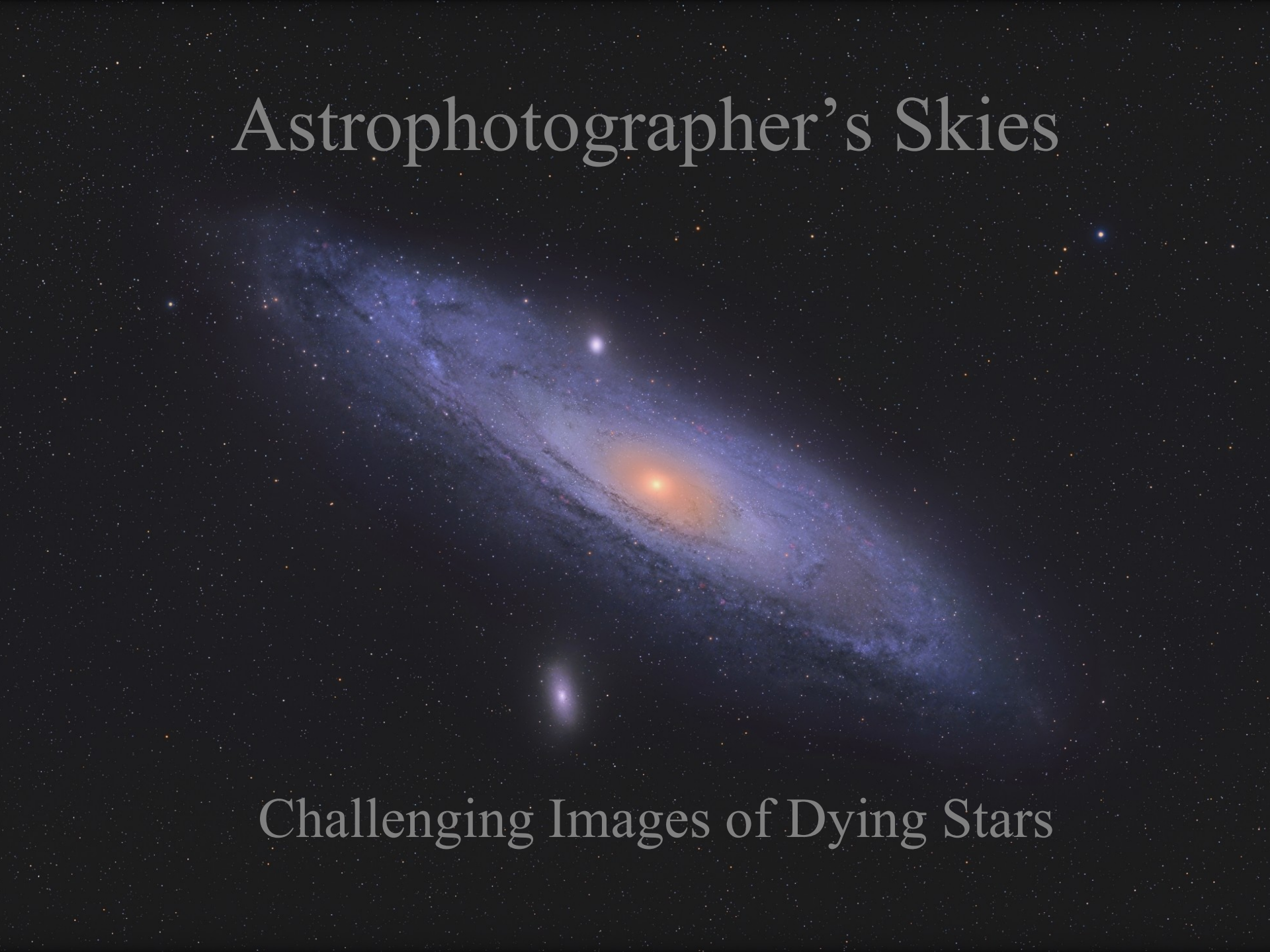
Astrophotographer's Skies



Challenging Images of Dying Stars

Stars don’t last forever

- A star’s fate is determined by its mass
  - Low mass stars live a very long time, some may last longer than the present age of the universe
  - Higher mass stars burn through their fuel quickly (a relative term here)

Low to Medium Mass Stars

- Red to yellow in colour
- Fuse hydrogen in their core at a sedate rate
- The balance between gravity and the outward pressure from the energy released by the core produces hydrostatic equilibrium at Sun like diameters
- Main sequence stars ranging from small red dwarves to larger than the Sun

How Lower Mass Stars Die

- When a low mass star runs out of fuel at its core it contracts and starts to fuse helium to carbon and oxygen.
- The star expands and puffs off its outer envelope as a planetary nebula
- The core collapses until electron degeneracy pressure halts the collapse
- When the nebula finally dissipates, what is left is the core of the star – a white dwarf
- These stellar remnants have densities in the 100's of tons per cubic centimeter and radii of a few thousand kilometers

M27

M27 also known as the Dumbbell Nebula is a bright planetary nebula in Vulpecula
Camera: Canon 60Da
Exposure: 2 hours and 20 minutes of total exposure
ISO: 800
Scope: Esprit 120
Filter: Optolong L-eNhance

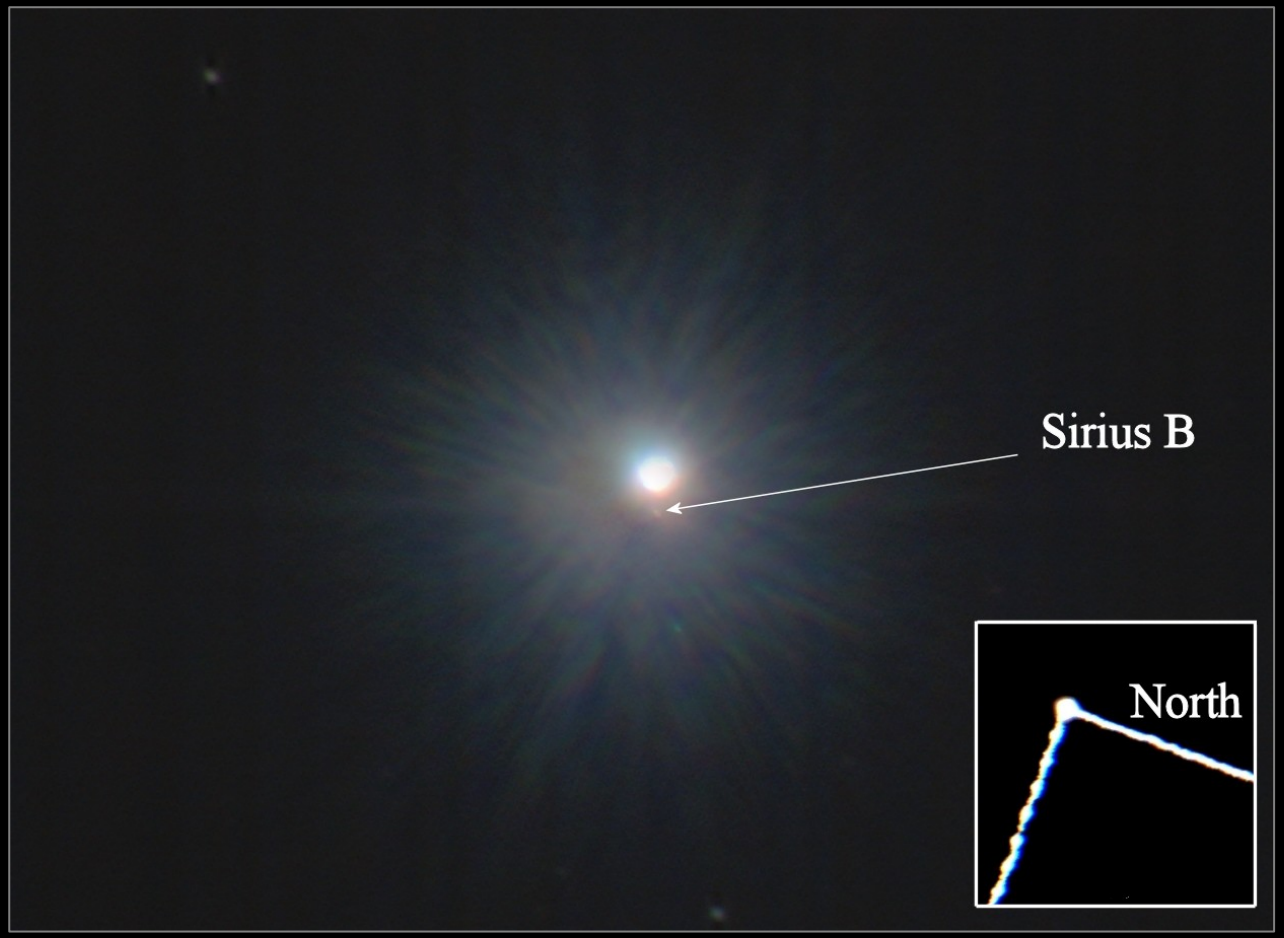
M57

M57 known as the Ring Nebula in Lyra
Camera: Zwo ASI2600MC Pro
Exposure: 90 minutes
Gain: 100
Scope: Esprit 120 with barlow
Filter: Optolong L-eNhance

White dwarf just visible at the center
Stars are suppressed by the filter

The Nearest White Dwarf

- Sirius B is the white dwarf companion of the bright star Sirius. The separation between the two is 11.3 arcseconds with a brightness difference of 9.94 magnitudes
- This shot was produced from a 12 second stack of 0.1 second exposures



Neutron Stars

- If the star is more massive than about 1.4 solar masses, electron degeneracy pressure cannot halt the collapse
- If the star is below 1.5 to 2 solar masses, neutron degeneracy pressure can still save the star
- The resulting neutron star has densities in the order of millions of tones per cubic centimeter and radii of tens of kilometers
- Created in supernova explosions

M1 the Crab Nebula

- A neutron star at the center of the Crab Nebula powers the system
- Two hours of 15 minute exposures using a Zwo ASI2600MC Pro and an Optolong L-eNhance filter taken from my light polluted driveway

My Driveway

Just to give you an idea about how well the latest generation of LPF's really work, this is my driveway, at 11 PM in October, where most of the images in this presentation were captured

CTB-1 or Abell 85

- Originally thought to be a planetary nebula thus its inclusion in the Abell Catalogue
- Now known to be a supernova remnant
- 5 hours using an Optolong L-eNhance filter and about 20 hours of processing

Black Holes

- If a stellar remnant is more massive than 2 solar masses after a supernova then no known force can stop the collapse
- The core continues to collapse to a singularity, cut off from the rest of the universe by its event horizon forming a black hole
- Predicted by general relativity

General Relativity Primer

$$G\mu\upsilon = 8\pi T\mu\upsilon$$

Expanding all terms and adding the incomprehensibility factors, then solving for a term not even in the original equation we have:

$$\begin{aligned}\Lambda^{\alpha\beta} = &- h^{\mu\nu}\partial^2_{\mu\nu}h^{\alpha\beta} + \partial_\mu h^{\alpha\nu}\partial_\nu h^{\beta\mu} + \frac{1}{2}g^{\alpha\beta}g_{\mu\nu}\partial_\lambda h^{\mu\tau}\partial_\tau h^{\nu\lambda} \\ &- g^{\alpha\mu}g_{\nu\tau}\partial_\lambda h^{\beta\tau}\partial_\mu h^{\nu\lambda} - g^{\beta\mu}g_{\nu\tau}\partial_\lambda h^{\alpha\tau}\partial_\mu h^{\nu\lambda} + g_{\mu\nu}g^{\lambda\tau}\partial_\lambda h^{\alpha\mu}\partial_\tau h^{\beta\nu} \\ &+ \frac{1}{8}(2g^{\alpha\mu}g^{\beta\nu} - g^{\alpha\beta}g^{\mu\nu})(2g_{\lambda\tau}g_{\epsilon\pi} - g_{\tau\epsilon}g_{\lambda\pi})\partial_\mu h^{\lambda\pi}\partial_\nu h^{\tau\epsilon}. \qquad (15)\end{aligned}$$

Simple don't ya think?

Cygnus X1 & the Tulip Nebula

- Two hours from mag 4 skies using an Optolong L-eNhance filter
- Over 30 hours of processing to get the brightness balance right

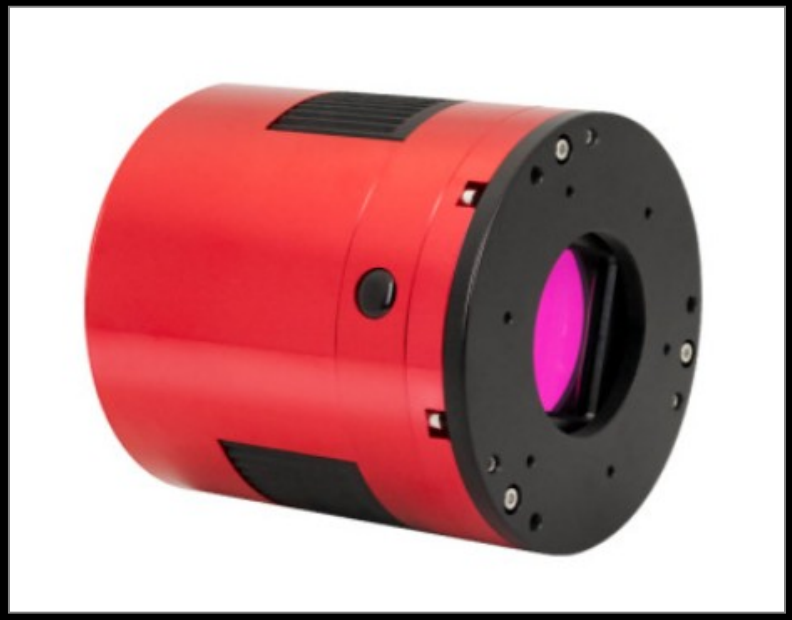
Dying Stars Make Our World

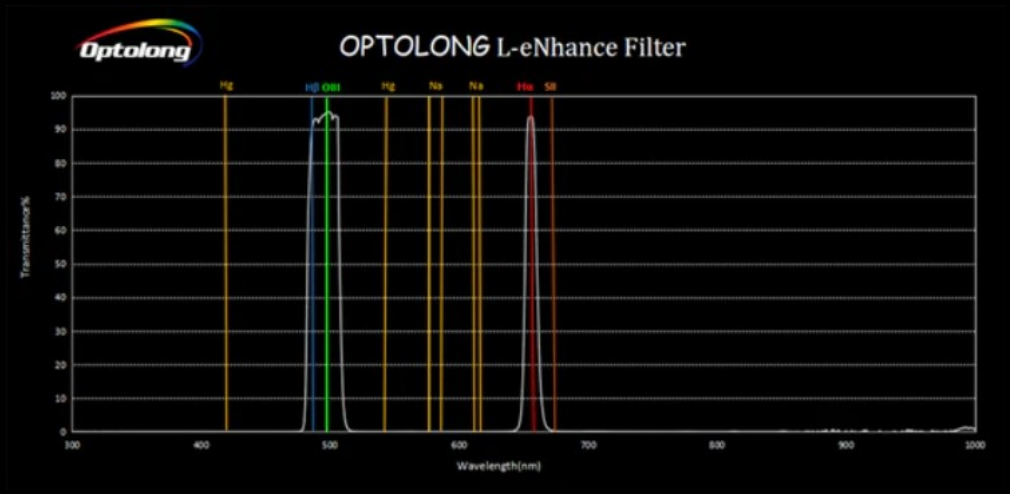
- All elements heavier than lithium are made in stars
- All the elements that make up the Earth and us were made in the core of a star
- So, the next time you stand under the night sky contemplating your existence
  - Thank a star

Modern Gear Makes Some Challenges Easy

My Gear

- Combination of modern APO refractors, low noise CMOS cameras and narrow band filters makes capturing what used to be a difficult image, easy.
- The Crescent and Soap Bubble Nebula shot was captured using a Zwo 2600MC Pro camera and an Optolong L-eNhance dual band filter.





My Complete System

Questions?