Experiments in Pixel Astronomy

TVS 2001

Gert Gottschalk

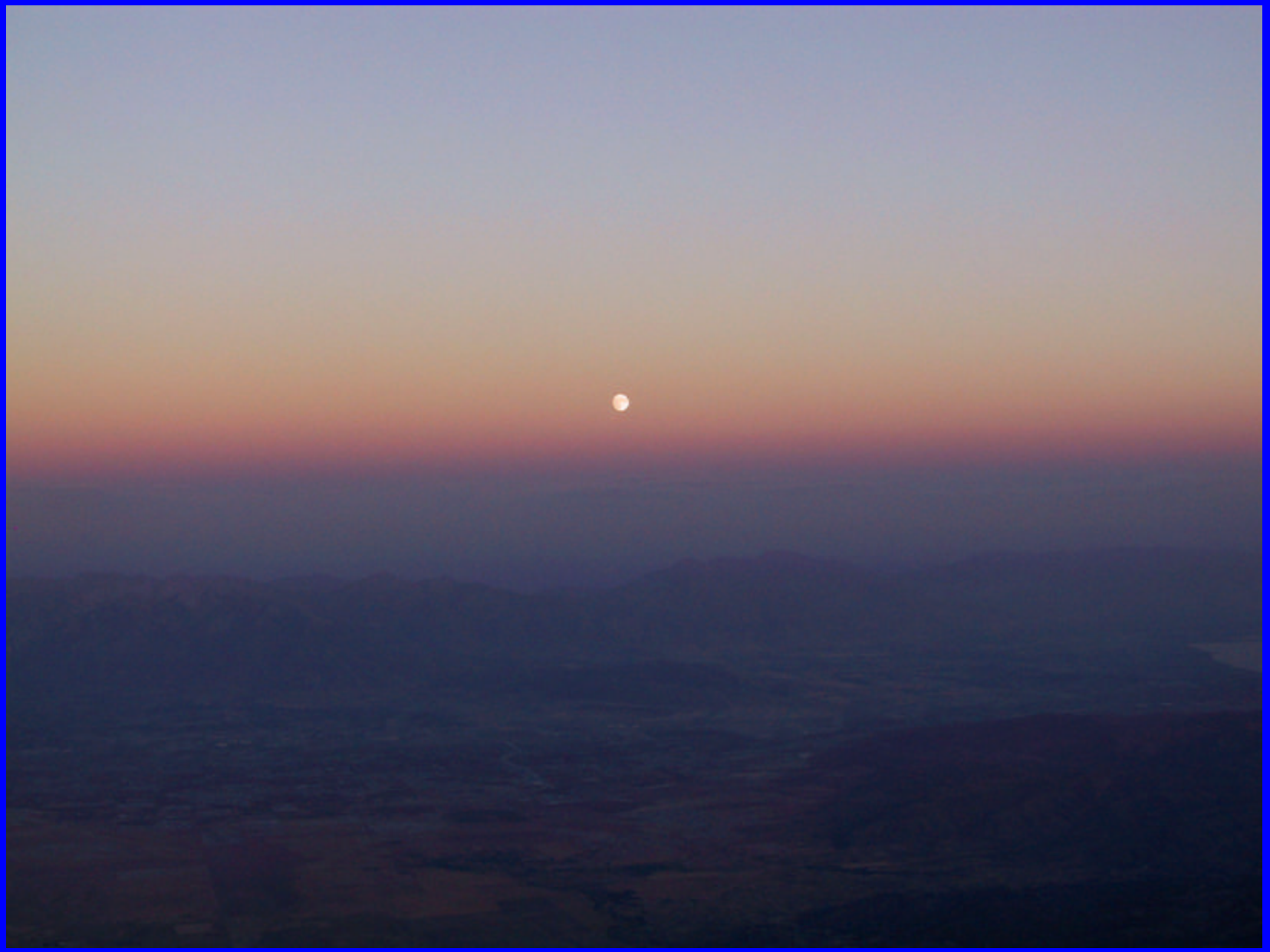
- Digital Cameras
  - Introduction
  - Hand held wide angle scenes
  - Hand held afocal projection
  - 3rd party afocal adapter
- Dedicated CCD Cameras
  - Introduction
  - Calibration and processing
  - Long exposures

- Digital Cameras Introduction
  - Today's models >3million Pixcels. Typical image sizes
    - 2048 x 1536
    - 1024 x 768
    - 640 x 480
  - Selection for image compression
    - None (Raw / Tiff)
    - Compressed (JPEG with different levels of lossiness)
  - Prefer models with more manual controls

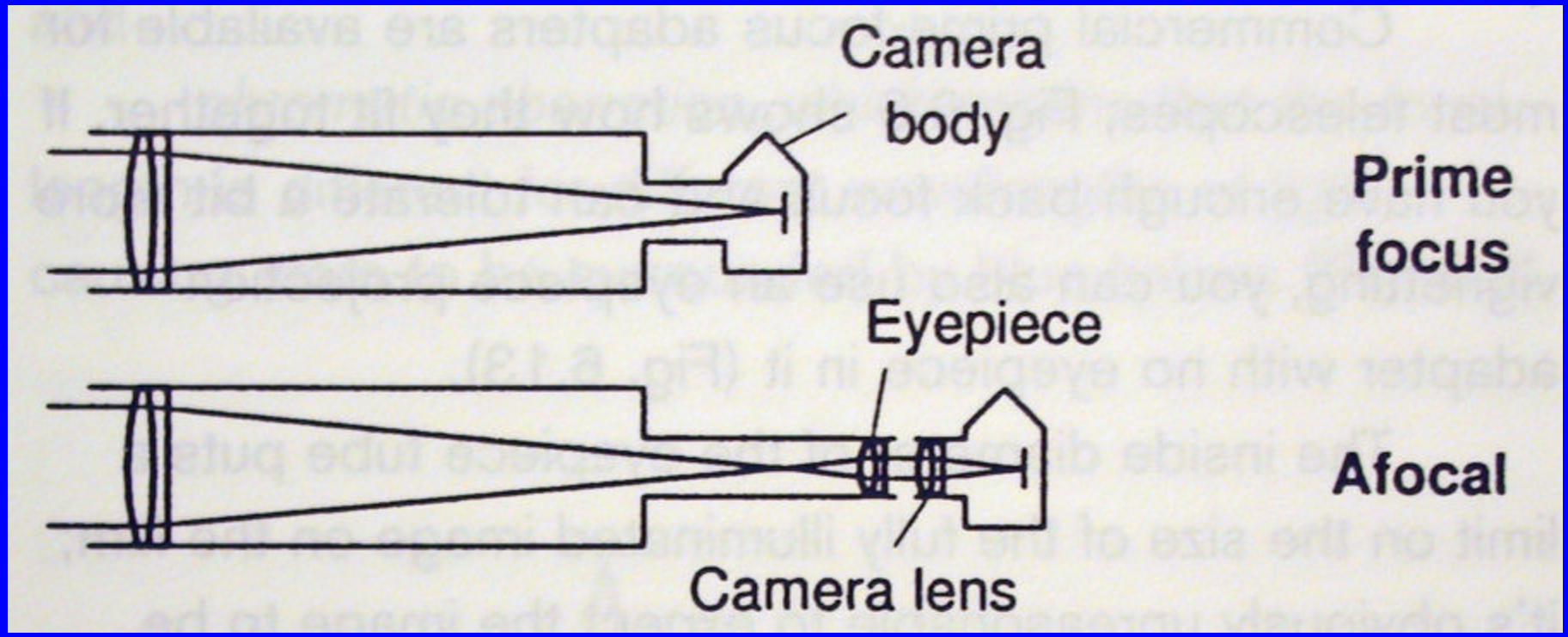
    (don't need long exposures, only used for sun, moon, planets)
  - Check for telescope adapter availability (Lens threads)
  - Models (Nikon, Canon, Olympus …)

Scenic wide angle shots (Sunset with moon)

Earth shadow with moon



Afocal projection (How it works)



Hand held afocal projection

Mars, June 10 2001 23:50PDT

13” f4 with 4.8mm Nagler eyepiece

Mars, June 14 2001 00:20PDT

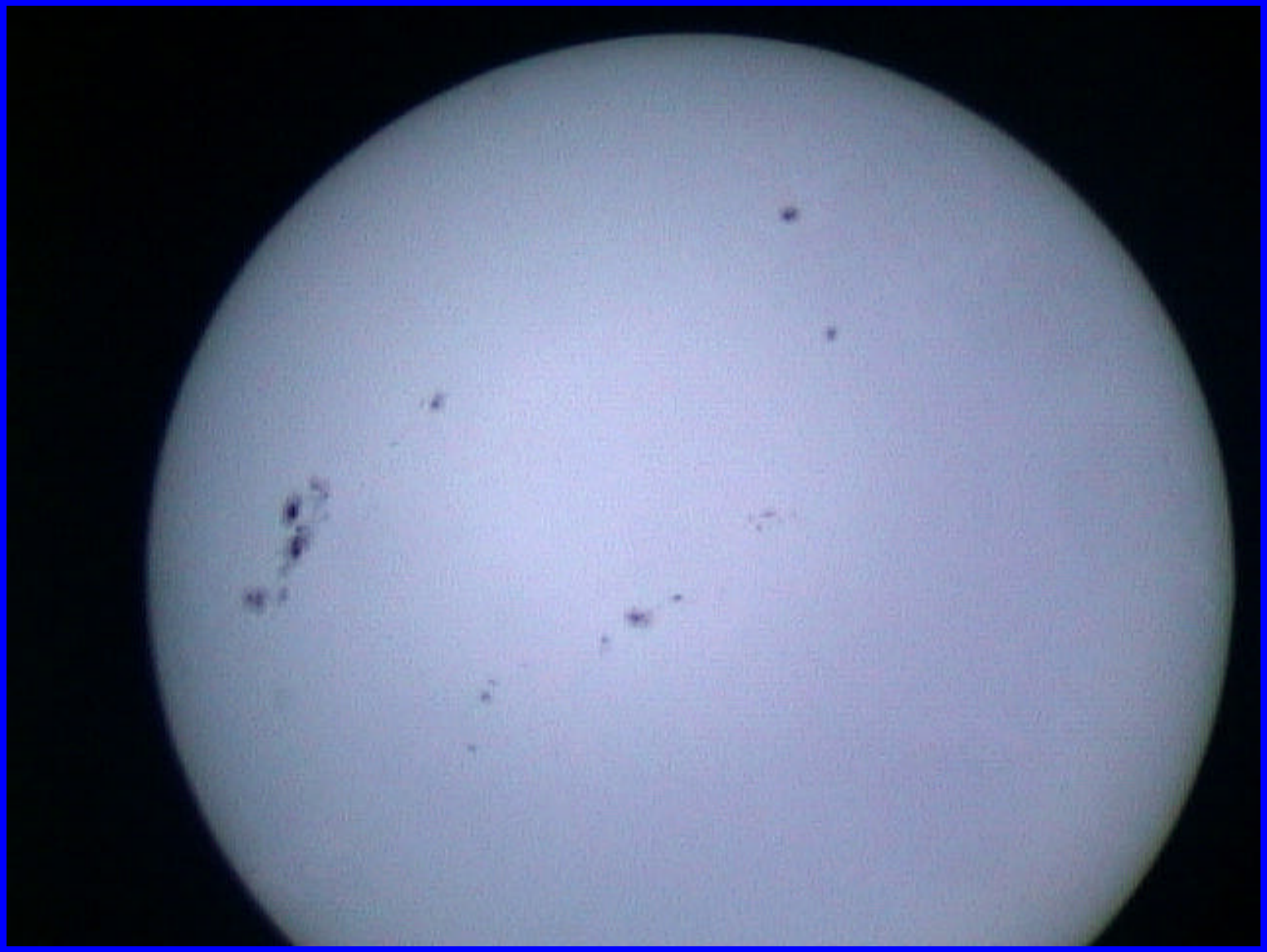
13” f4 with 4.8mm Nagler eyepiece

Mars, June 17 2001 23:40PDT

13” f4 with 4.8mm Nagler eyepiece + 2.5x barlow

Hand held afocal projection

Sun spots, March 31 2001, 80mm APO refractor



Digital Camera with afocal adapter

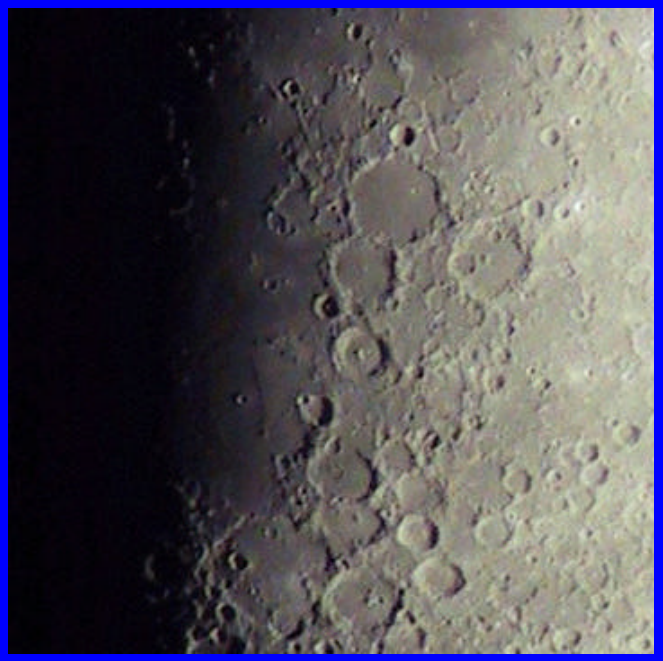
Same optics as hand held but solid adapter provides coupling between telescope/eyepiece and camera.

Adapters available for popular cameras from various sources:

- Scopetronix
- Vixen
- Williams Optics
- Tele Vue

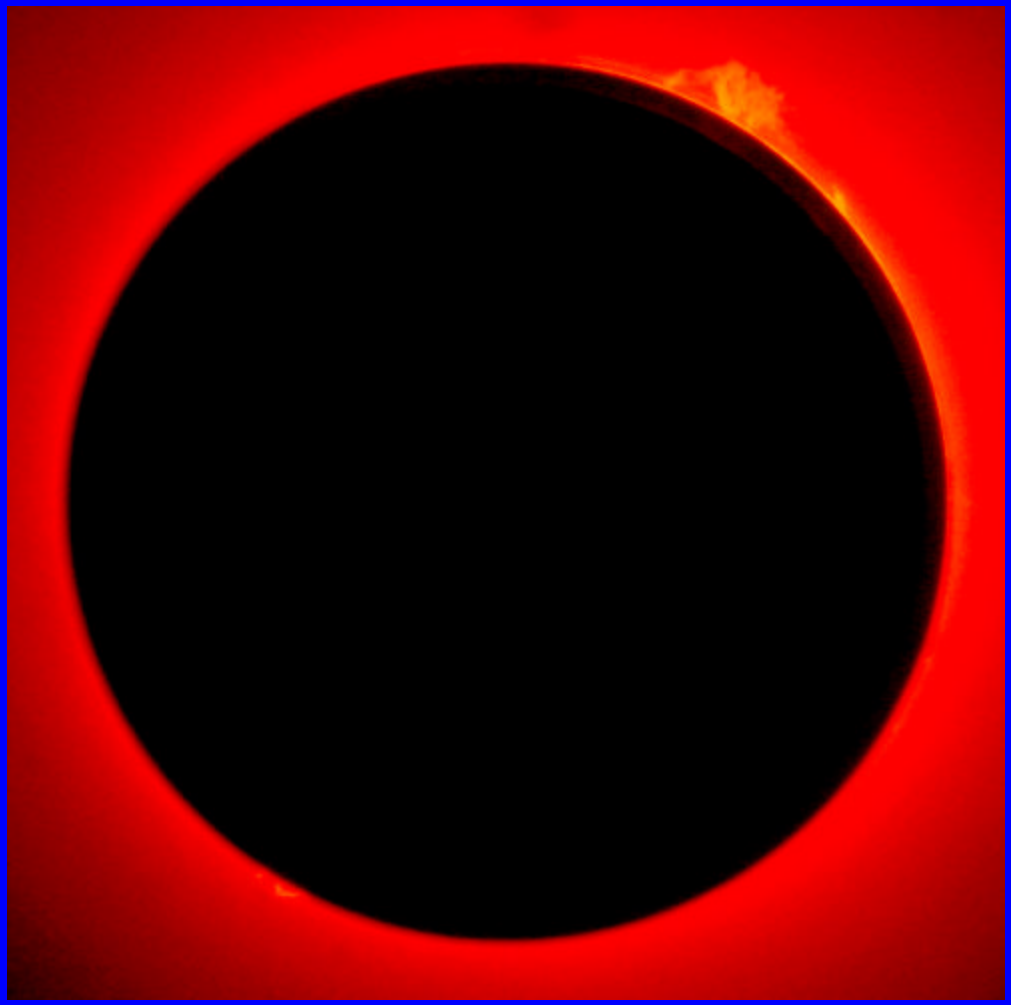
Afocal projection adatpter

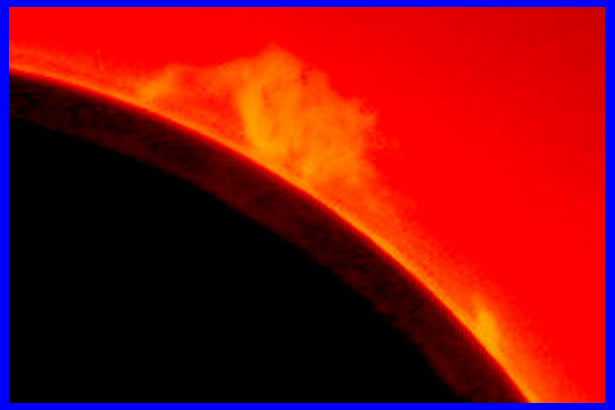
Moon Sept. 25 2001, 80mm APO refractor



Afocal projection adatpter

Solar prominences, October 9 2001, 80mm APO refractor with prominence viewer





Dedicated CCD Cameras

- Less pixcels than digital cameras (1 generation)
- Mostly B/W (few with RGB color filters)
- Exposure times 0.01sec … hours (possible by cooled silicon chip)
- Dedicated to scientific data processing
- Requires PC to operate (few stand alone models)
- 10 x price
- Mounted to telescope

CCD Cameras Manufacturer

- Santa Barbara Instruments (SBIG)
- Apogee Instruments
- Finger Lakes Instruments
- Starlight Express (UK)
- Cookbook (home brew)
- Many more made by amateurs in small volume

Cameras use CCD silicon chips from

- Kodak KAF 1602E (ST8)
- Thomson THX7899M (AP10)
- Texas Instruments (ST-237A)
- Marconi CCD47-10 (AP47)
- SiTE SI-003A (AP8)
- Sony ICX084AL (Starlight HX5)
- Tektronics TK-1024

CCD Image formation and calibration

Light striking the silicon creates a small electric charge in an array cell

The charge is accumulated and stored in the cell during the exposure

The amount of charge depends on

- the amount of light that hit the silicon
- the sensitivity of the array cell
- spurious charge generated in the cell without light

In the read out process the charge is transferred to the edge of the array and sequentially passed out of the silicon chip

The signal is amplified and converted into digital format

The digital image is displayed on a computer screen

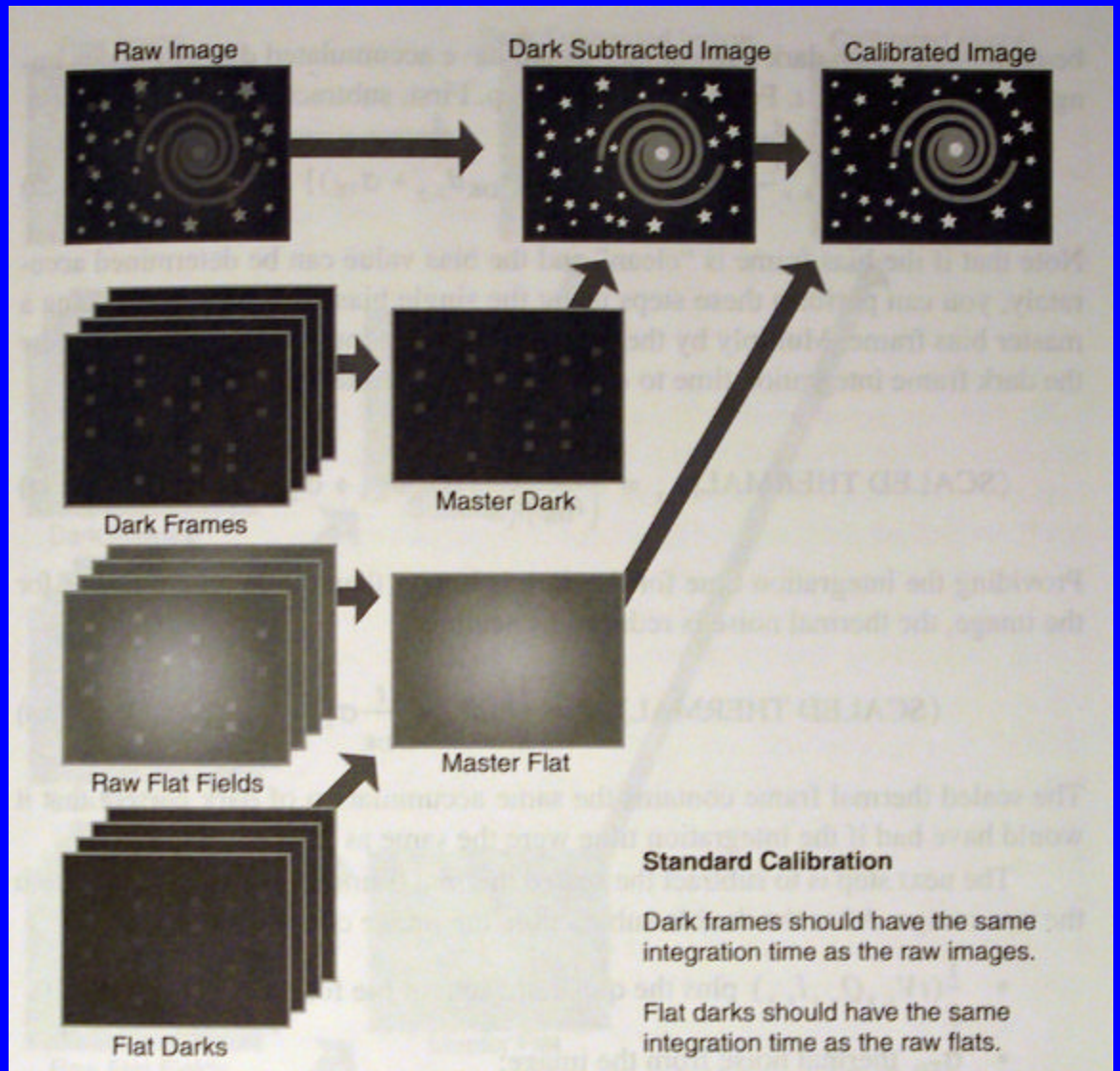
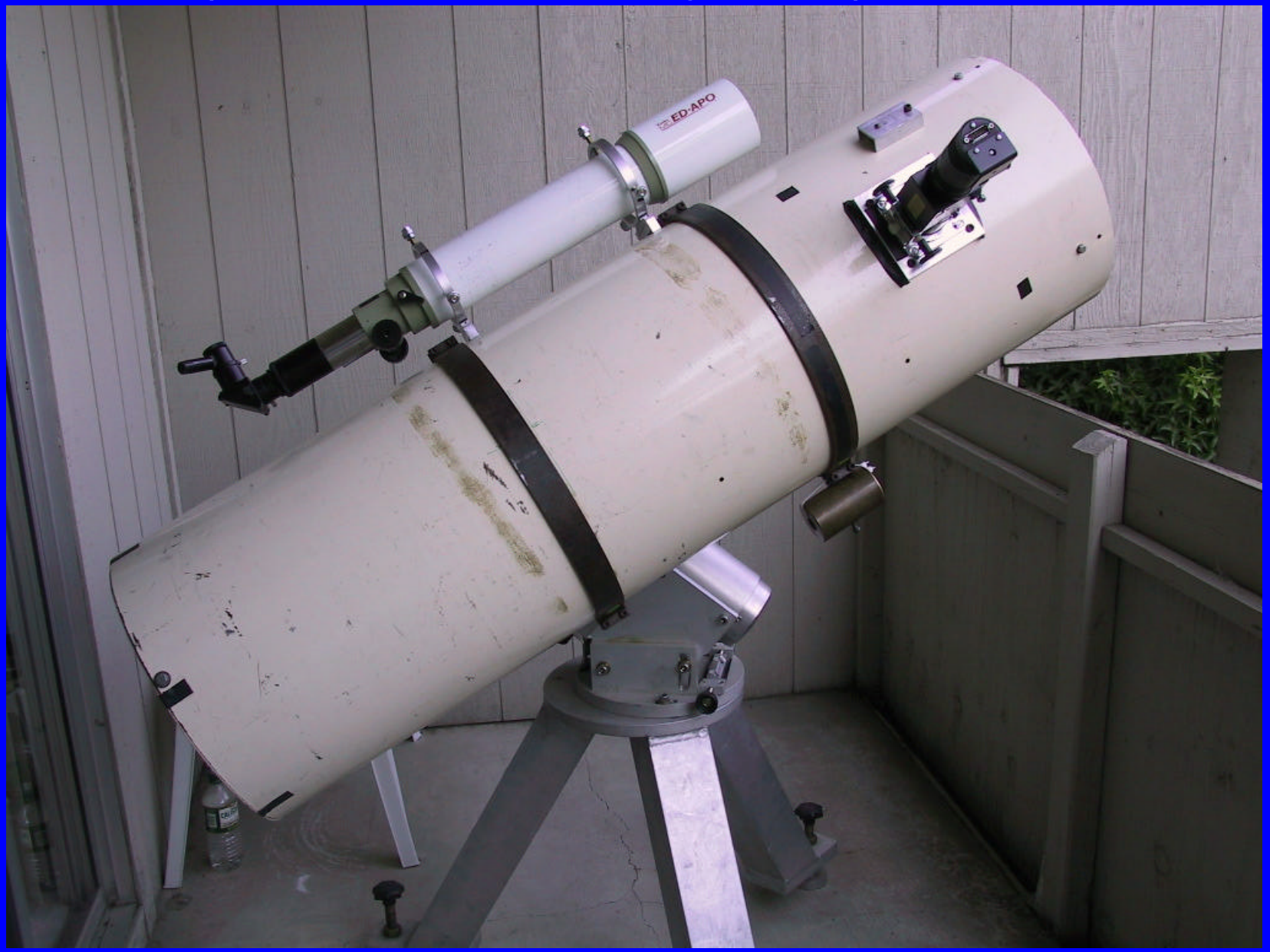


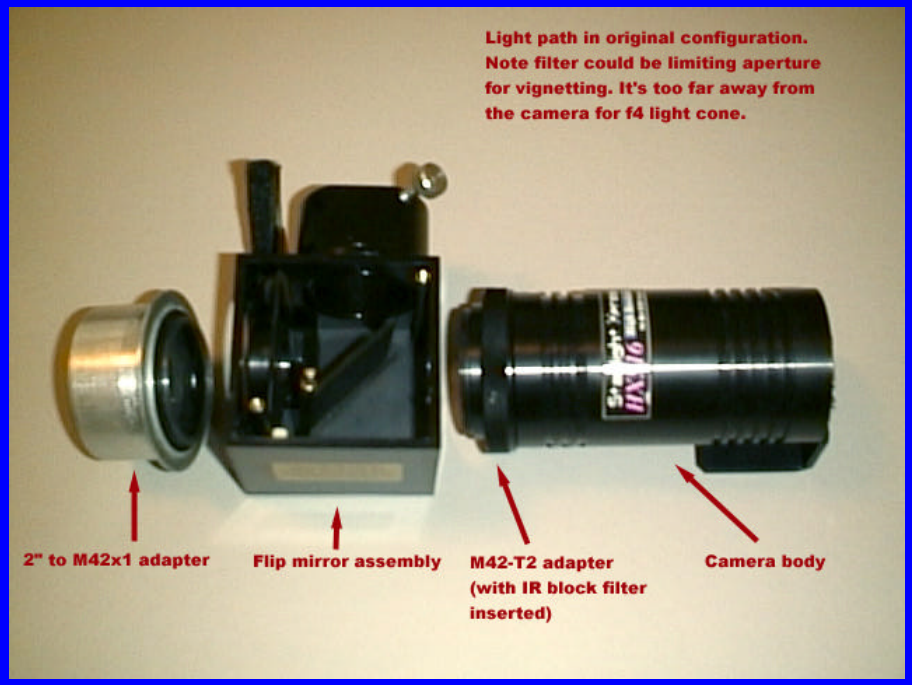
Figure 4.19 Although standard calibration requires multiple darks, flats, and flat darks, it produces an image corrected for bias, dark current, and vignetting. Dark frames must have the same integration time as that of your images. Standard calibration does an excellent job for most types of routine CCD imaging.

13 Telescope with CCD Camera and guide scope

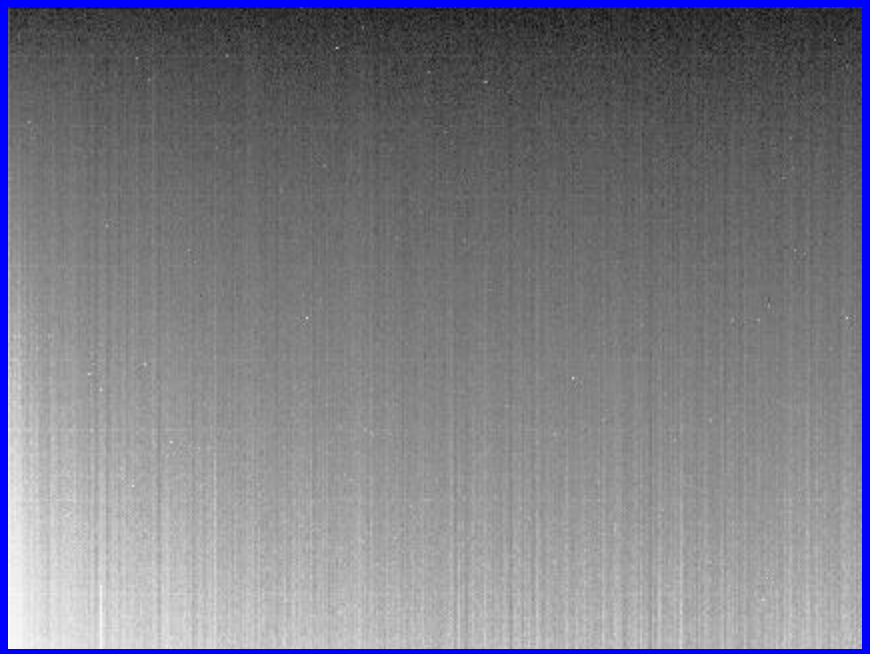


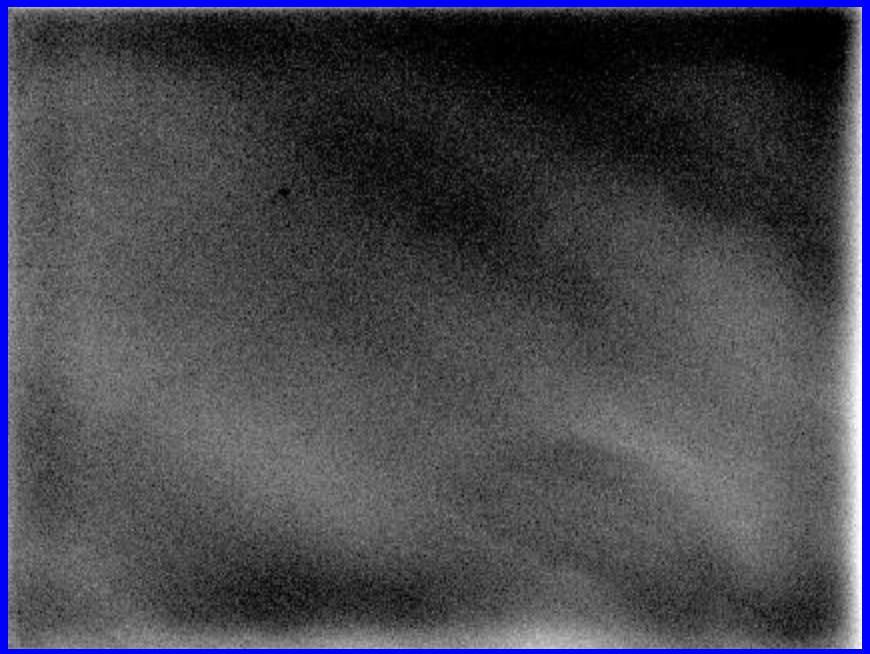
Flip mirror with slot for color filter (poor man's filter wheel)

Modification to flip mirror to avoid vignetting



Sample processing sequence (dark subtract, divide by flat)





NGC 7479 (average of 10 exposures)

M16

NGC 6930 group

NGC 6814

NGC 6978/7/6/5 (Galaxies down to 14.8mag)

CCD color imaging

Color images are composed of light in three basic colors (red, green, blue)

Three images takes in these colors through filter can be combined into a color image

An RGB color image can be combined with a B/W image to add ‘structure’ information. This is an LRGB image

Calibration flat images have to be taken for each color channel

NGC 6926 LRGB image 13.2mag (total >3hrs exposure)

Future work

- Solar and planetary images with digital camera
- Improve CCD calibration
- Image nicely structured galaxies (in LRGB)
- Save $$$$ for bigger / better CCD