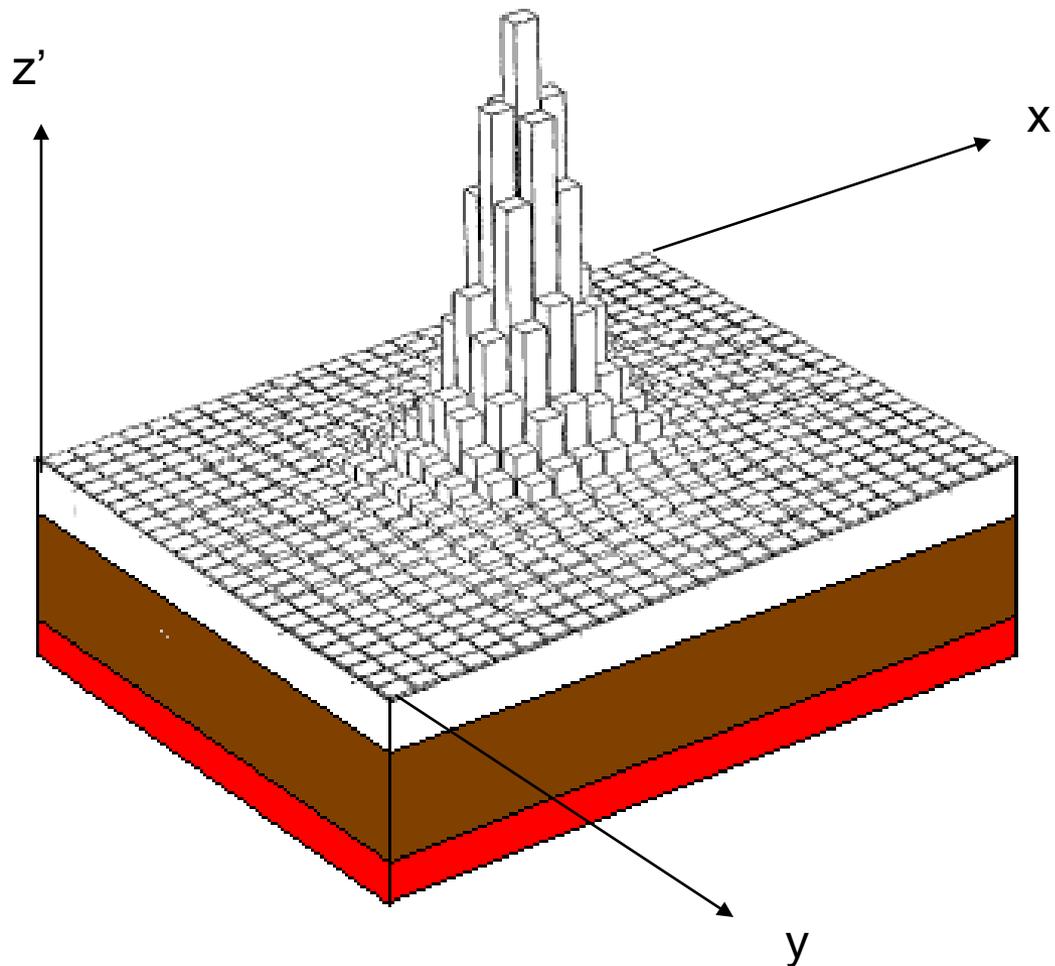


CCD image values are positive integers: "counts"

CCD image

- A digital image, also called a "frame"
- Each pixel value = # "counts", or "ADUs" (Analog to Digital Units)
- Almost every photon that hits a pixel releases an electron which can subsequently be counted.
- Let z' = counts in a pixel, in some raw image

Photons, thermal electrons, bias --- all contribute



Counts contributed from...

 Photo-electrons

 Thermal electrons
(dark current)

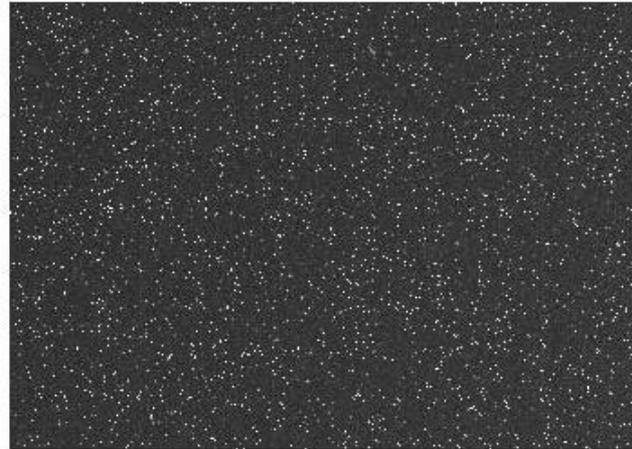
 Bias
(electronics
offset from zero)

Example: Dark Correction

Raw Image



Dark Frame



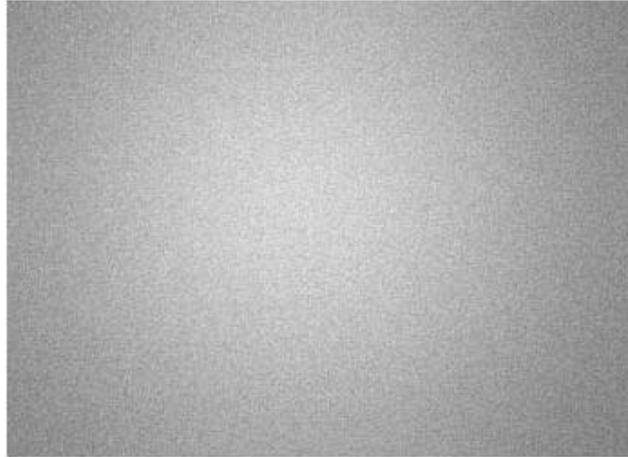
First step in image correction (also called “calibration”): Subtract a Dark Frame from the Raw Image frame. The Dark Frame should have the same exposure time (integration time) as the Raw Image. The bottom Image is the Raw Image minus the Dark Frame.

Example: Flat-Field Correction

Raw Image



Flat Field Image



Second step:
Correct for uneven image illumination, and uneven pixel-to-pixel differences in sensitivity, by dividing the image resulting from dark correction by a Flat Field Image. The Flat Field Image is simply a dark-corrected image of a flatly illuminated screen, that has had its largest value set to unity and all other values scaled accordingly.

The top left image is a dark-corrected image. Top right is a Flat Field Image. Bottom left and right: two different views of the resulting flat-corrected image.

Image processing software we use

CCDSOft

Used at the observatory to take images (light frames (raw frames of the sky), dark frames, flat-field frames). Saves the images in FITS format (FITS = "Flexible Image Transport System").

FITS images produced taken by our camera, and recorded by CCDSOft as 16-bit integer images. In other words, each pixel is an integer value that can range from 0 to $2^{16}-1$ (0 to 65535).

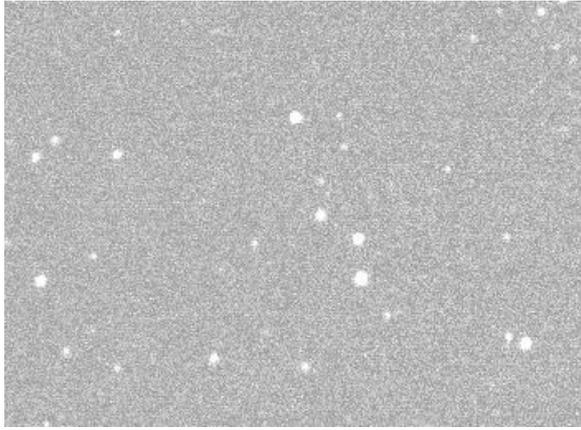
A value of 100 is added to all image values produced by SBIG cameras. In other words, this additional artificial 100 is present in each displayed pixel value in all our programs.

CCDOps

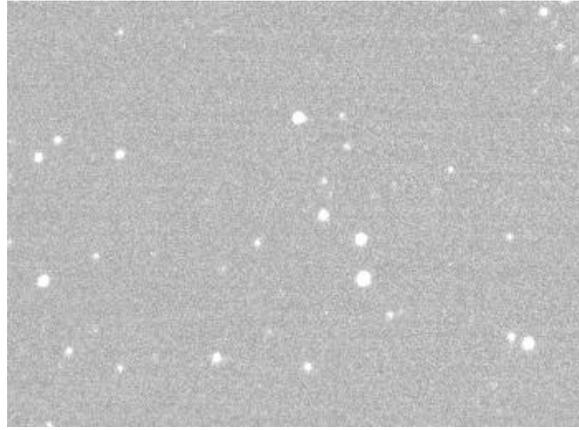
Windows program from SBIG. A basic image processing program for astronomy.

- On the computers in Hahn North 103.
- Can be freely downloaded from SBIG.
- Only works with integer-valued images.
- Automatically compensates for/adds a 100 count bias to all SBIG images (as does CCDSoft).
 - In other words, it removes 100 in memory from each pixel value, just before combining any images, in any way. Then it adds 100 back to each pixel before outputting the resulting image. All final displayed images have this 100 present in each pixel value. All saved images have this 100 present in each pixel value. All displayed image values have this 100 present in them.

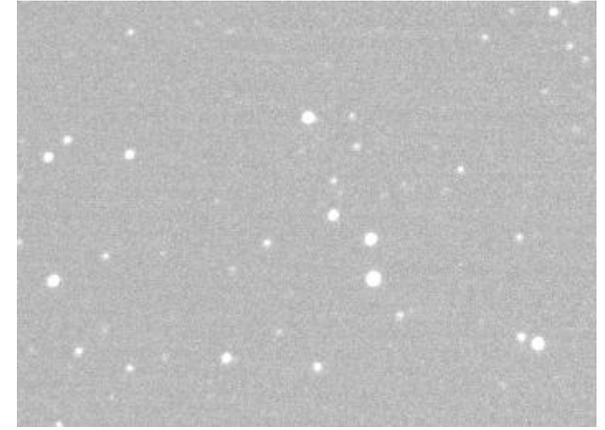
Signal-to-noise ratio is increased by increasing the exposure time, or by averaging sets of images



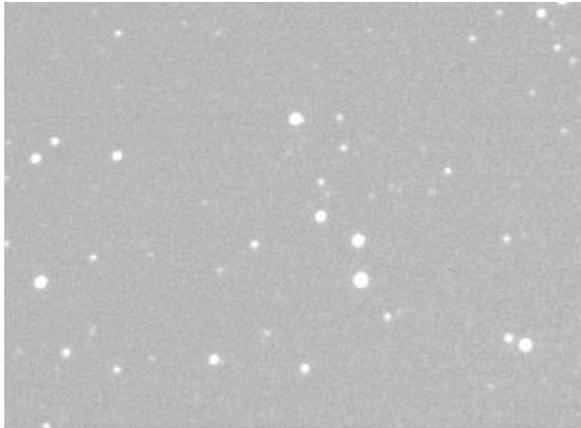
1 image



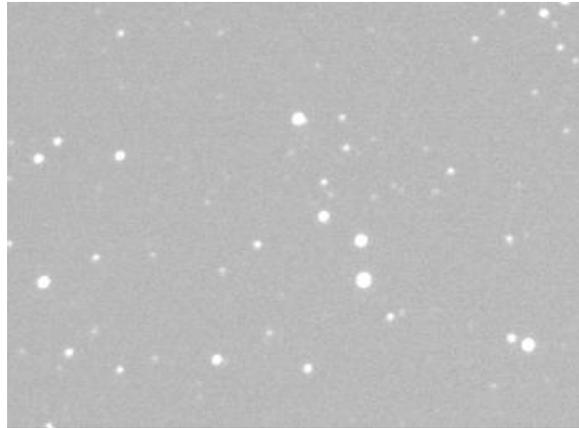
2 images



4 images



8 images



16 images

You can increase the S/N ratio in your result by averaging a set of accurately overlaid images. But you can only do this *after* having dark- and flat-corrected the individual images.