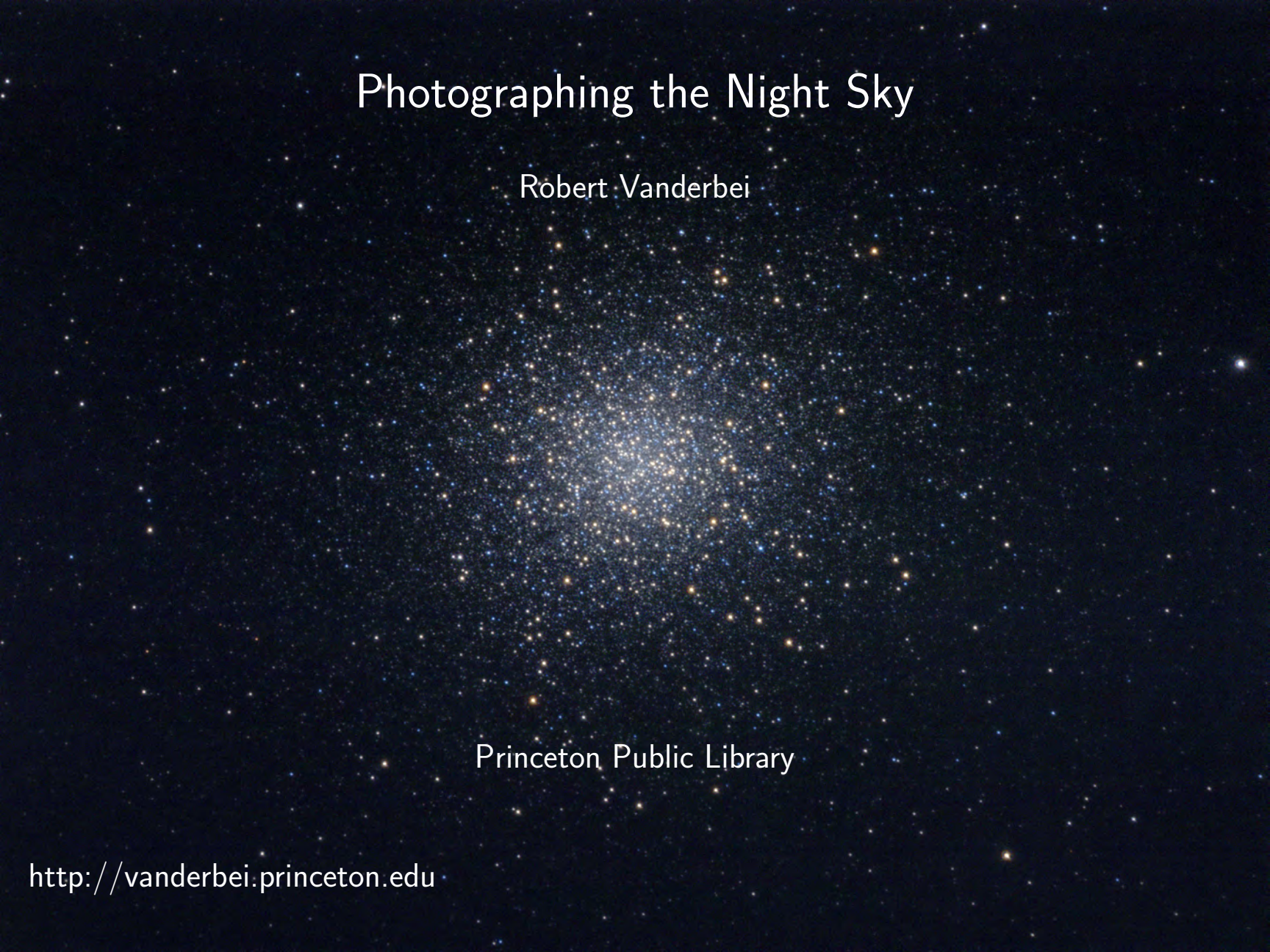


# Photographing the Night Sky

Robert Vanderbei

Princeton Public Library

http://vanderbei.princeton.edu

# DSLR on a Tripod

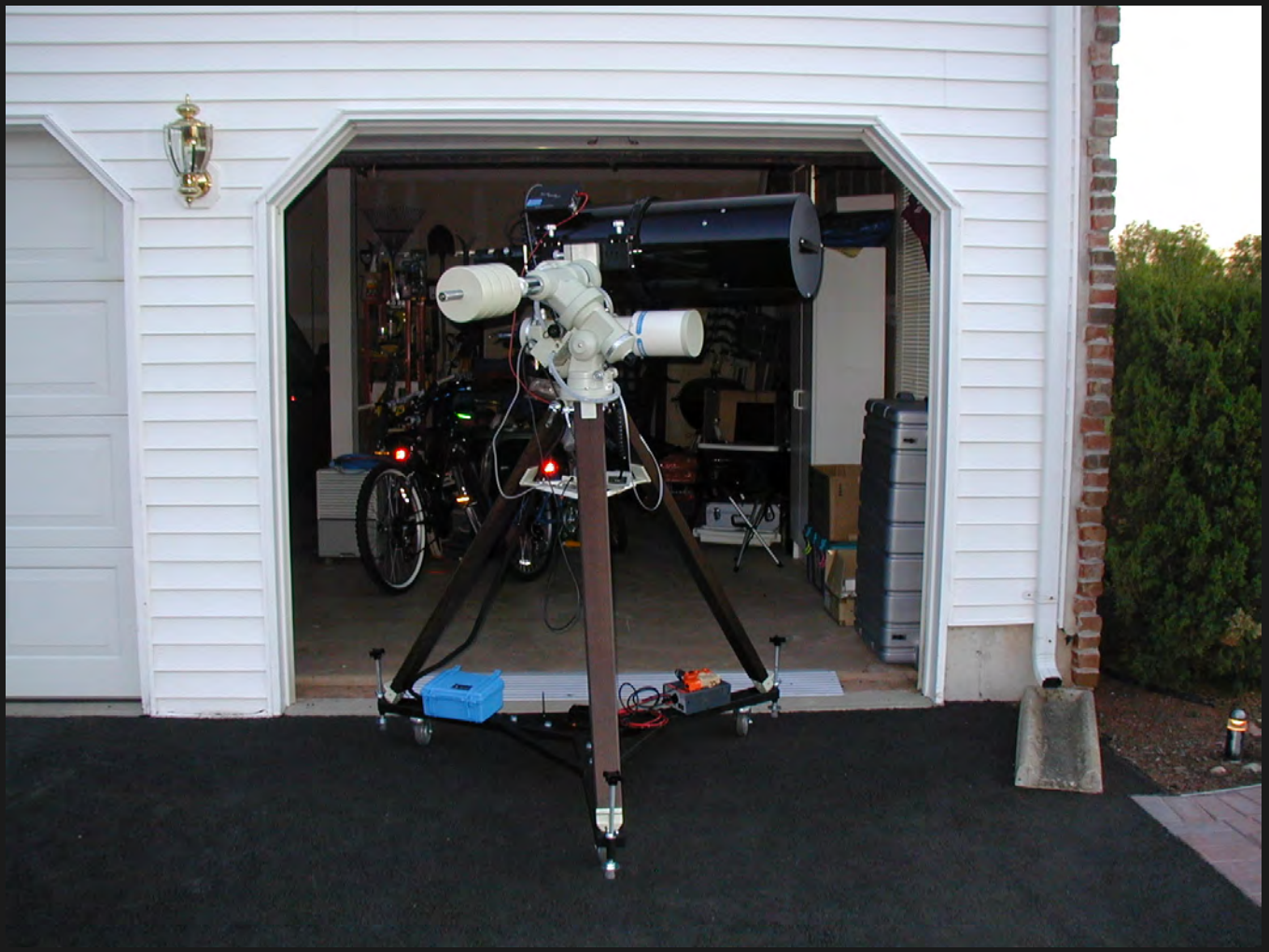
# Ritchey-Chretien and Takahashi FSQ

1. Mount

2. Camera
   Computer
   Software

3. Telescope (OTA)

# Move equipment outside.



# Ready To Go...

# The Pictures Are Better Than The "Visual" View

# Why Astrophotography?

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

Visual Experience

Long Exposure

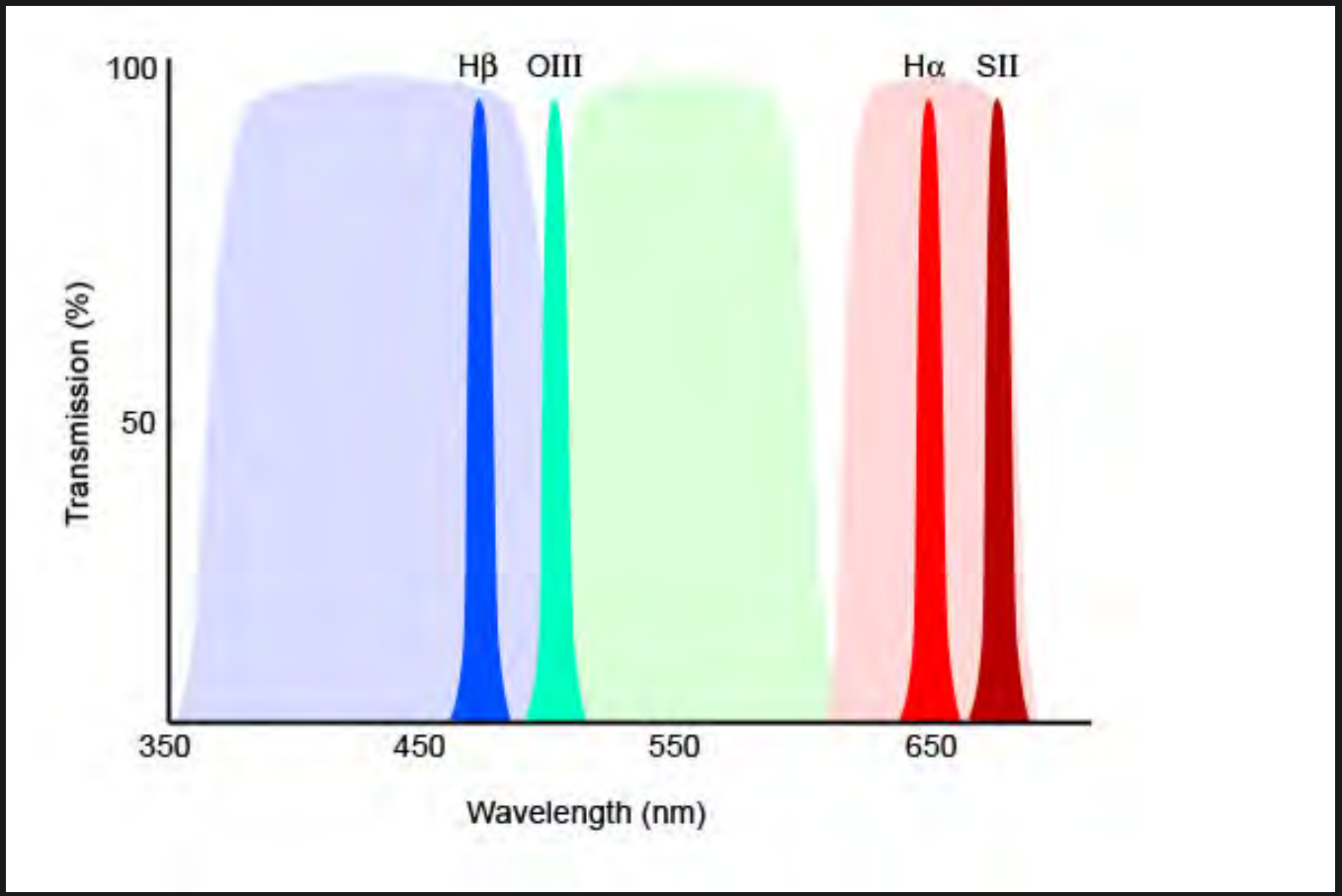
Light Pollution Subtracted

# 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: $\sim 30°$C below ambient
- Download: $3.5$ seconds
- Format: 16 bit
- Weight: 350g

# Combatting Light Pollution

## Narrow-Band Filters



# Example

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

**Mount:** Questar

**Camera:** Starlight Express SXV-H9

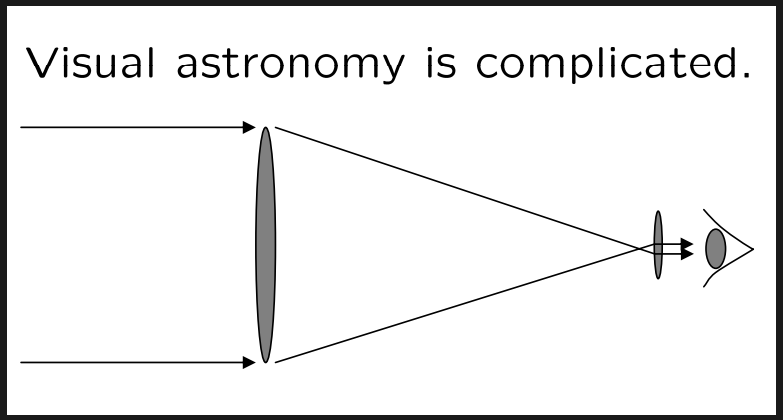
**Filter:** Dichroic H$\alpha$

## Fundamental Principles

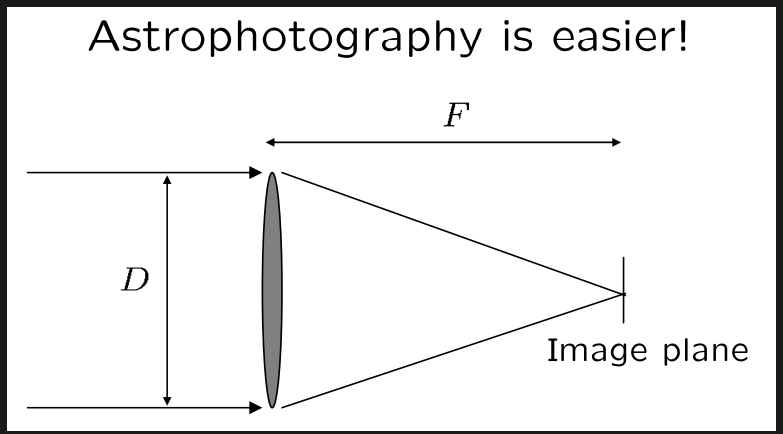
- *Focal length* determines *field of view*
- *F-ratio* determines *exposure time*

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

# Visual Astronomy vs. Astrophotography




- *Aperture* determines *photon flux*




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

# M1 – Crab Nebula

# M13 – Great Globular Cluster in Hercules

# M16 – The Eagle Nebula (aka Pillars of Creation)

# M27 – Dumbbell Nebula

# M31 – The Andromeda Galaxy

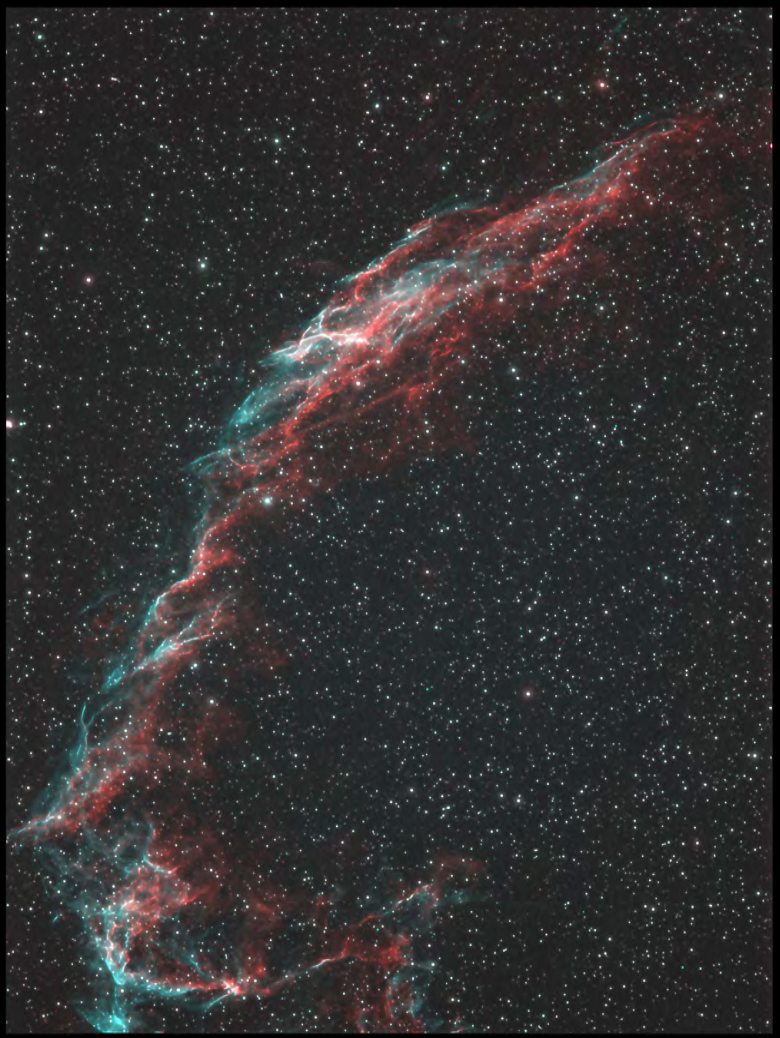
# M42 – Great Orion Nebula

# M45 – Pleiades (aka Subaru)

# Western Veil Nebula

# Eastern Veil Nebula

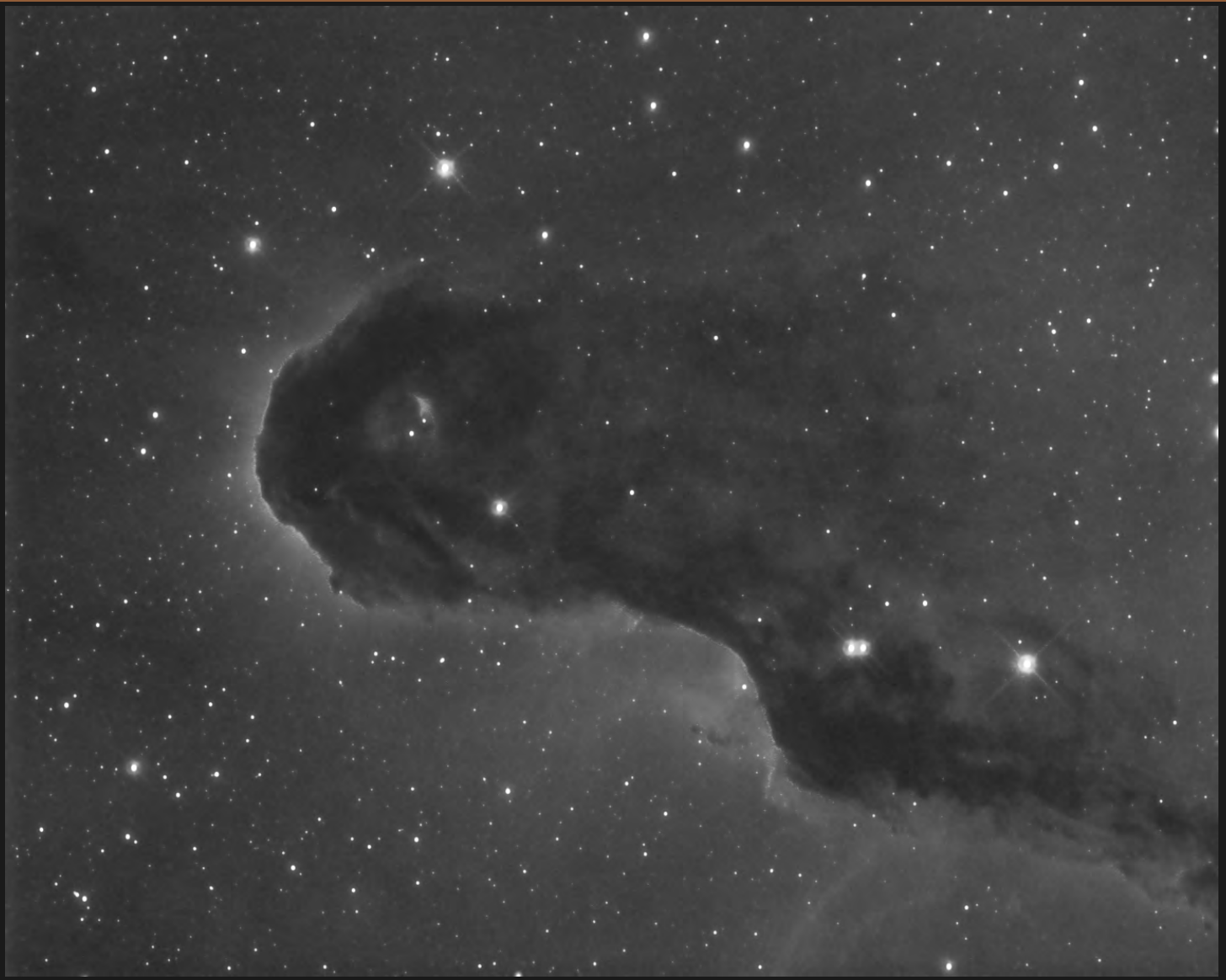
# Veil Nebula



# Bubble Nebula

# Helix Nebula

# Elephant Trunk



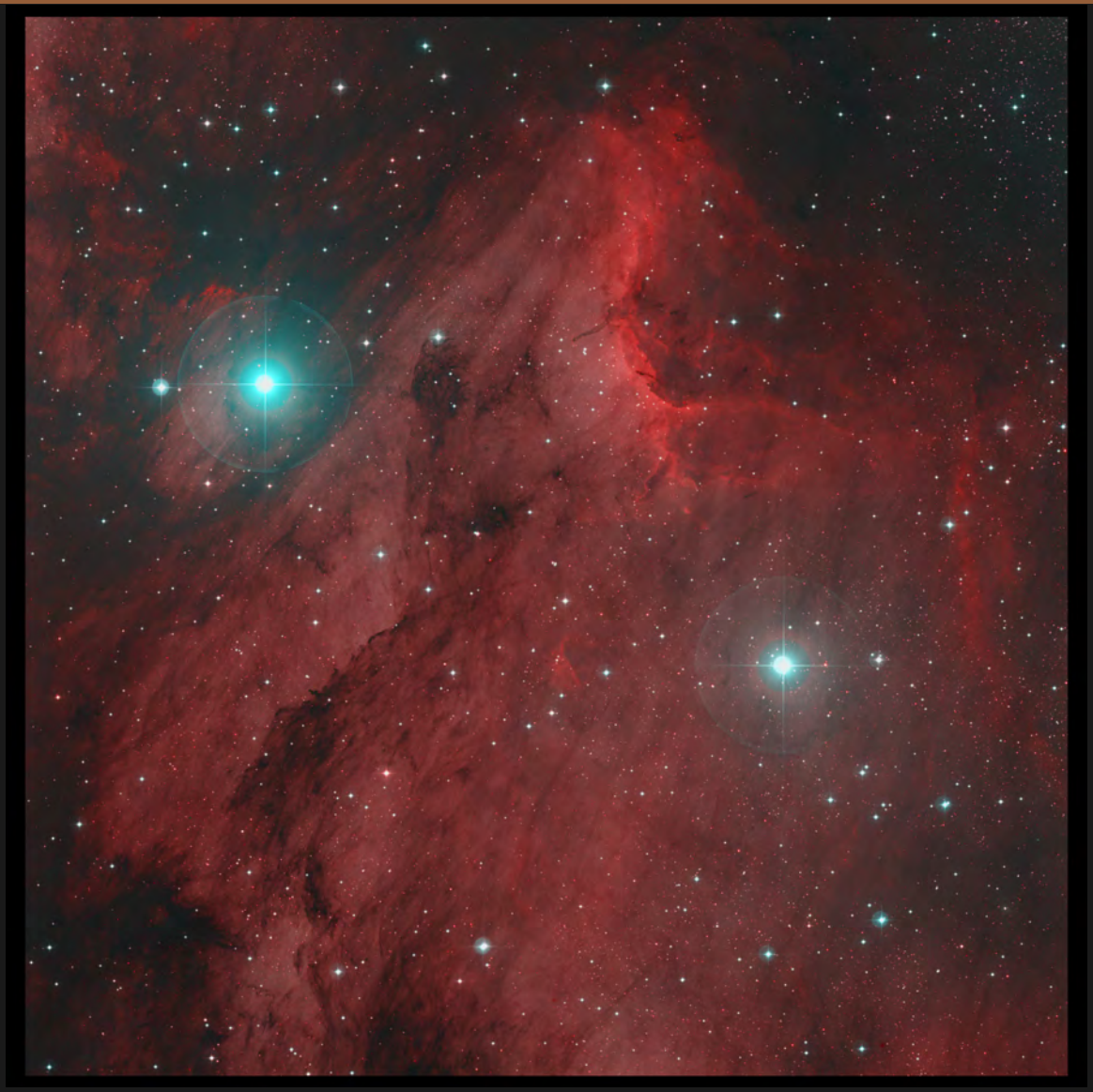
# IC434 – The Horsehead Nebula

# Running Man Nebula

# Rosette Nebula

# Rosette Nebula

# Pelican Nebula



# Thank You

# Questions?

# A Little About Me

- Born/Raised: Grand Rapids, MI
- Undergrad: Chemistry, 1976, Rensselaer Polytechnic Institute (RPI)
- Grad: Applied Math, 1981, Cornell
- Postdocs:
  - NSF Fellow, Math, NYU
  - Visiting Lecturer, Math, Univ. of Illinois Urbana/Champaign
- Industry:
  - AT&T Bell Labs, Math Research Center
- Academia: Princeton, 1990-present

- Hobbies/Passions:
  - Soaring
  - Tennis
  - Astronomy
  - Photography
  - Math/Computation
  - Local Warming, Purple America, etc.

# M1 – Crab Nebula

- *What:* Supernova remnant
- *When:* Oct. 27, 2006
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* Luminance=60min, H$\alpha$=140min, O-III=20min
- *Sub-Exposures:* 20-minutes, guided

- *Distance:* $6500 \pm 1600$ lightyears
- *Diameter:* $11$ lightyears

# M13 – Great Globular Cluster in Hercules

- *What:* Gravitationally bound cluster of stars
- *When:* Oct. 27, 2006
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress Trius SX-694
- *Exposure:* Luminance=6min, Red=8min, Green=6min, Blue=6min
- *Sub-Exposures:* 20-second, unguided

- *Distance:* $22,000$ lightyears
- *Diameter:* $168$ lightyears

# M16 – The Eagle Nebula (aka Pillars of Creation)

- *What:* Young star cluster and diffuse emission nebula
- *When:* June 26 2005, July 17 2006, July 8 2007
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* H$\alpha$=266min, O-III=66min
- *Sub-Exposures:* 4-minute, 6-minute, 10-minute, guided

- *Distance:* $5,700 \pm 400$ lightyears
- *Pillar Height:* $9.5$ lightyears

# M27 – Dumbbell Nebula

- *What:* Planetary nebula
- *When:* Aug. 6, 2016
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress Trius SX-694
- *Exposure:* H$\alpha$=90min, O-III=80min
- *Sub-Exposures:* 10-minute, guided

- *Distance:* $1360 \pm 200$ lightyears
- *Diameter:* $1.4$ lightyears

# M31 – The Andromeda Galaxy

- *What:* Nearby galaxy
- *When:* Oct. 26, 2008
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ refractor
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* Luminance=80min, Red=40min, Green=40min, Blue=40min
- *Sub-Exposures:* 2-minute, unguided

- *Distance:* $2,500,000$ lightyears
- *Diameter:* $220,000$ lightyears

# M42 – Great Orion Nebula

- *What:* Young star cluster and diffuse emission nebula
- *When:* Nov. 25, 2006
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* H$\alpha$=32min, O-III=35min
- *Sub-Exposures:* 1-minute, guided

- *Distance:* $1,344 \pm 20$ lightyears
- *Diameter:* $24$ lightyears

# M45 – Pleiades (aka Subaru)

- *What:* Open star cluster
- *When:* Jan. 3, 2008
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ refractor
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* Red=16min, Green=20min, Blue=122min
- *Sub-Exposures:* 2-minute, unguided

- *Distance:* 444 lightyears

# Veil Nebula

- *What:* Supernova remnant
- *When:* July 25 2008, July 24 2008
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ refractor
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* H$\alpha$=60min, O-III=60min. *Exposure:* H$\alpha$=52min, O-III=24min
- *Sub-Exposures:* 2-minute, 4-minute, unguided

- *Distance:* $1470$ lightyears
- *Diameter:* $70$ lightyears

# Bubble Nebula

- *What:* Emission nebula w/ stellar wind
- *When:* Oct. 21 2006, Sept. 7 2016
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress SXV-H9 and Trius SX-694
- *Exposure:* H$\alpha$=350min, O-III=230min
- *Sub-Exposures:* 10-minute, 20-minute, guided

- *Distance:* $9,100 \pm 2000$ lightyears
- *Diameter:* $8 \pm 2$ lightyears

# Helix Nebula

- *What:* Planetary nebula
- *When:* Oct. 2, 2008
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* H$\alpha$=86min, O-III=54min
- *Sub-Exposures:* 2-minute, guided

- *Distance:* $714 \pm 70$ lightyears
- *Diameter:* $5.7$ lightyears

# Elephant Trunk

- *What:* Star birth area in interstellar medium
- *When:* Aug. 29, 2016
- *Where:* Driveway
- *Telescope:* 10" Ritchey-Chretien
- *Camera:* Starlight Xpress Trius SX-694
- *Exposure:* H$\alpha$=156min
- *Sub-Exposures:* 6-minute, guided

- *Distance:* $22,000$ lightyears
- *Diameter:* $168$ lightyears

# IC434 – The Horsehead Nebula

- *What:* Dark nebula (dust cloud)
- *When:* Oct. 8, 2004
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ refractor
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* H$\alpha$=116min, G=18min, B=18min
- *Sub-Exposures:* 2-minute, unguided

- *Distance:* $1,400$ lightyears

# Running Man Nebula

- *What:* Bright reflection nebula
- *When:* Jan. 28, 2008
- *Where:* Driveway
- *Telescope:* 4" Takahashi FSQ refractor
- *Camera:* Starlight Xpress SXV-H9
- *Exposure:* Red=24min, Blue=100min
- *Sub-Exposures:* 2-minute, unguided

- *Distance:* $1,500$ lightyears
- *Diameter:* $15$ lightyears