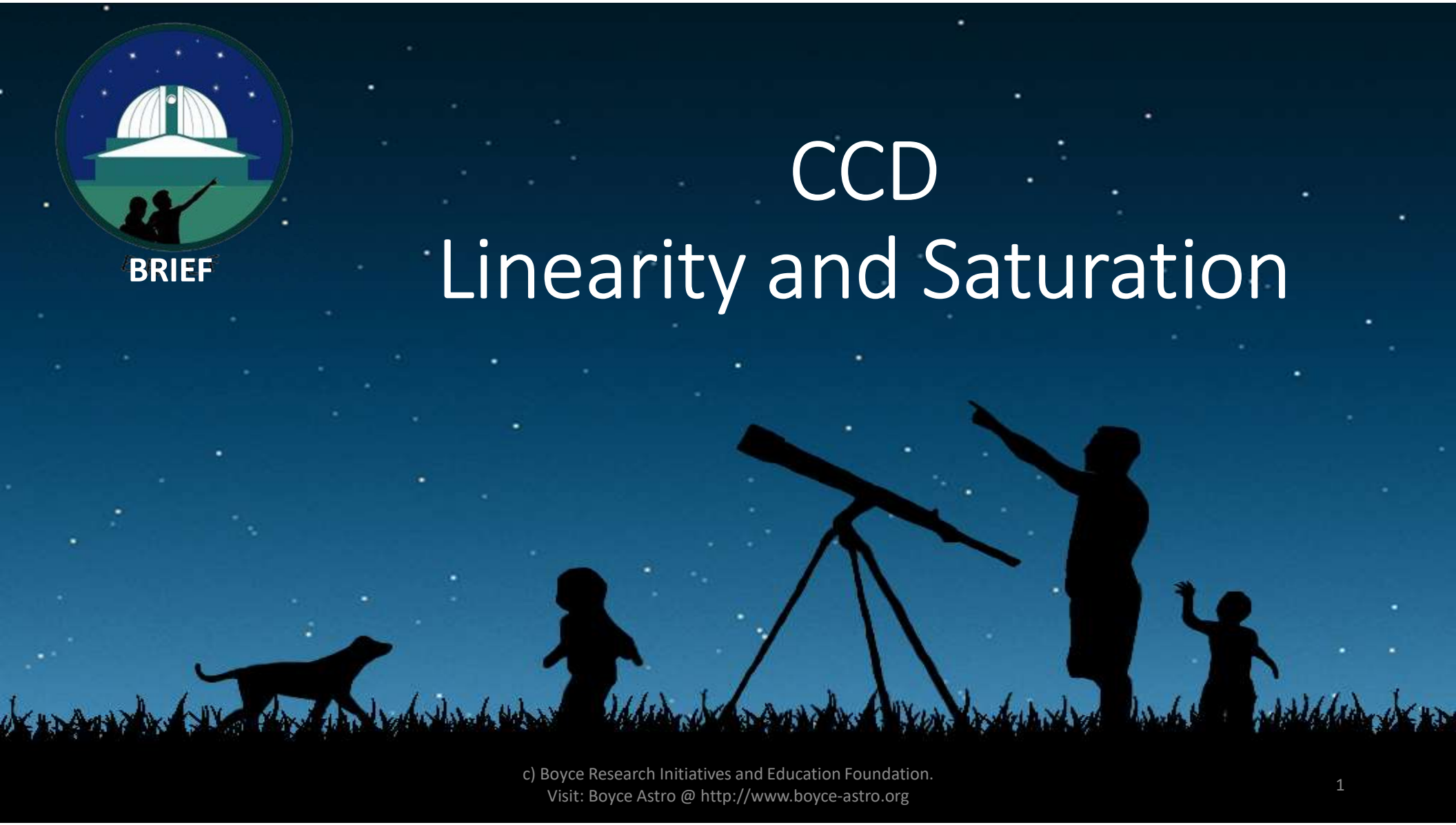
BRIEF

CCD
Linearity and Saturation



Overview

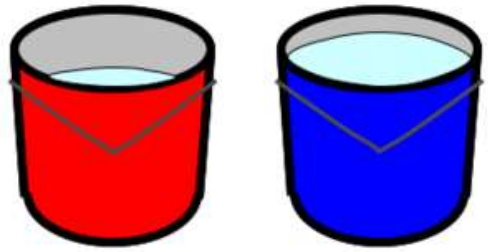
Saturation and Linearity are closely related in CCD imaging and need to be managed.

A CCD pixel begins an image essentially empty. As the photons are collected, the pixel well begins to fill.

At some point, the pixel well will become saturated and unable to hold more photons.

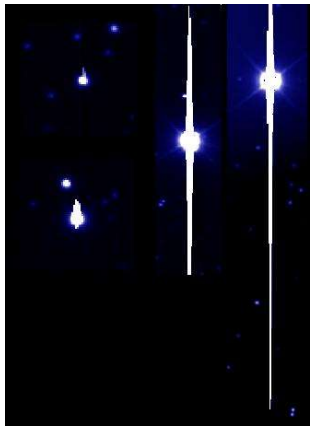
Prior to becoming saturated, the response of the CCD chip will change from Linear to non-linear.

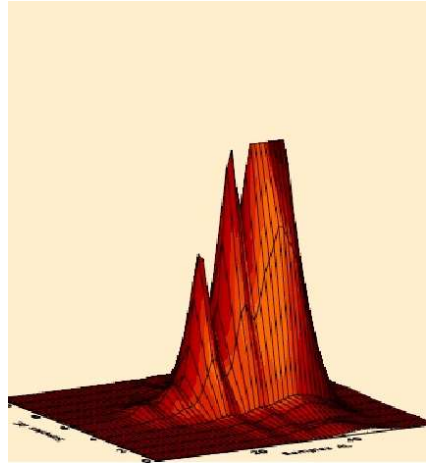
Both of these can have a negative impact on a science image and must be managed.



Saturation Overview

Saturation is the point at which a pixel cannot receive any additional photons. It has reached its Full Well Depth, or in other words, the bucket is full.





Remember from the CCD Overview, that the chip is comprised of individual pixels. These pixels can hold a finite amount of photons. This maximum is the Saturation Level.

When pixels are saturated, their electrons “bleed” along columns into nearby pixels: Blooming.

As a CCD pixel nears saturation, the response of the pixel becomes non-linear

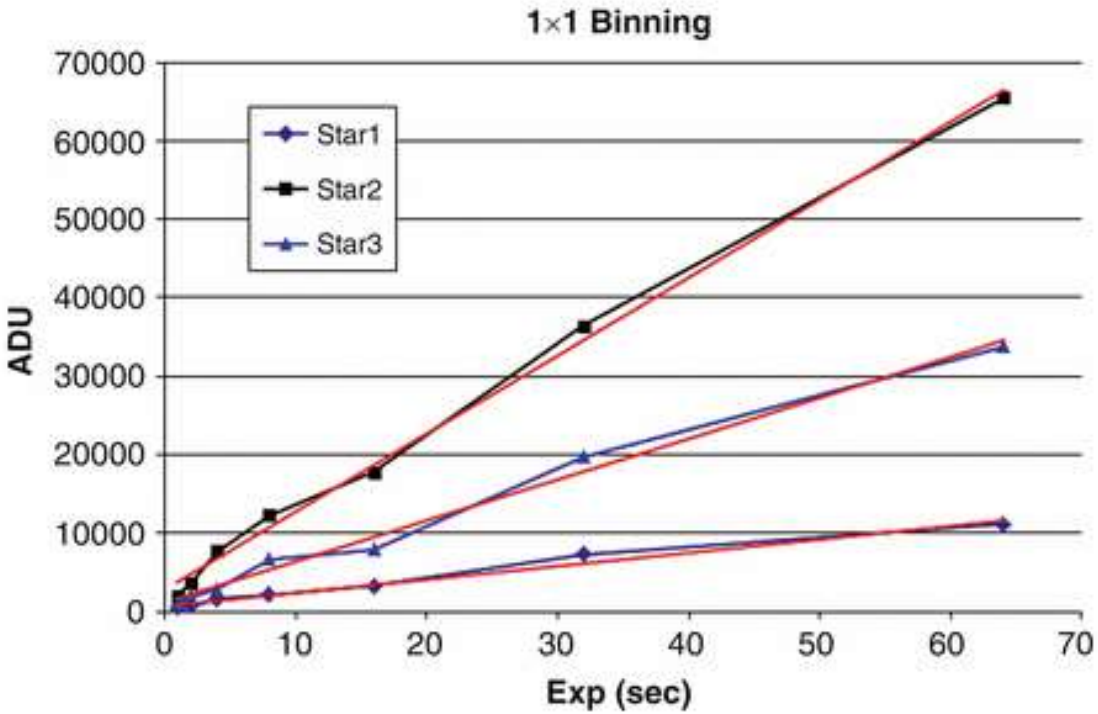
Linearity

Most CCD detectors have a point where the pixels become saturated and stop receiving photons.

At this point, any additional photons will not be captured.

Since photometric data relies on all photons, the data will be unusable.

Therefore, saturation must be avoided when performing Photometry. HOWEVER, saturation is acceptable when performing Astrometry or imaging for Pretty Pictures.



Source: Brian D. Warner

Full Well Depth and Linearity

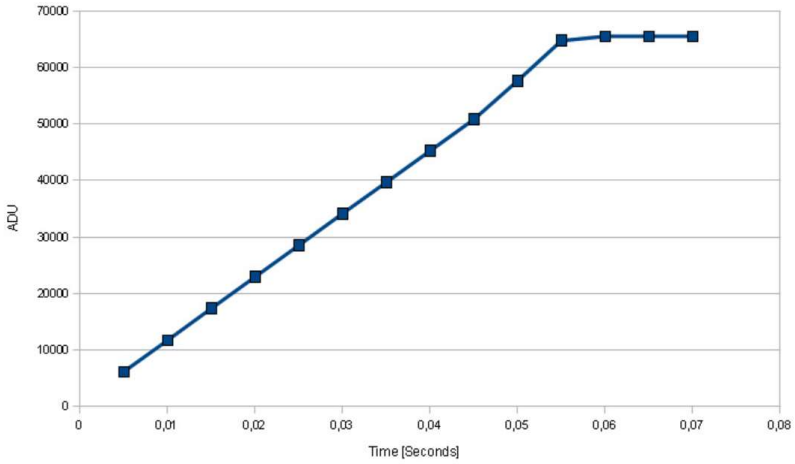
Full Well Depth: maximum number of photoelectrons an individual pixel can hold.

A main advantage of CCD cameras is that their sensitivity is linear.

Thus, the number of photons collected for a particular object will have a linear relation to other objects on the same chip.

If one object is twice as bright, it will collect twice as many photons as the other.

This is good……..to a point. Once a pixel approaches a certain number of photons, the response will become non-linear. At this point, data is being lost and the image has no value. Where this occurs is particular to each photographic system.

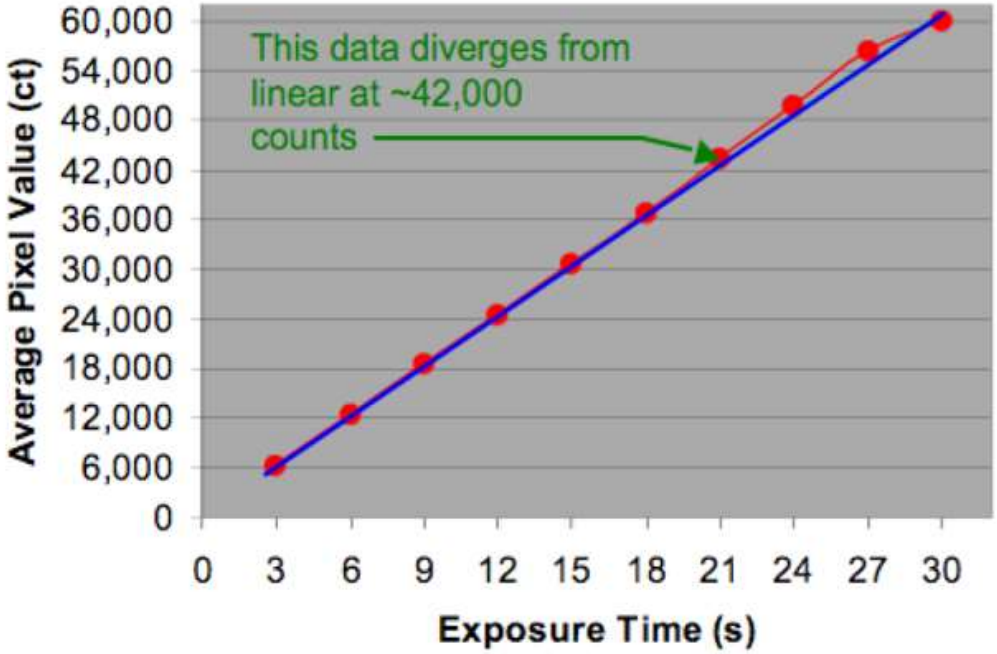


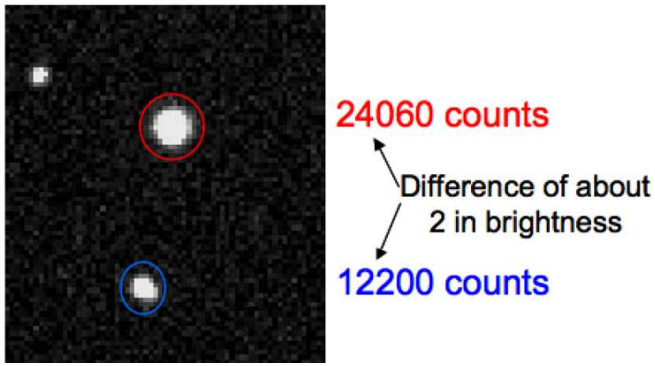
Saturation Overview

The means of controlling Saturation is Exposure Time.

Exposure time will vary based on the brightness of the object being measured and the quantum efficiency of your CCD.

However, if your target object is dim, over-saturation of other non-target stars will be ok since the science data desired would be unaffected.



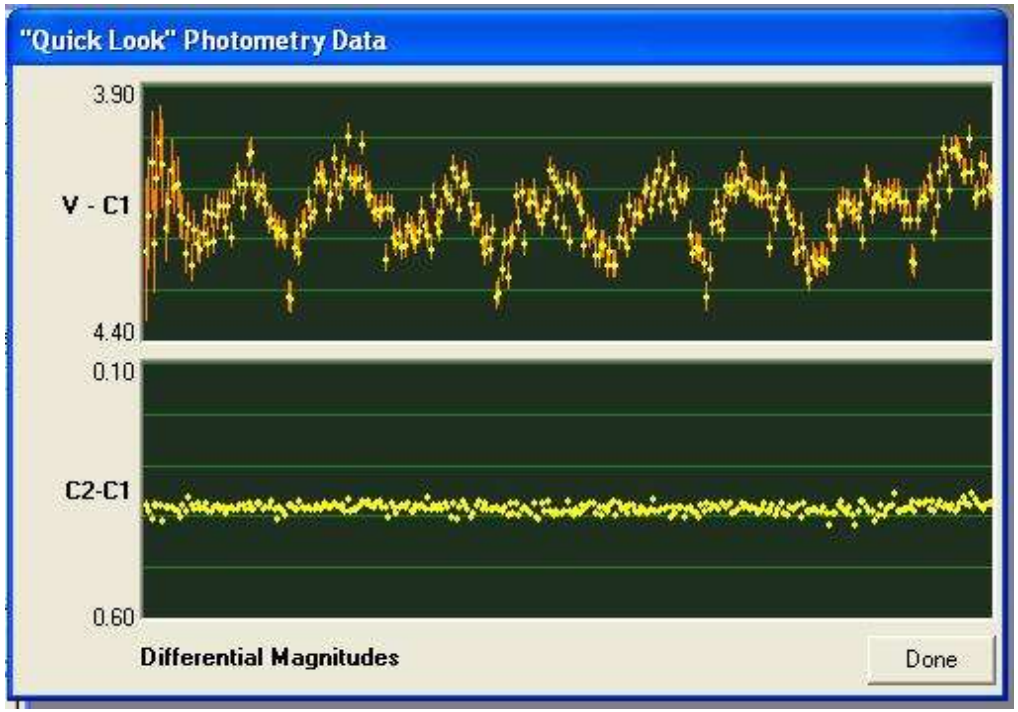


CCD Linearity

When conducting Photometry, the goal is to have a long enough exposure to have a good SNR yet, not so long that the CCD chip goes non-linear.

When this is accomplished, you will get a result similar to this. The image on the bottom is a Comparison Star that is showing no flux variability. On the top is the variable star measured relative to the Comparison Star.

If the exposure time caused non-linearity, this data would not be truly representative of the variable star or its Comparison Star.



Summary

Saturation and Linearity are common to all CCD cameras. Both of these items must be managed in scientific imaging.

Before imaging, know the limitations and characteristics of your system.

If either of these points are reached during scientific imaging, that image is not useful, and should be disregarded.

Questions?