Sizing Up the Universe

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Some Things to Discuss...

- Textbook
- Course Expectations
- Grading
- Student Background
- Homework
- Projects?
- Nighttime imaging?
- Software
How I Got Interested
Camera on a Tripod
Telescope Images
1. Mount

2. Camera
   Computer
   Software

3. Telescope
Move equipment outside.
Ready To Go...
Lecture 1 Got to Here
Our Solar System
SuperMoon...

Minimoon
Distance = 399,686 km = 1.333 ls
22:09 EST, Feb 3, 2015

Supermoon
Distance = 353,615 km = 1.180 ls
23:30 EDT, Aug 9, 2014
APOLLO at Apache Point Observatory

2.3 watt laser
2 km diameter Moon patch
10^-10 sec pulse
3.5m aperture
Quantum Efficiency (QE) = 1

Vanderbei:
5mW laser
200 km diameter
10 sec pulse
0.25m aperture
QE = 0.5

\[
\begin{align*}
2 \text{ photons} & \quad \Rightarrow \quad V \\
\Rightarrow \quad V \\
\Rightarrow \quad 11.2 \times 10^{-1} & \quad = \quad 112 \text{ photons}
\end{align*}
\]
Lunar Eclipse (2010 Dec. 21)
Jupiter and Saturn
Crescent Venus (Daytime!)
Venus Transit 2012

Distance to Sun = 8.3 light-minutes,
Distance to Venus = 2.4 light-minutes
Lecture 2 Got to Here
Jupiter in the Daytime
Disclaimer:
The Pictures Are Better Than The “Visual” View

Distance to Jupiter 41 light-minutes
Comets Come and Go...
Lecture 3 Got to Here
Venturing Beyond the Solar System
Barnard’s Star
Barnard’s Star
Barnard’s Star
Barnard’s Star
The measured parallax is 0.5478 arcsecs. Corresponds to a distance of 5.97 lightyears.
Nebulae In Our Home Galaxy (the Milky Way)

Diameter: 180,000 light-years
Lecture 4 Got to Here
Dumbbell Nebula
Lecture 5 Got to Here
Orion Nebula—Close Up
Starlight Express SXV-H9 on 10” RC at f/9
Hα (13 nm bandwidth)

06:20–06:22 EDT
6 × 5 seconds

SUNRISE at 06:23 EDT local time
Orion in the Daytime

Starlight Express SXV-H9 on 10′′

$H_\alpha$ (13 nm bandwidth)

06:22–06:36 EDT

$33 \times 1$ seconds

SUNRISE at 06:23 EDT local time
Orion in the Daytime

Sept. 9, 2007

06:36–06:47 EDT
118 × 0.2 seconds

SUNRISE at 06:23 EDT local time
Orion in the Daytime

06:47–06:55 EDT
110 × 0.2 seconds

SUNRISE at 06:23 EDT local time
Orion in the Daytime

06:55–07:03 EDT
110 × 0.1 seconds

SUNRISE at 06:23 EDT local time
Back to Nighttime
Rosette Nebula—New Camera
Driveway vs. Mt. Palomar

Driveway

Mt. Palomar (48-inch)
Driveway vs. Mt. Palomar – Denoised

Driveway

Mt. Palomar (48-inch)
Lecture 6 Got to Here
Eagle Nebula
Ring Nebula
Owl Nebula
Eskimo Nebula
Crescent Nebula
Crescent Nebula
Soap Bubble Nebula
Lecture 7 Got to Here
Clusters Clustered Around the Milky Way
Galaxies Beyond Our Milky Way
M82 and M81

Distance: 11.7 million light-years
Whirlpool Galaxy

May 9, 2005
Sombrero Galaxy
Lecture 8 Got to Here
Deerlick Galaxy Cluster
Why Astrophotography?

Long Exposures, Permanent Record, Digital Enhancement, Light Pollution!

Visual Experience

Long Exposure

Light Pollution Subtracted
Old Astronomical CCD camera

- StarlightXpress SXV-H9
- Pixel size: 6.45 × 6.45 microns
- Pixels: 1392 x 1040
- Quant. Eff.: ∼ 65%
- Readout Noise: ∼ 7 electrons
- Cooling: ∼ 30°C below ambient
- Download: 3.5 seconds
- Weight: 350g
New Astronomical CMOS camera

- ZWO ASI2400MC-Pro
- Pixel size: 5.94 × 5.94 microns
- Pixels: 6072 x 4042
- Quant. Eff.: ∼ 80%
- Readout Noise: ∼ 1.1 electrons
- Cooling: ∼ 35°C below ambient
- Download: 0.125 seconds
- Weight: 1360g
Example

“Telescope”: 200mm f/3.5 Vivitar lens ($30)
Mount: Questar
Camera: Starlight Express SXV-H9
Filter: Dichroic Hα

Fundamental Principles

- *Focal length* determines *field of view*
- *F-ratio* determines *exposure time*

Total exposure time = 156 mins.
Field of view = $1.9° \times 2.5°$. 
Combatting Light Pollution

Narrow-Band Filters
L-Extreme Filter

Optolong L-eXtreme Filter

Transmittance %

Wavelength (nm)

Hg  HB OIII  Hg  Na  Na  He  SII