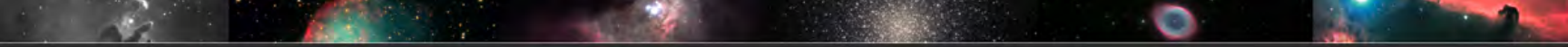


# Imaging the Universe: Is Anyone Else Out There

*Robert J. Vanderbei*

2013 February 20

Butler College Life Skills Seminar

http://www.princeton.edu/∼rvdb

I've Always Loved Photography

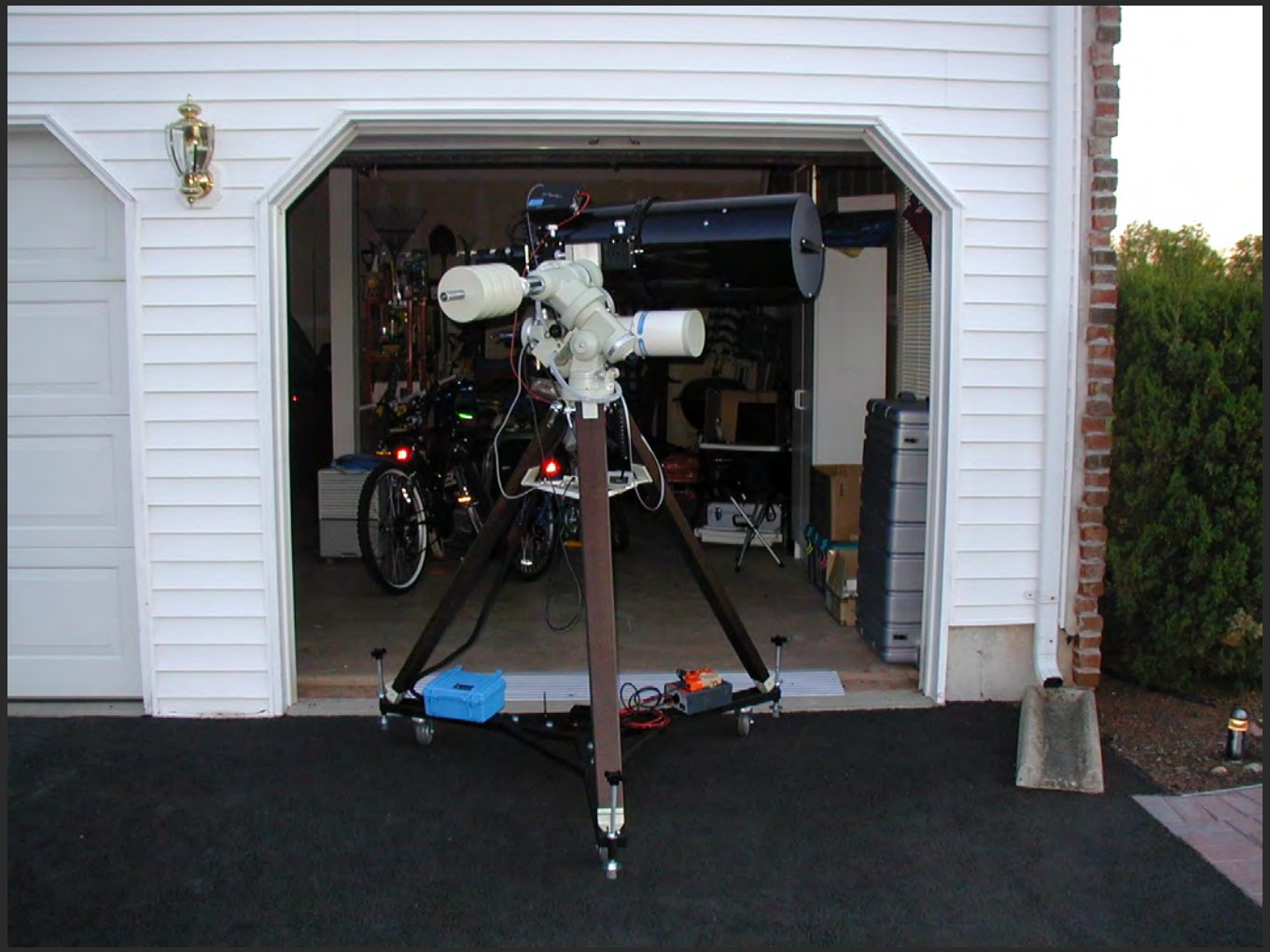
DSLR on a Tripod

# What Got Me Interested in Astrophotography

# Fancier Equipment

1. Mount
2. Camera
   Computer
   Software
3. Telescope (OTA)

# Move equipment outside.



# Ready To Go...

# Small and Portable Alternative...

# Our Solar System

# SuperMoon...


Daytime Moon

# Lunar Eclipse (2010 Dec. 21)

# Lunar Eclipse Montage

# Jupiter and Saturn

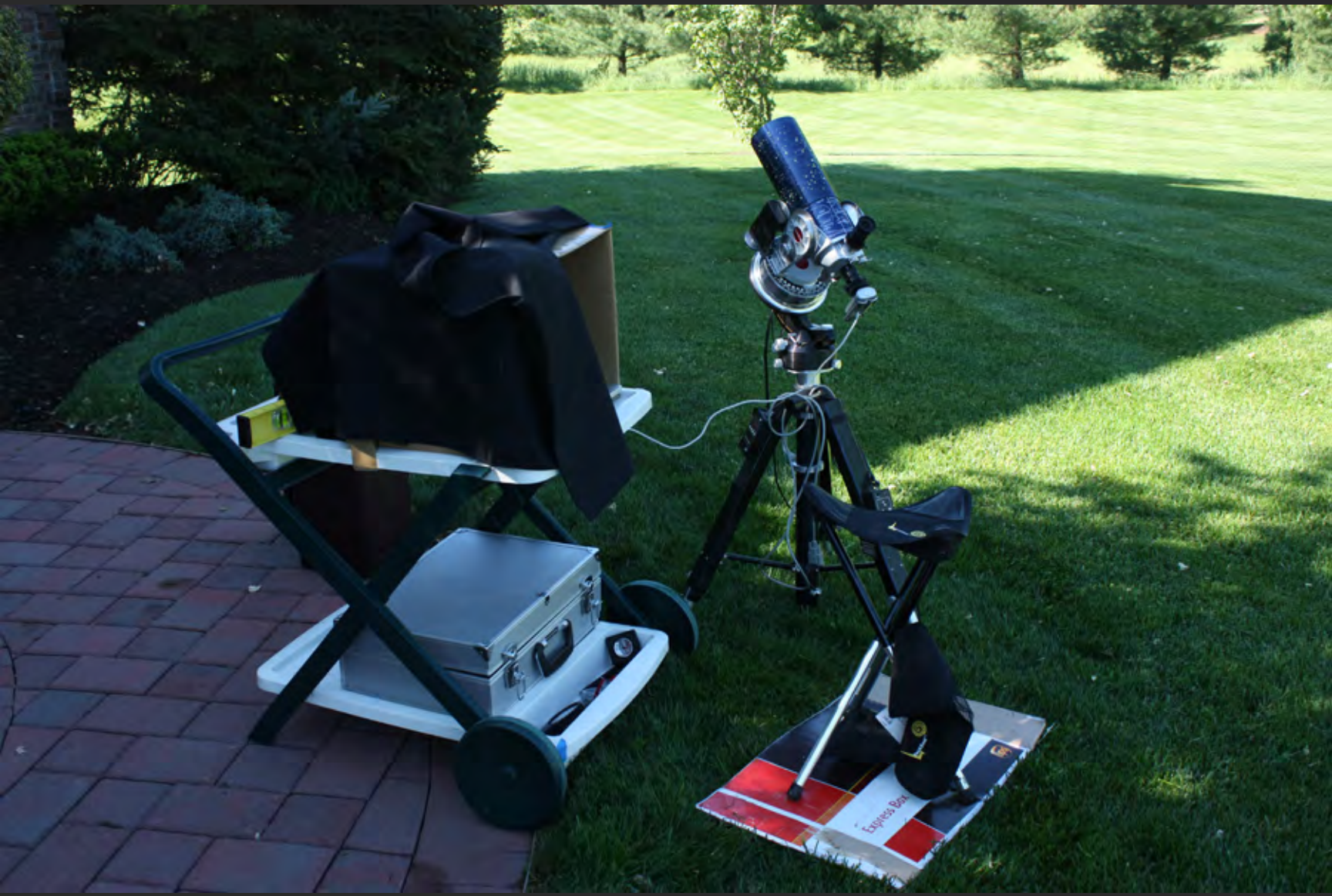
# Crescent Venus (Daytime!)

# Venus Approaches the Sun

# Venus Transit 2012

# Venus Transit Weather

# Jupiter in the Daytime


Express Box

**Disclaimer:**

The Pictures Are Better Than The “Visual” View

# Comets Come and Go...

# Lulin


17P-Holmes

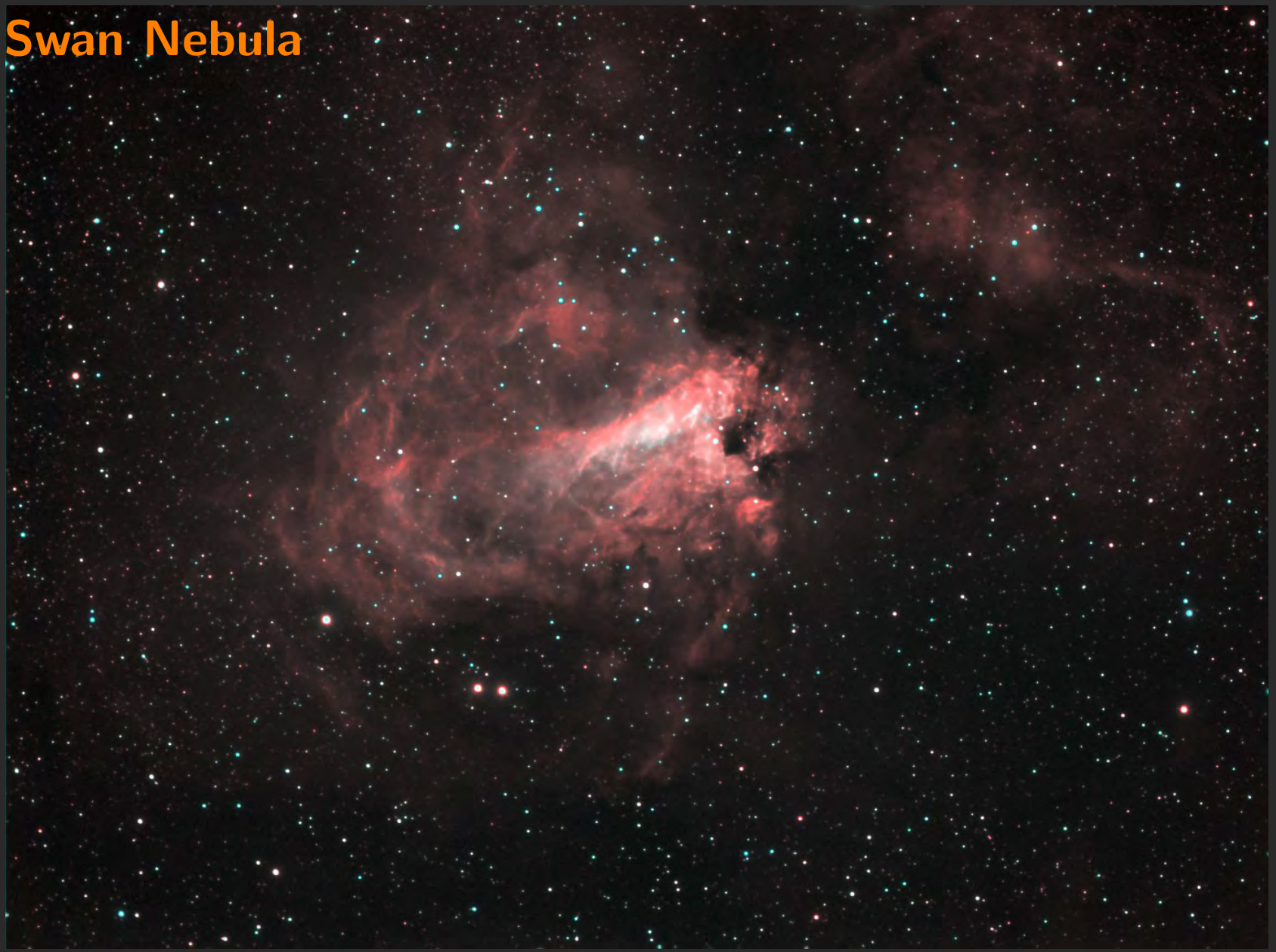

Garradd


Comet 103p Hartley and Double Cluster

# Nebulae In Our Home Galaxy (the Milky Way)

# Crab Nebula


Lagoon Nebula


Swan Nebula

# Dumbbell Nebula

# Orion Nebula

# Orion Nebula—Close Up

# Orion Nebula—Driveway Version

# Orion Nebula—Hubble Space Telescope

# Orion in the Daytime

Sep 9, 2007

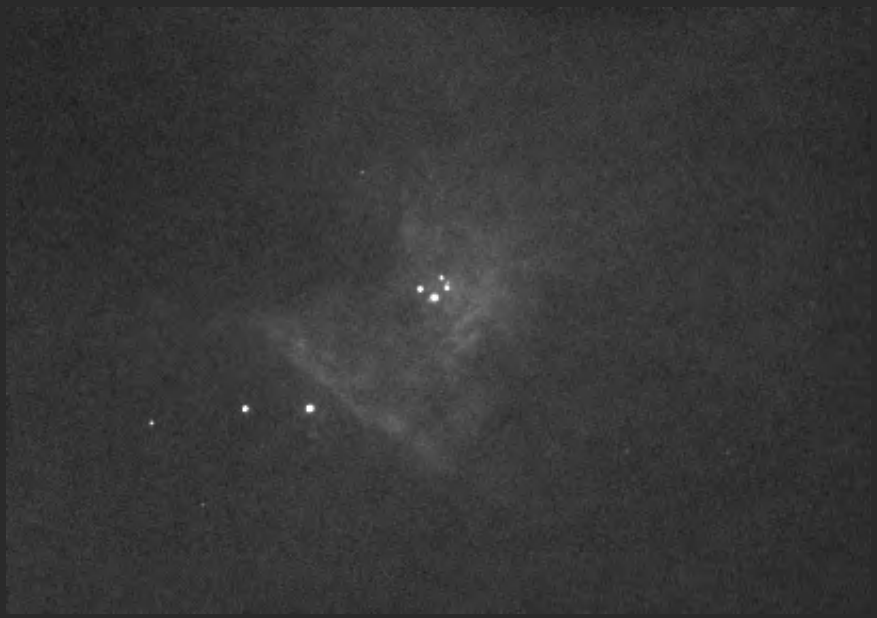
Starlight Express SXV-H9 on 10" RC at f/9
H$\alpha$ (13 nm bandwidth)

06:20–06:22 EDT
$6 \times 5$ seconds

SUNRISE at 06:23 EDT local time

06:22–06:36 EDT

$33 \times 1$ seconds



SUNRISE at 06:23 EDT local time

06:36–06:47 EDT

$118 \times 0.2$ seconds

SUNRISE at 06:23 EDT local time

06:47–06:55 EDT

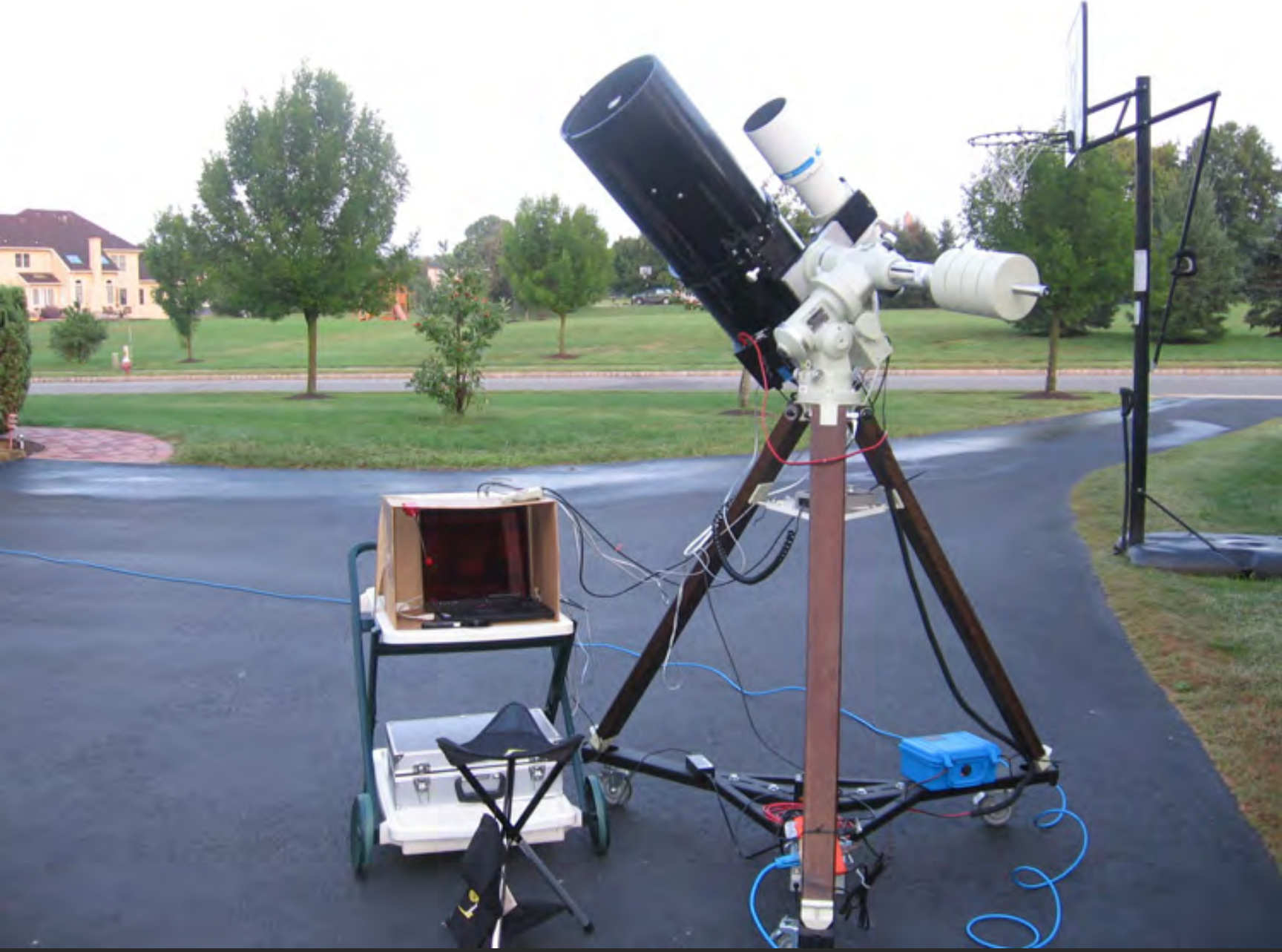
$110 \times 0.2$ seconds

SUNRISE at 06:23 EDT local time

06:55–07:03 EDT

$110 \times 0.1$ seconds

SUNRISE at 06:23 EDT local time



# Back to Nighttime

# Running Man Nebula


Rosette Nebula

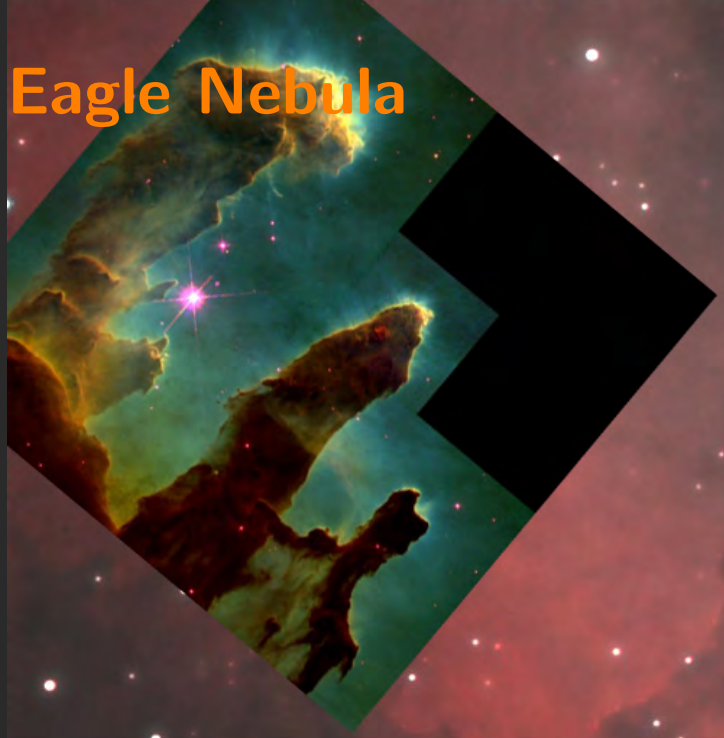
# Rosette Nebula—Widefield

# Rosette Nebula—Driveway vs. Mt. Palomar

Driveway

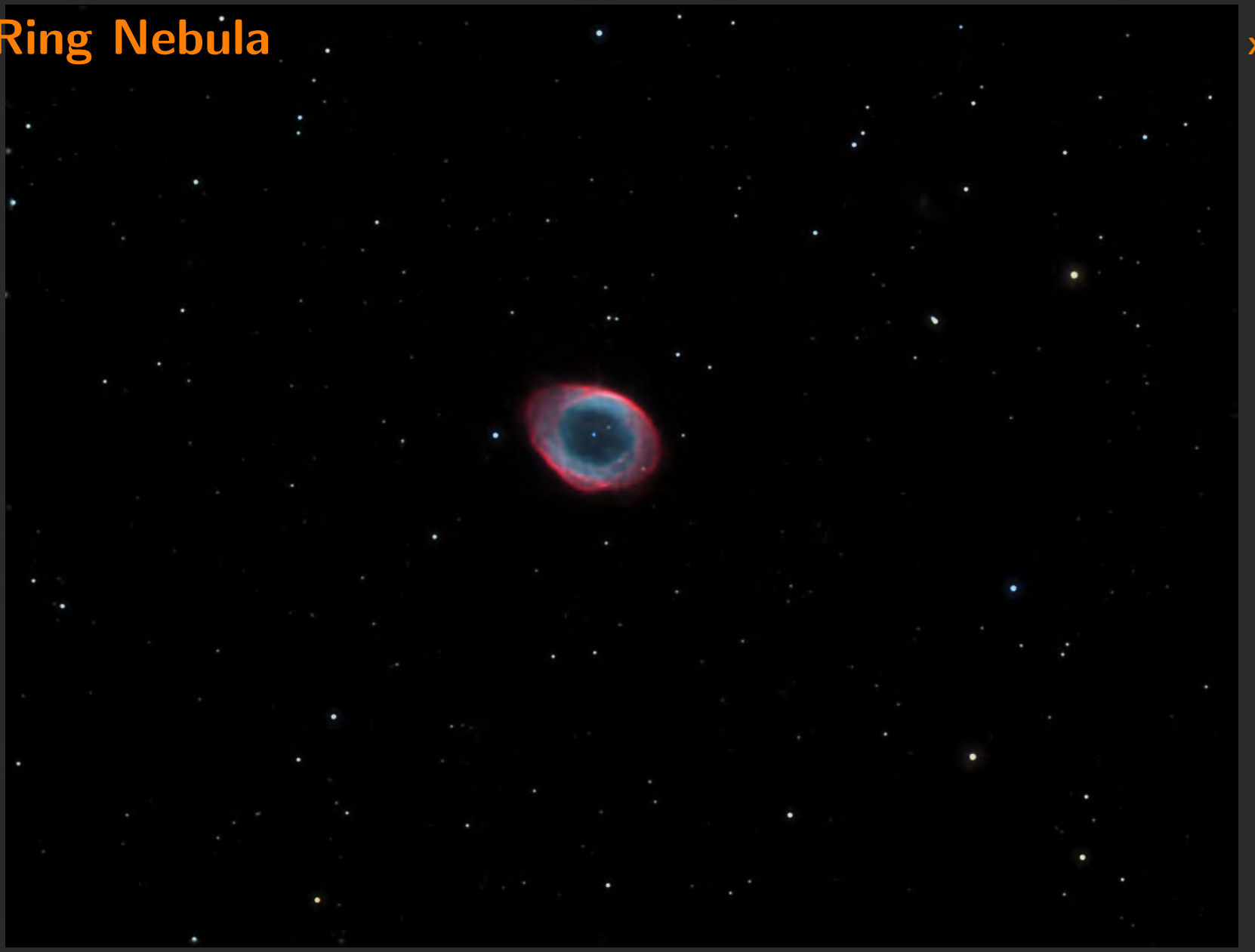
Mt. Palomar (48-inch)

# Pleiades aka Subaru



Eagle Nebula

# Ring Nebula



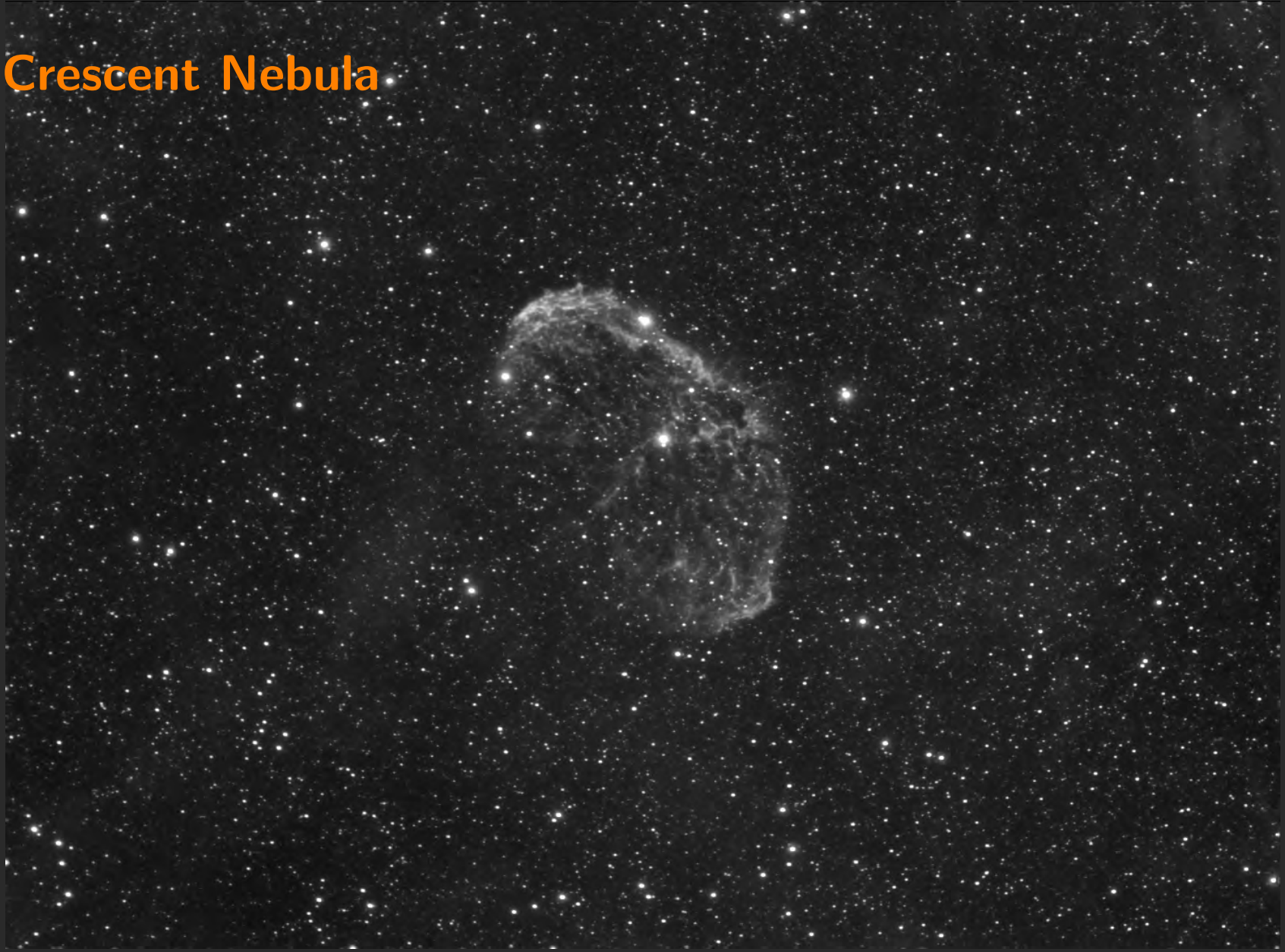

Little Dumbbell Nebula

# Owl Nebula


Pacman Nebula

# Eskimo Nebula

# Crescent Nebula



# Veil Nebula


Bubble Nebula

# Horsehead Nebula

# Clusters Clustered Around The Milky Way

# Hercules Globular Cluster

x


M15

# Galaxies Beyond Our Milky Way


M82 and M81
x

# Whirlpool Galaxy

# Whirlpool Galaxy—Supernova 2005cs

# Whirlpool Galaxy

# Whirlpool Galaxy—Supernova 2011dh

# Sombrero Galaxy

x

# NGC 4565

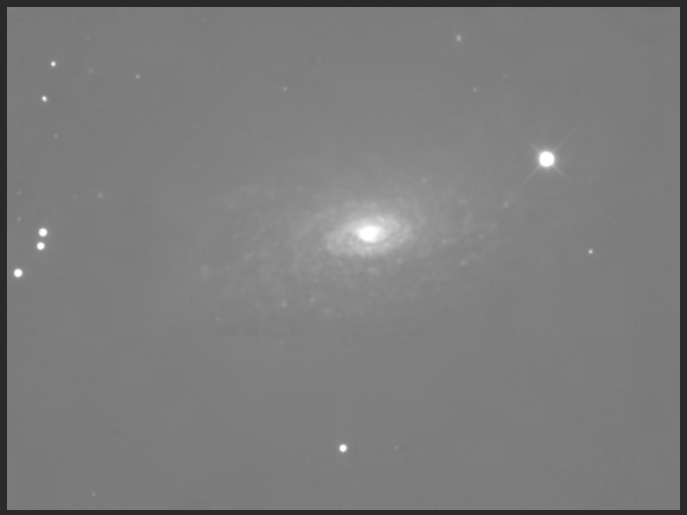
# Deerlick Galaxy Cluster

# Is Anyone Else Out There?

# Why Astrophotography?

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

Visual Experience



Long Exposure

Light Pollution Subtracted

# Astronomical CCD camera

- Pixel size: $6.45 \times 6.45$ microns
- Pixels: 1392 x 1040
- Quant. Eff.: $\sim 65\%$
- Readout Noise: $\sim 7$ electrons
- Cooling: $\sim 30^{\circ}$C below ambient
- Download: $3.5$ seconds
- Format: 16 bit
- Weight: 350g

# Example

**"Telescope":** 200mm f/3.5 Vivitar lens ($30)

**Mount:** Questar

**Camera:** Starlight Express SXV-H9

**Filter:** Dichroic H$\alpha$

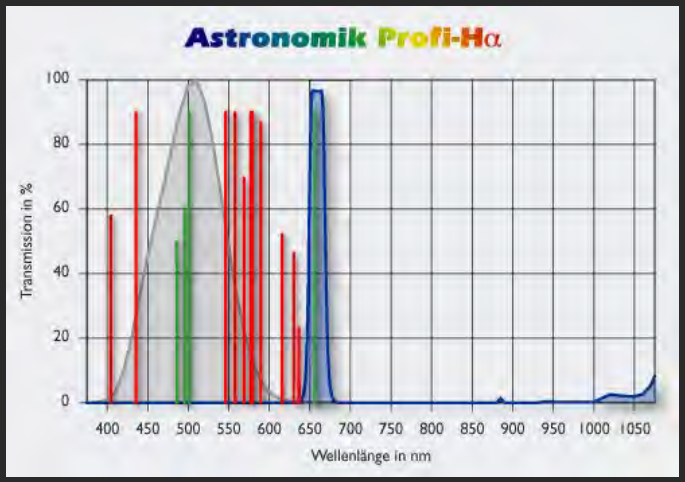
## Fundamental Principles

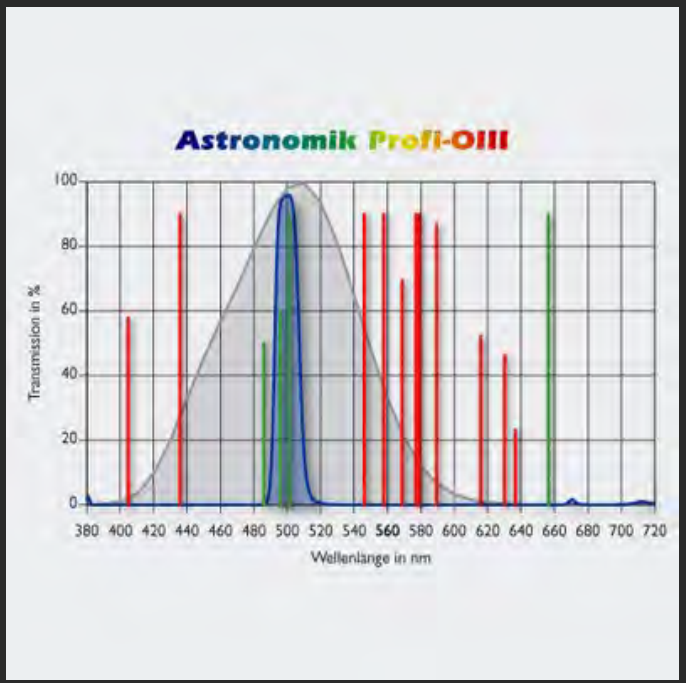
- *Focal length* determines *field of view*
- *F-ratio* determines *exposure time*

Total exposure time $= 156$ mins. Field of view $= 2.5°$.

# Combatting Light Pollution

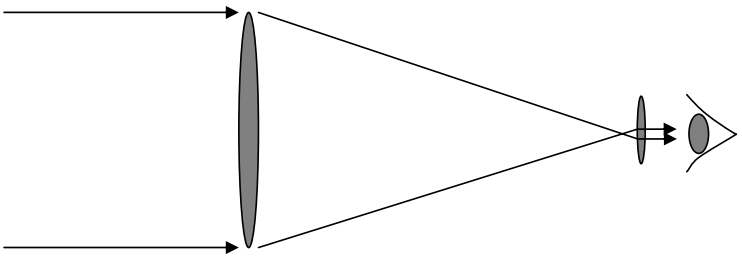
## Narrow-Band Filters



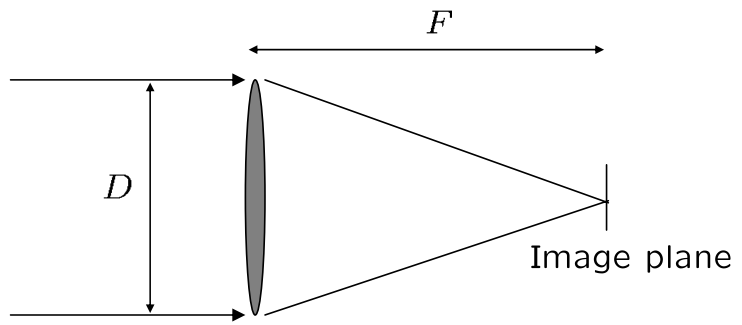
# Visual Astronomy vs. Astrophotography

Visual astronomy is complicated.



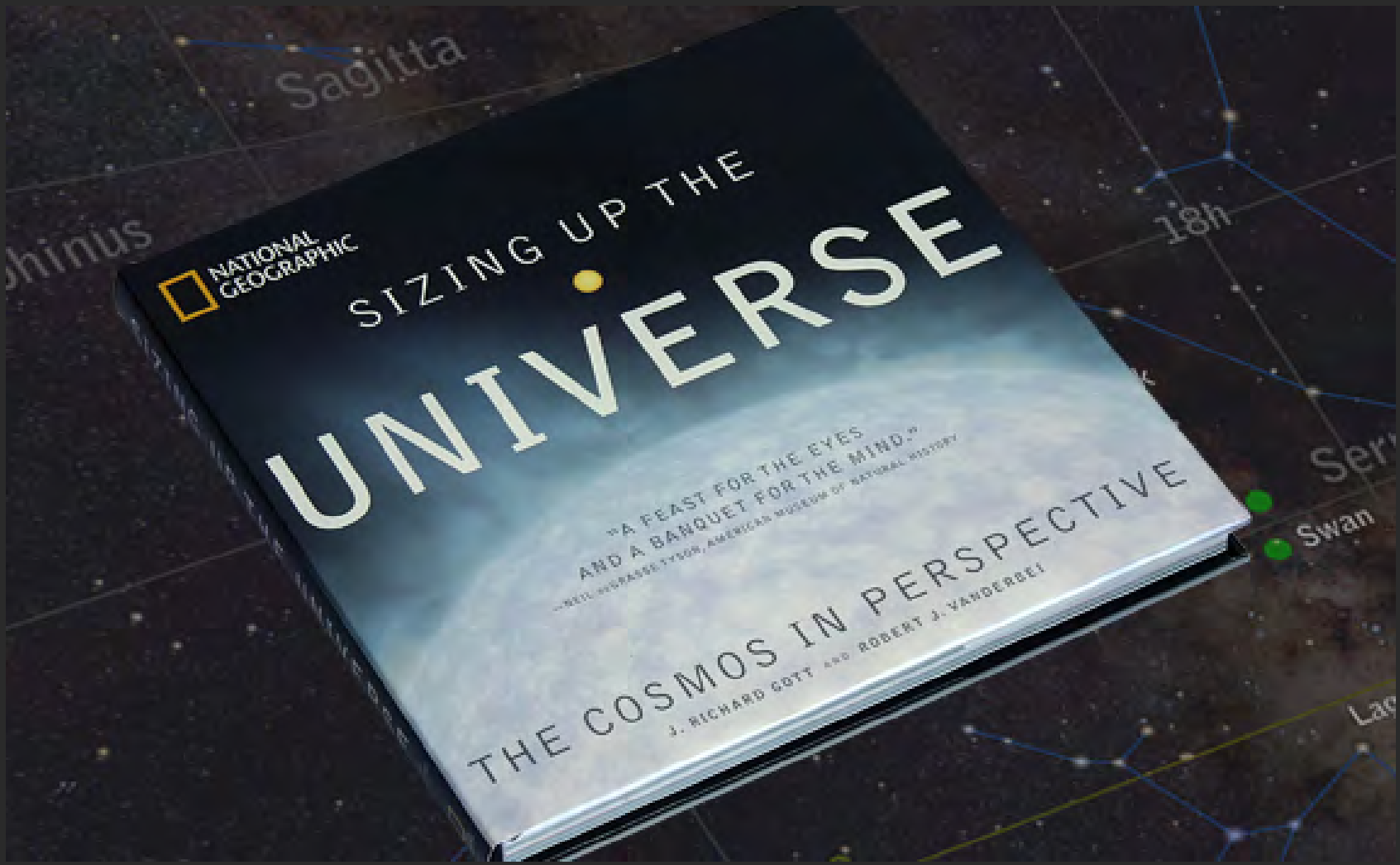
- *Aperture* determines *photon flux*

Astrophotography is easier!




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

# Further Reading...



# Let The Movie Begin

# Backup Slides

# Biases