

Digital Imaging

Harken Observatory
Pewaukee Public Library

The Harken Observatory

The Harken Astronomical Observatory provides education and brings the wonders of our incredible universe to families of our community in the friendly and casual environment of our new library.

It is a hands on experience with rare access to high tech and powerful equipment.

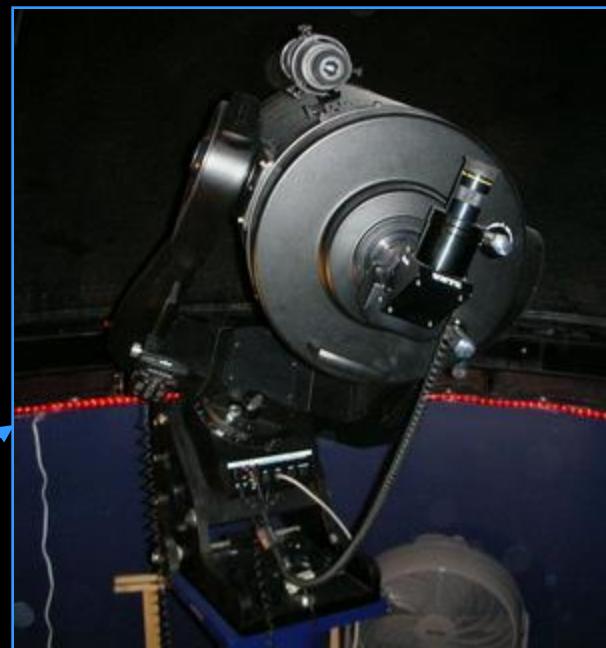
All funds, including original construction and equipment, are donated.

Equipment

- Meade LX200-GPS Schmidt-Cassegrain Reflector Telescope
 - Aperture: 12 inches (305 mm)
 - Focal Length: 120 inches (3048 mm)
 - Focal Ratio: f/10
- Digital Cameras (StarLight Express SXV-H9C, Meade LPI, Meade DSI-2)
- Computerized Control Station w/ remote Station

Operate the scope

- in the dome
- on the platform
- downstairs



Digital Imaging

- Why Digital Imaging?
- NOISE!
- Peeling the Onion
- An Example

Why Digital Imaging?

- Since we do not have access for the handicapped to go up into the dome, we are, by law, prohibited from letting the general public up there.
- Only instructors are allowed upstairs.
- Anyone can become an instructor (hint, hint!)

NOISE!

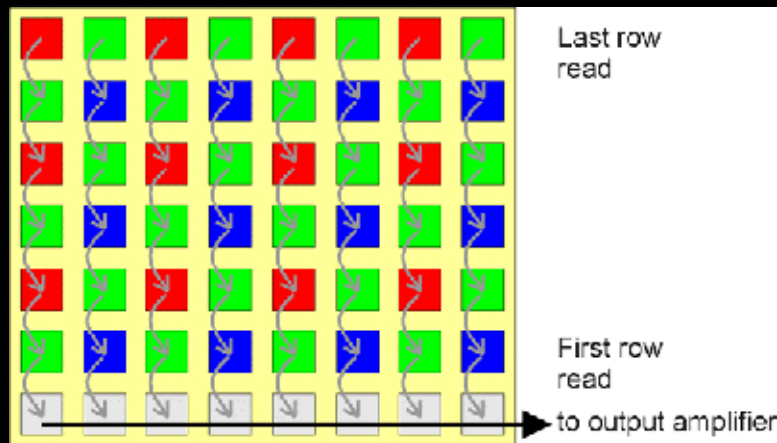
- Noise is any extra (usually unwanted) information.
- Some examples:
 - The crackle in a radio transmission
 - Static or interference on the TV
 - A jackhammer outside your office

Noise in Digital Imaging

- Read-Out Noise
- Dark Current
- Vignetting, Dust
- Unequal pixel response to light (QE efficiency)
- Statistical properties of light

Read-Out Noise

- Read-Out Noise is random variations in pixel brightness as the CCD chip is read.
- The last pixels read-out have gotten more light than the first ones read.



Dark Current

- CCD chips see heat as well as light.
- The longer an exposure lasts, the more heat shows up as light.
- This is called Dark Current.
- Many astronomical cameras have built-in cooling to reduce dark current.

Vignetting and Dust

- Vignetting is the uneven illumination of the camera.
- The image will have a bright center with dim edges.
- Dust blocks light if it is close to the chip.
- Other defects in the optics can show up in a image, too.

Statistical Properties of Light

- Light strikes the CCD chip like random drops of paint.
- For the very faint deep sky objects like galaxies and nebulae, the light is only slightly above the sky background.
- Larger sample sizes (longer exposures) are needed to separate the image from the background.

Quantum Efficiency

- The sensitivity of a pixel to light is called its Quantum Efficiency (QE)
- No manufacturing process is perfect.
- Some pixels are more sensitive than others.
- Some are “Hot” or show very brightly.
- Some are “Dead” or don’t register at all.

Peeling the Onion

- We peel the Onion from the outside-in
 - Read-Out Noise
 - Dark Current
 - Vignetting, Dust and QE
 - Statistical Light accumulation

Peeling the Onion

- The process of removing the layers of noise is called calibration
- Calibration can reduce:
 - Read-Out Noise
 - Dark Current
 - Vignetting, Dust and Differences in Pixel Sensitivity

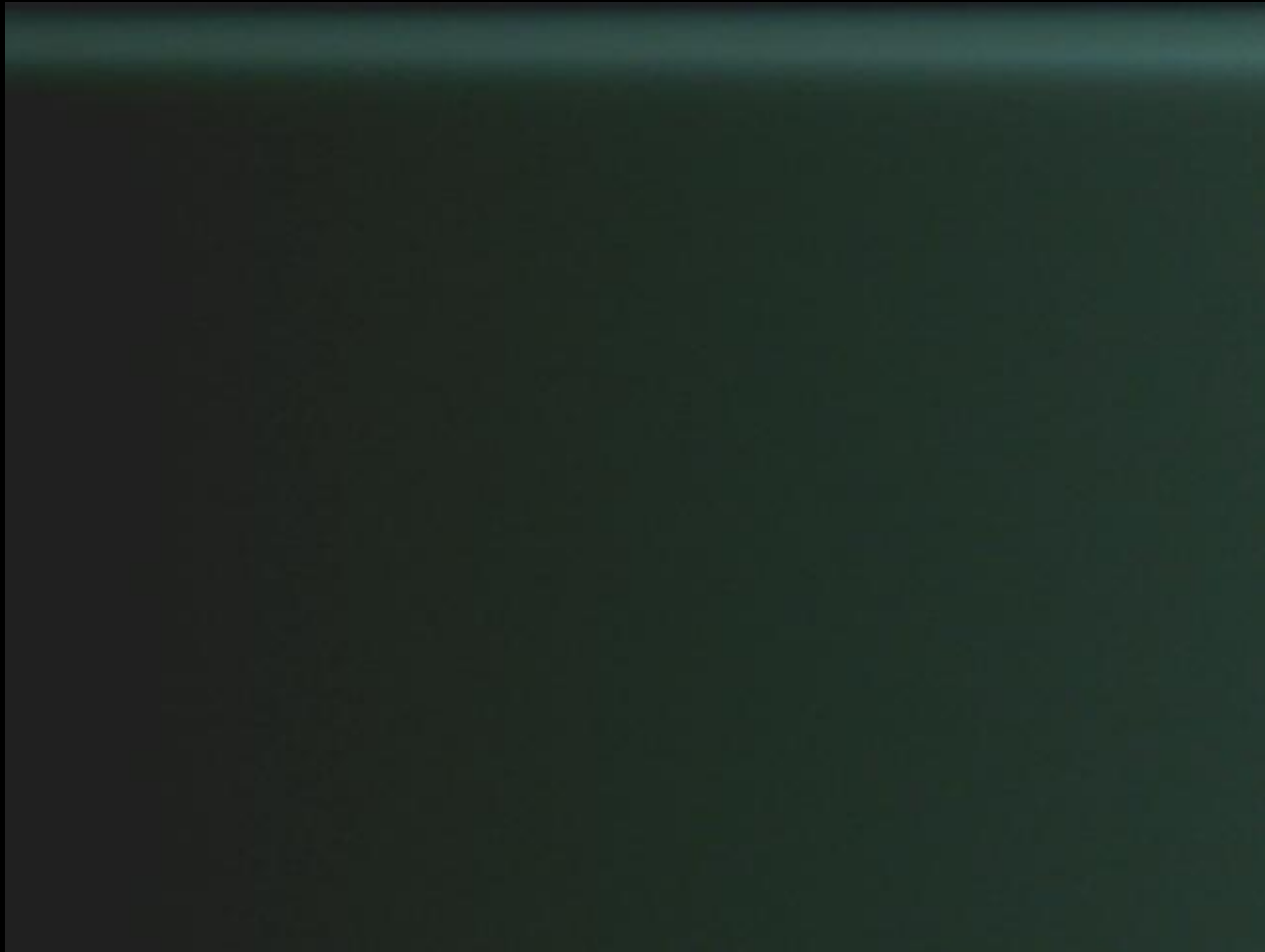
Peeling the Onion

- The effects of the statistical nature of light can be reduced by increasing the sample size – taking longer exposures
- Digital images can be added together. This is called stacking.
- Ten 1-minute exposures = One 10-minute exposure!

Read-Out Noise

- A Bias Frame is a zero length exposure with the lens cap on.
- The Bias Frame is subtracted from the raw image to eliminate Read-Out Noise.

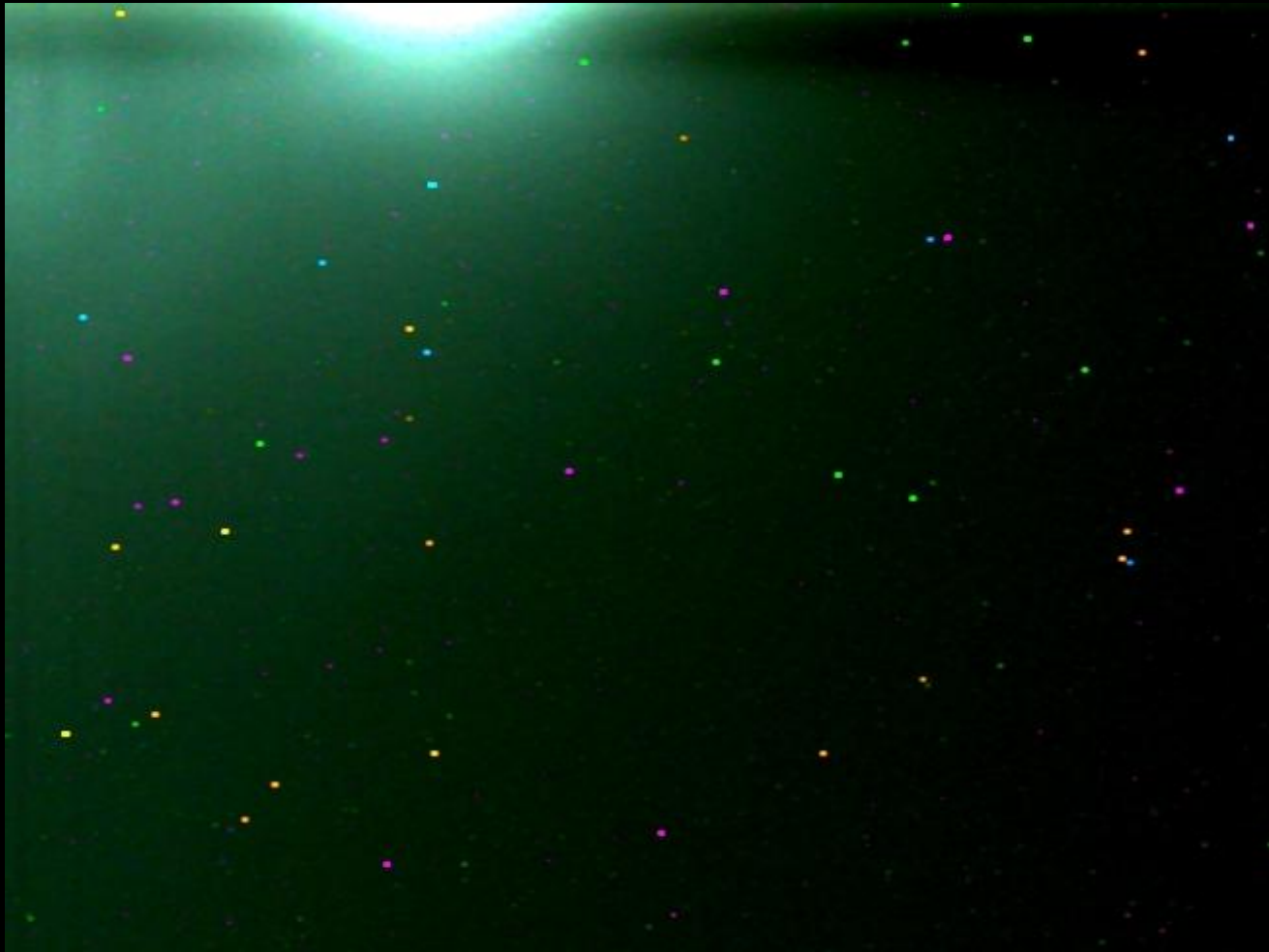
Bias Frame



Dark Current

- A Dark Frame is an exposure with the lens cap on for the same length of time as the image.
- The Dark Frame is subtracted from the raw image to eliminate Dark Current.

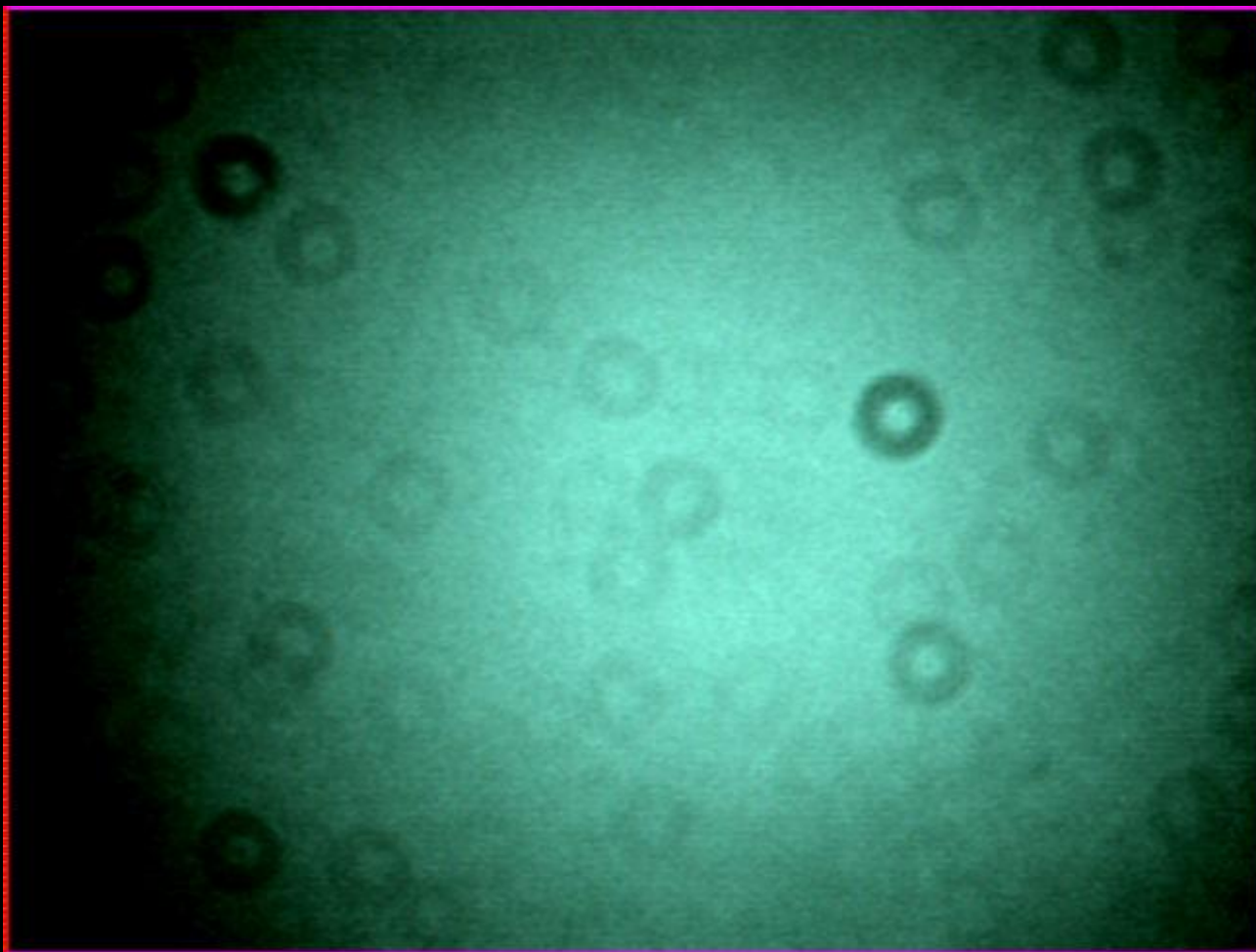
Dark Frame



Vignetting, Dust and QE

- A Flat Frame is an exposure of a completely blank background such as an illuminated screen or twilight sky.
- The Flat Frame is divided-out of the raw image to eliminate optical defects.
- QE differences are also reduced.

Flat Frame



Statistical Light Accumulation

- The only way to collect enough light to reduce the statistical noise is longer exposure times.
- Film exposures often lasted an hour or more.
- Digital images can be added together using a computer.

Read Out Noise Dominates



Longer Exposures = Smoother Image



First the Raw Images



Stacked Images



After Dark Subtraction



Stacked Images



After Flat Fielding



Stacked Images



Adjust Color and Brightness



Some Links

- www.pewaukeeastro.com (The Harken Observatory & Club site)
- www.astronomy.com (Astronomy Magazine)
- www.skyandtelescope.com (Sky & Telescope)