

Stars: A Cosmic Story of Life and Death

Through the Lens of an Astrophotographer

M22

M25

M18

Omega Nebula (M17)

Eagle Nebula (M16)

NGC 6604

IC 4701

Sagittarius Star Cloud (M24)

M21

Lagoon Nebula (M8)

Trifid Nebula (M20)

M23



Tanuj (TJ)Bagchi

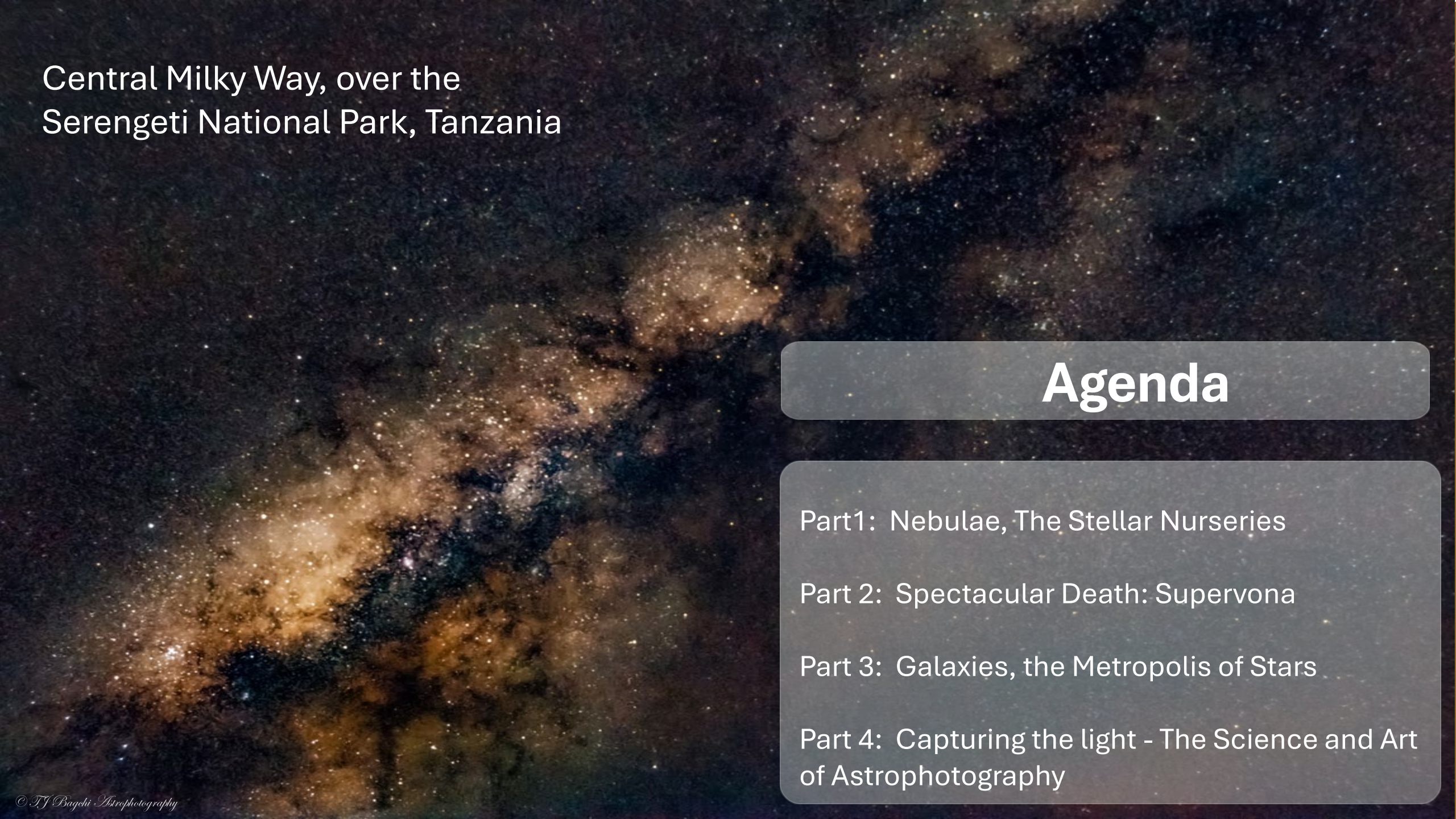
Professor, Computer Science

Lone Star College

Email: Tanuj.Bagchi@lonestar.edu

LinkedIn: <https://www.linkedin.com/in/tanuj-bagchi/>

Instagram: @ASTROBAGCHI



Central Milky Way, over the
Serengeti National Park, Tanzania

Agenda

Part1: Nebulae, The Stellar Nurseries

Part 2: Spectacular Death: Supervona

Part 3: Galaxies, the Metropolis of Stars

Part 4: Capturing the light - The Science and Art
of Astrophotography

The background of the slide is a high-resolution astronomical image of the Eagle Nebula (M16). The nebula is depicted in vibrant shades of red and orange, with darker blue and black regions representing the surrounding interstellar space. The central part of the nebula shows a bright, glowing core with intricate filamentary structures and a prominent dark, shadowed region. Numerous small, bright stars are scattered throughout the field of view, particularly concentrated within the nebula's structure.

Part 1:

**Nebula, The Stellar
Nursery**

The Eagle Nebula (M16)

What is a Nebula?

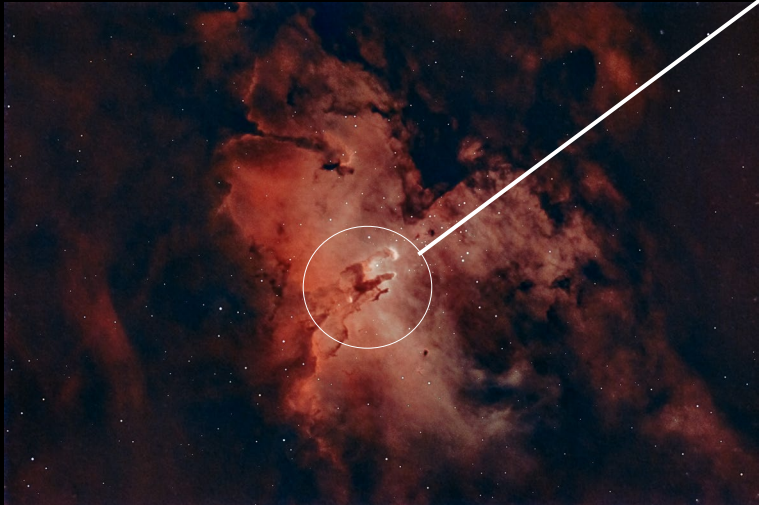
- ❑ Giant cloud of gas and dust
 - 98% Hydrogen and Helium, 2% heavier elements
 - Space dust is fine particles of Silicate, Calcium, Carbon etc.
 - The dust helps to scatter the light
- ❑ The color depends on what gas and how hot
 - Red – Hydrogen: 656.3nm
 - Blue and green – Oxygen: 500.7 & 495.9
- ❑ Size varies greatly
 - Fraction of a light year to thousands of light years in diameter
- ❑ Different Types of Nebulae
 - Emission: An internal stellar light source
 - Reflection: Lit by the light of nearby stars
 - Dark: Cloud of gas and dust floating around
- ❑ Stellar Nursery
 - When dense clouds of gas and dust collapses under gravity and starts nuclear fusion: The birth of a star

The California Nebula
(NGC 1499)



Aurora Borealis
Yellowknife Canada

The Pillars of Creation: A Stellar Nursery



Hubble Space Telescope



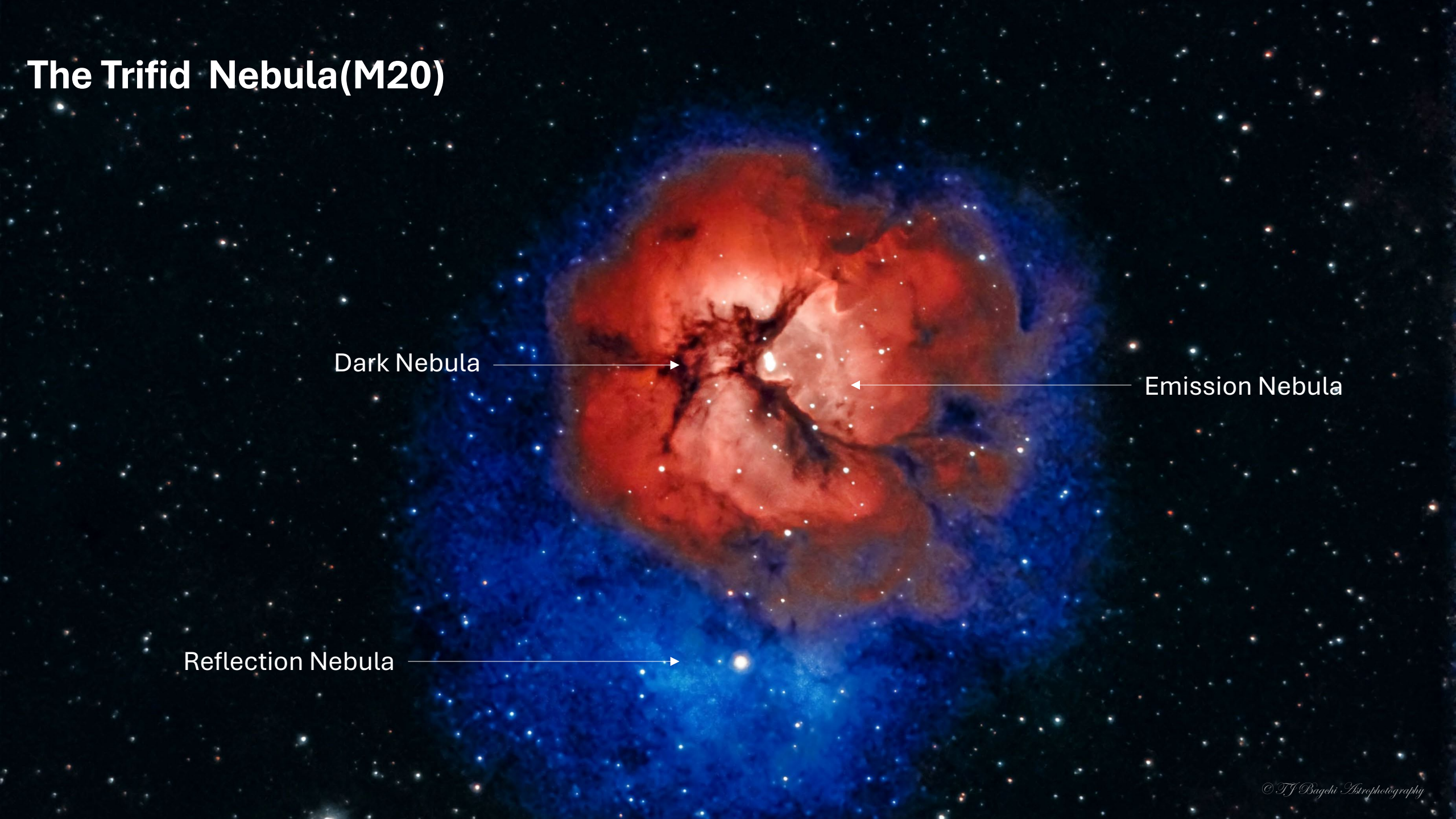
Astrobagchi (amateur) Telescope

The Trifid Nebula (M20)

Dark Nebula

Emission Nebula

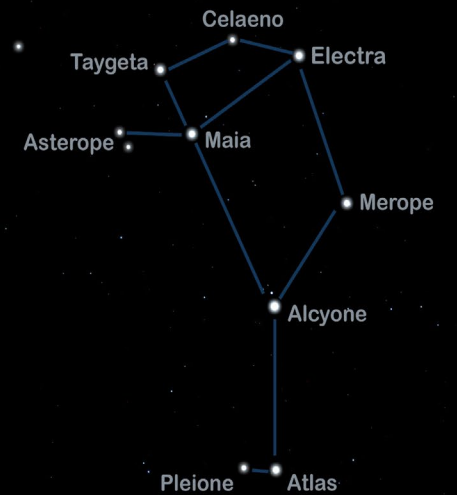
Reflection Nebula



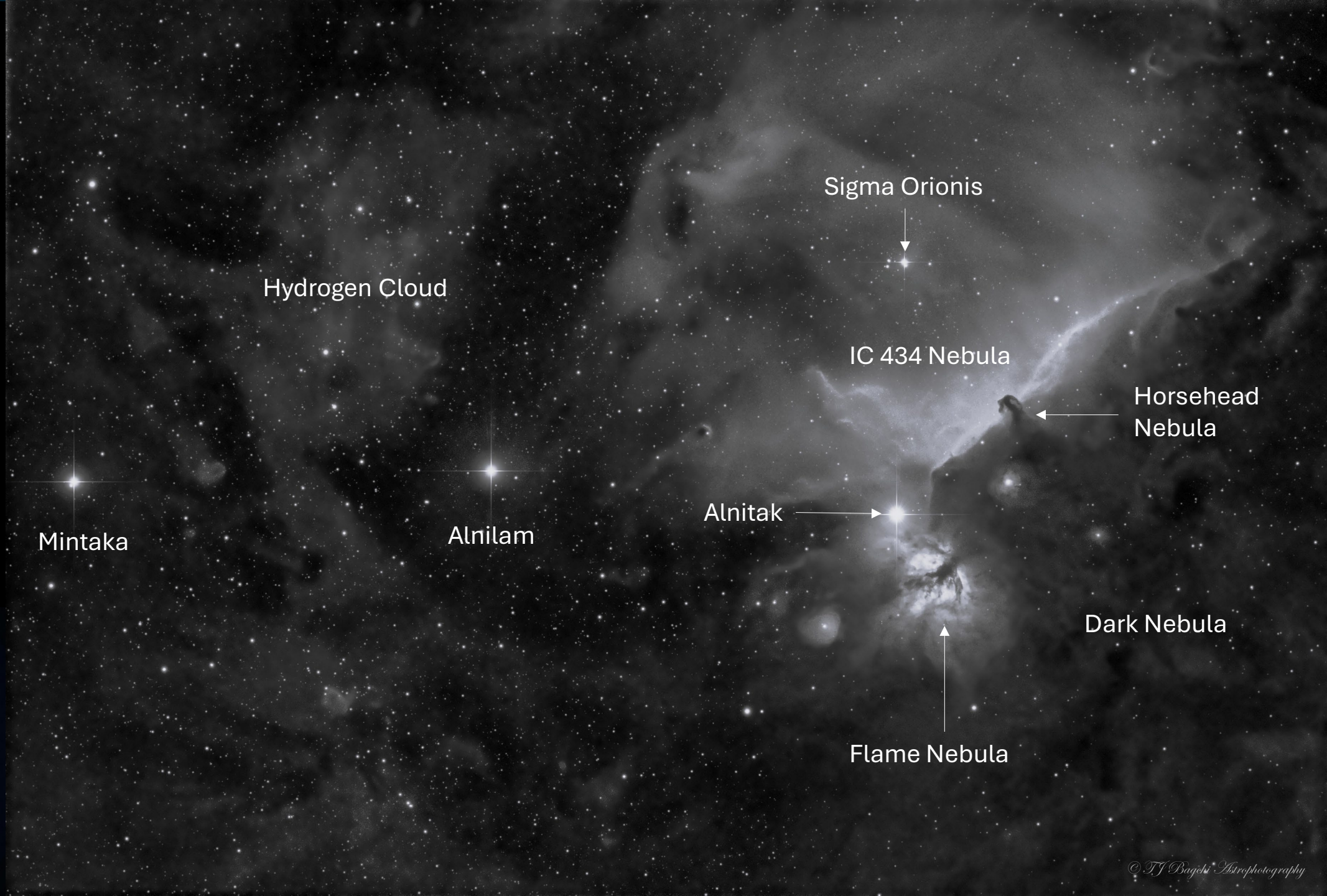
The Pleiades: A Reflection Nebula



The Pleiades



Orion's Belt



**The Horsehead: A Dark
Nebula (Bernard 33)
Silhouette Against an
Emission Nebula (IC 434)**



The Horsehead: A Closer Look



Horsehead Nebula in Infrared



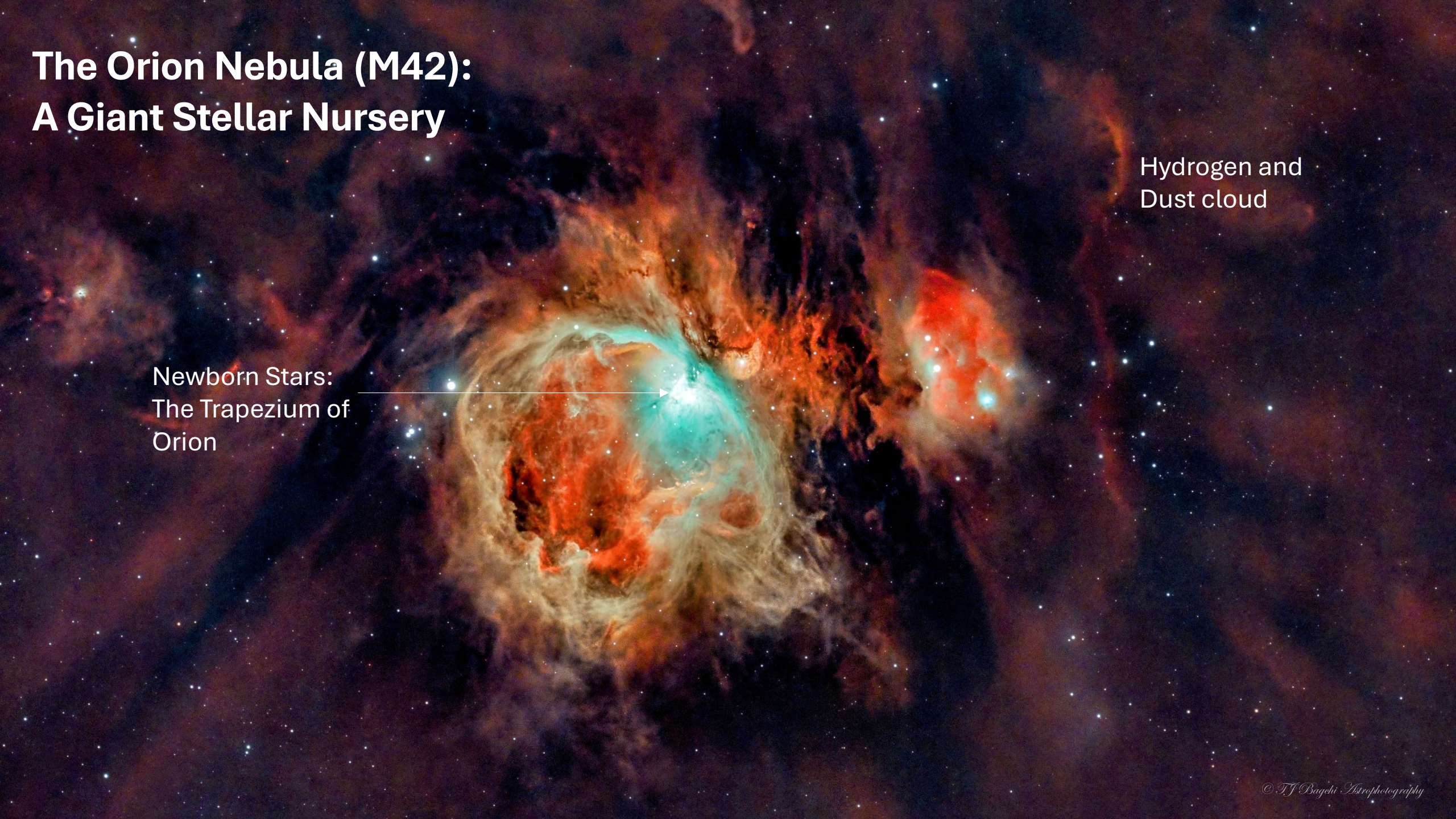
Hubble
Heritage

NASA, ESA, and the Hubble Heritage Team (STScI/AURA)
HST WFC3/IR • STScI-PRC13-12a

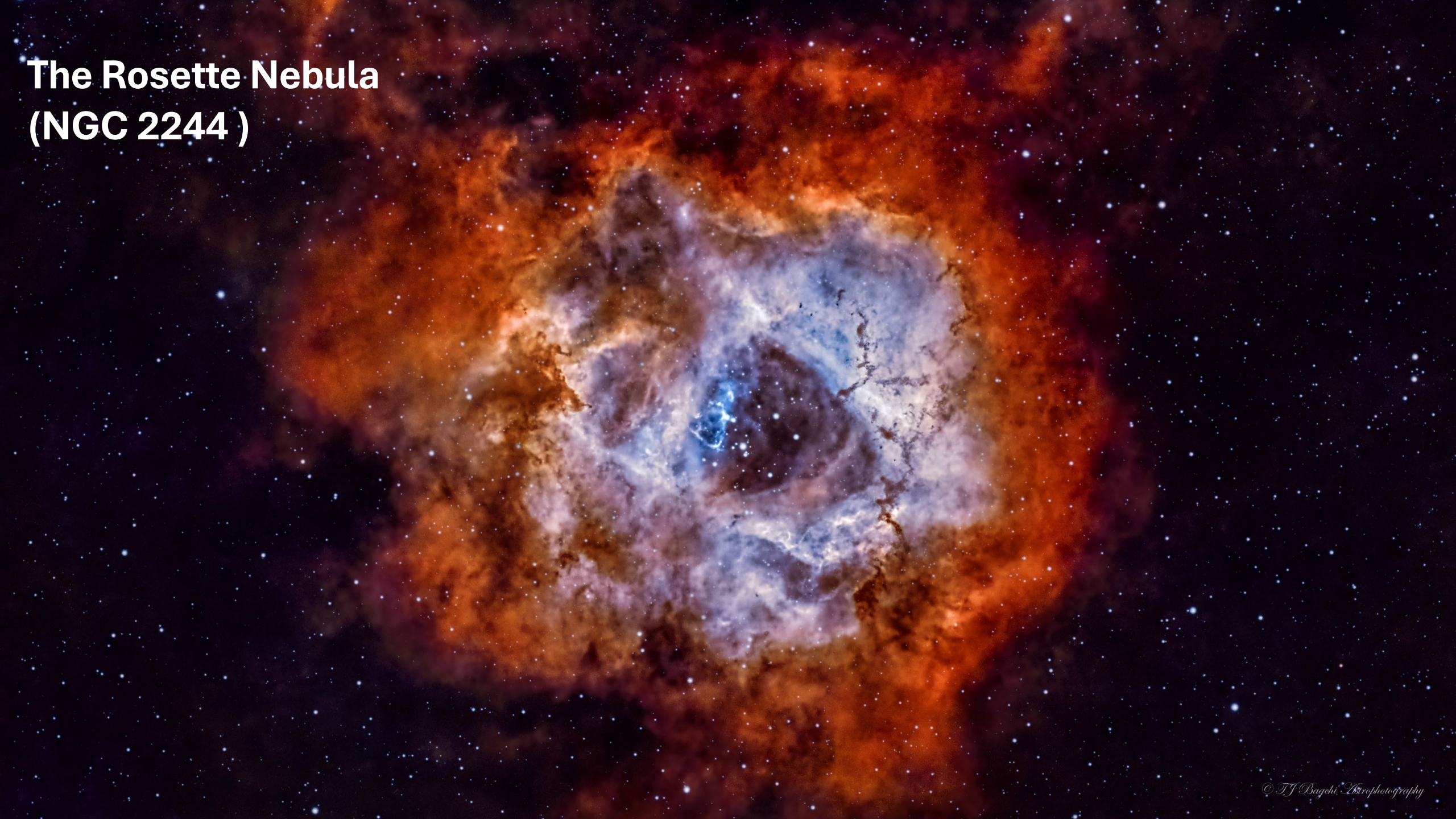
The Orion Nebula (M42): A Giant Stellar Nursery

Hydrogen and
Dust cloud

Newborn Stars:
The Trapezium of
Orion



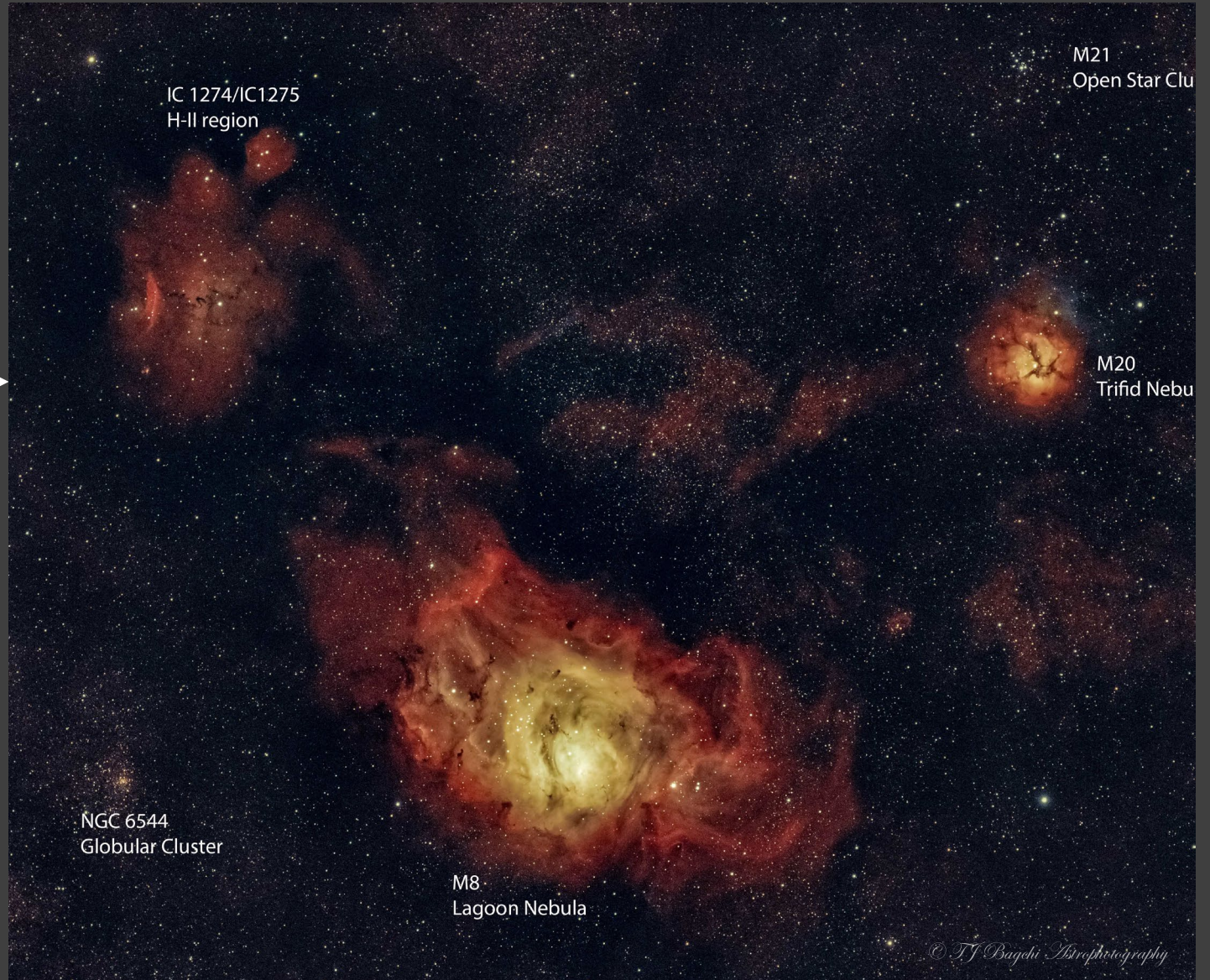
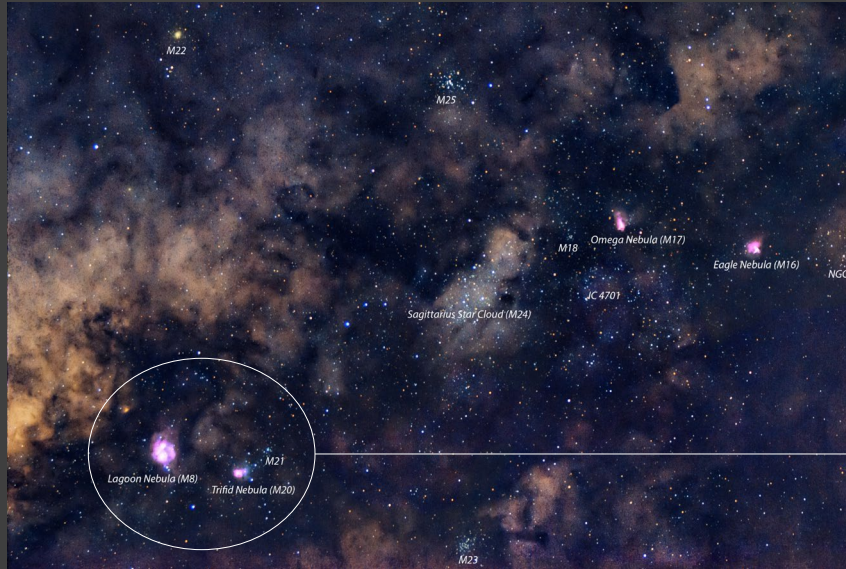
The Rosette Nebula (NGC 2244)



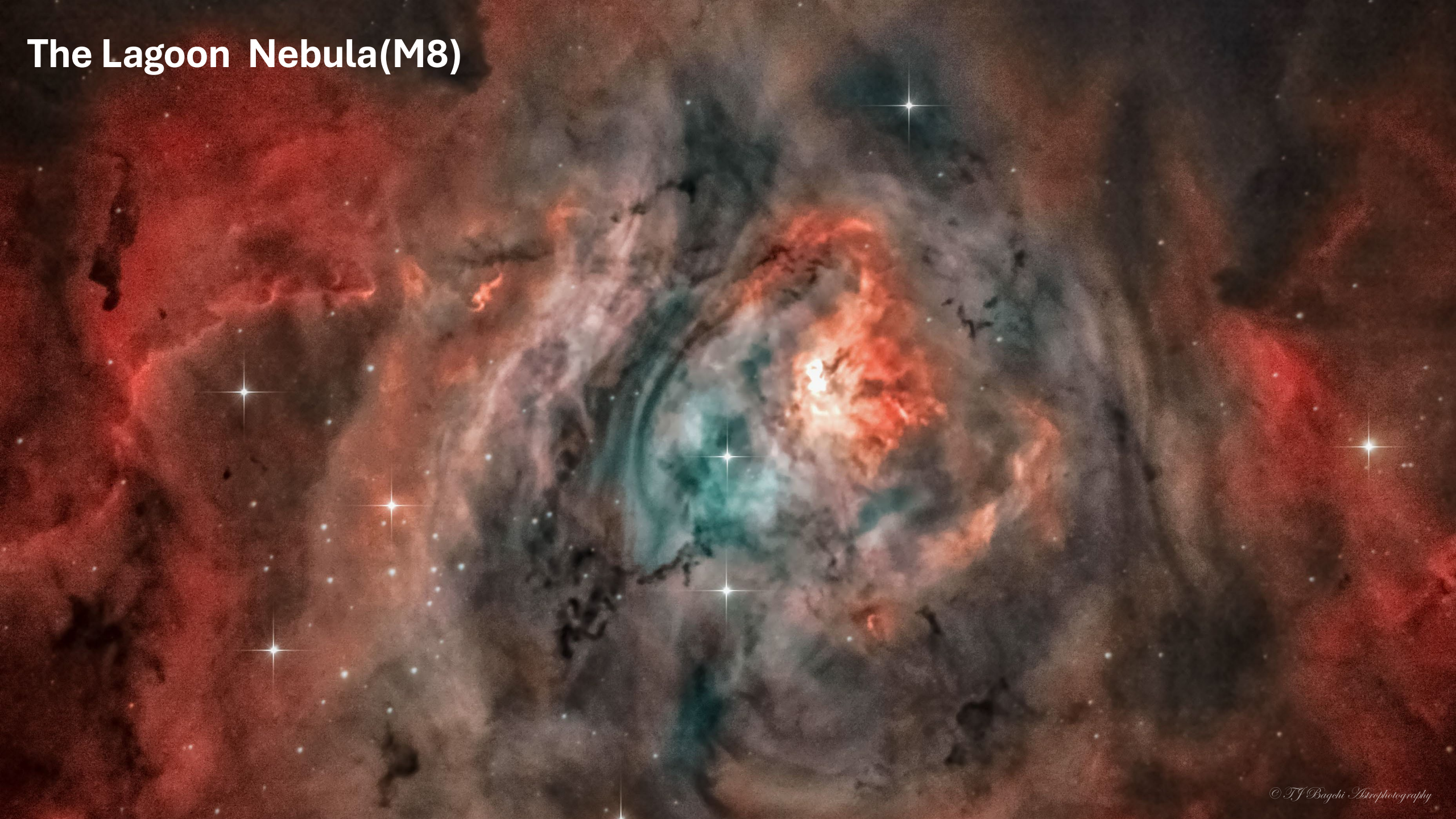
**The Soul Nebula
(IC 1848)**

**The Heart Nebula
(IC 1805)**

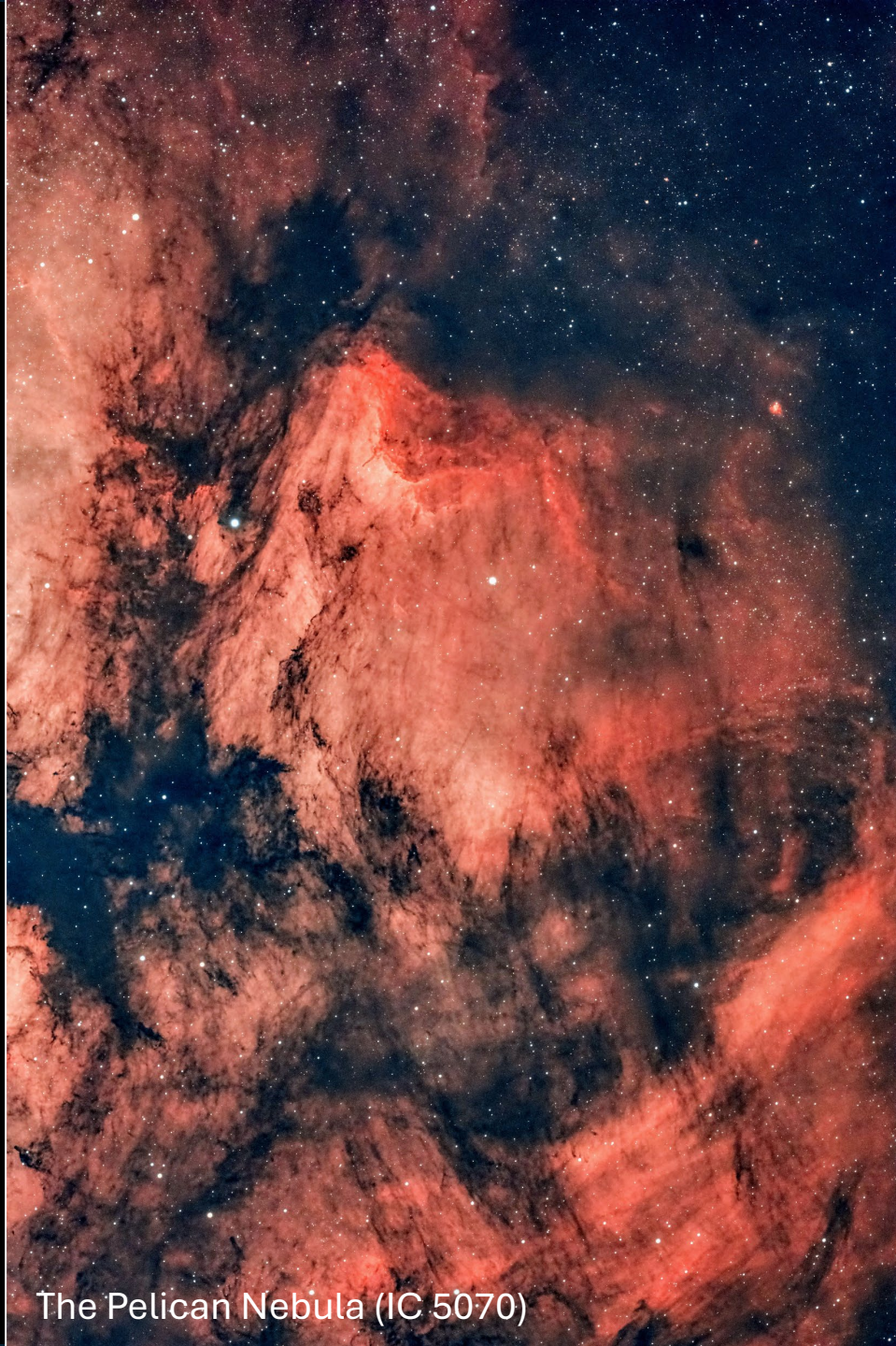
Where are the Nebulae?



The Lagoon Nebula (M8)



What's
in a
Name?



The Pelican Nebula (IC 5070)



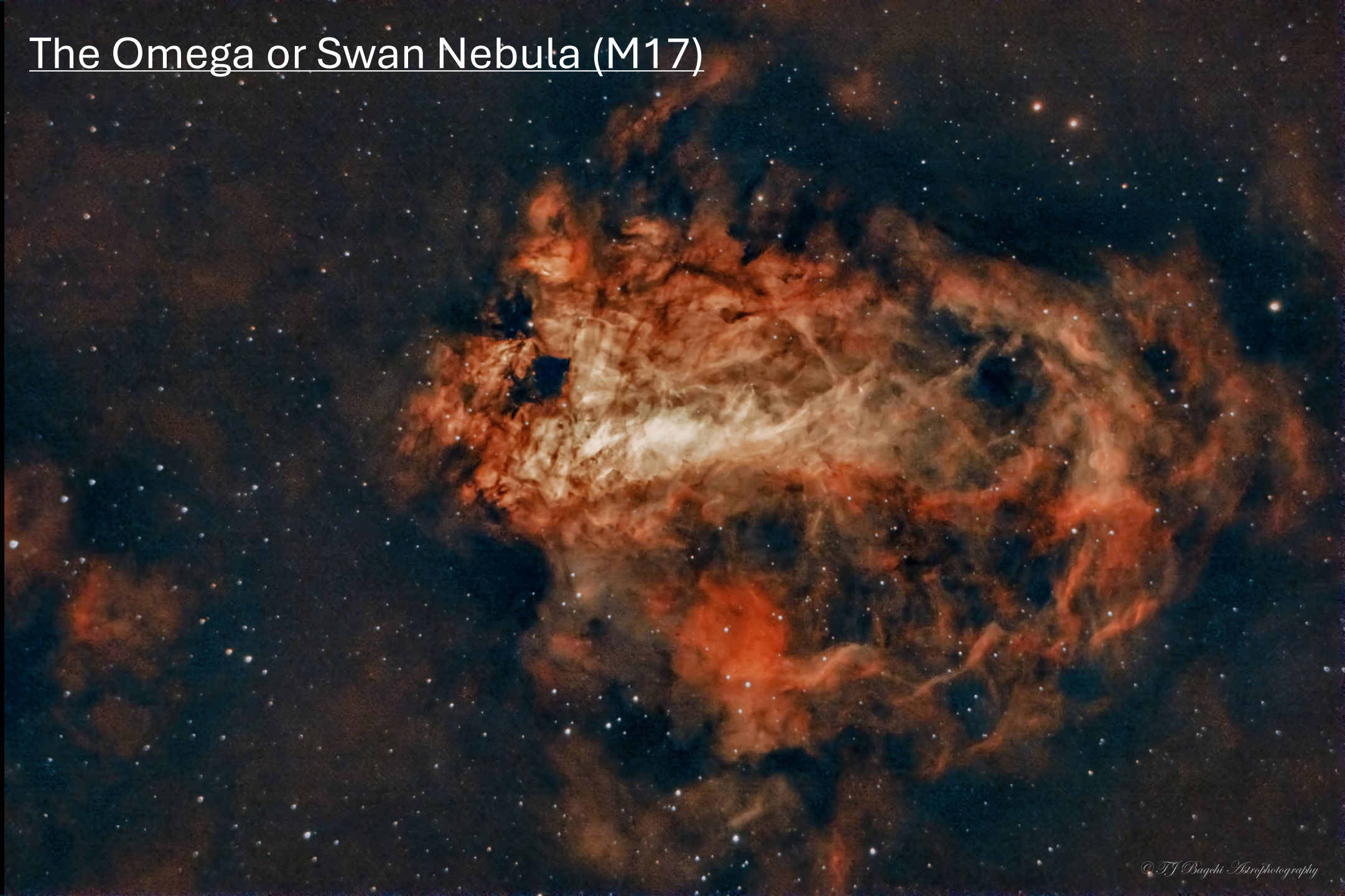
The Flying Dragon Nebula (SH2-114)



The Lobster Claw Nebula (SH2-157)

The Omega or Swan Nebula (M17)

Can you
Spot the
Omega
or the
Swan?



The Omega or the Swan Nebula

Messier 17 (M17)



Major Astronomical Catalogues

Messier (M)

1774–1781

Charles Messier (France)

Bright nebulae, star clusters & galaxies

Created to avoid comet confusion

NGC / IC

1888–1908

J. L. E. Dreyer

- Systematic deep-sky catalogue
- 7,800+ NGC objects
- 5,000+ IC additions

Caldwell (C)

1995

Sir Patrick Moore

- Modern observing list
- Bright non-Messier objects
- Includes southern sky
- Amateur-focused

Sharpless (Sh / Sh2)

1953 & 1959

Stewart Sharpless

- H II emission nebulae
- Star-forming hydrogen regions
- From Palomar Sky Survey

Barnard (B)

1919–1927

E. E. Barnard

- Dark nebulae (dust clouds)
- Seen in silhouette
- Block background Milky Way stars

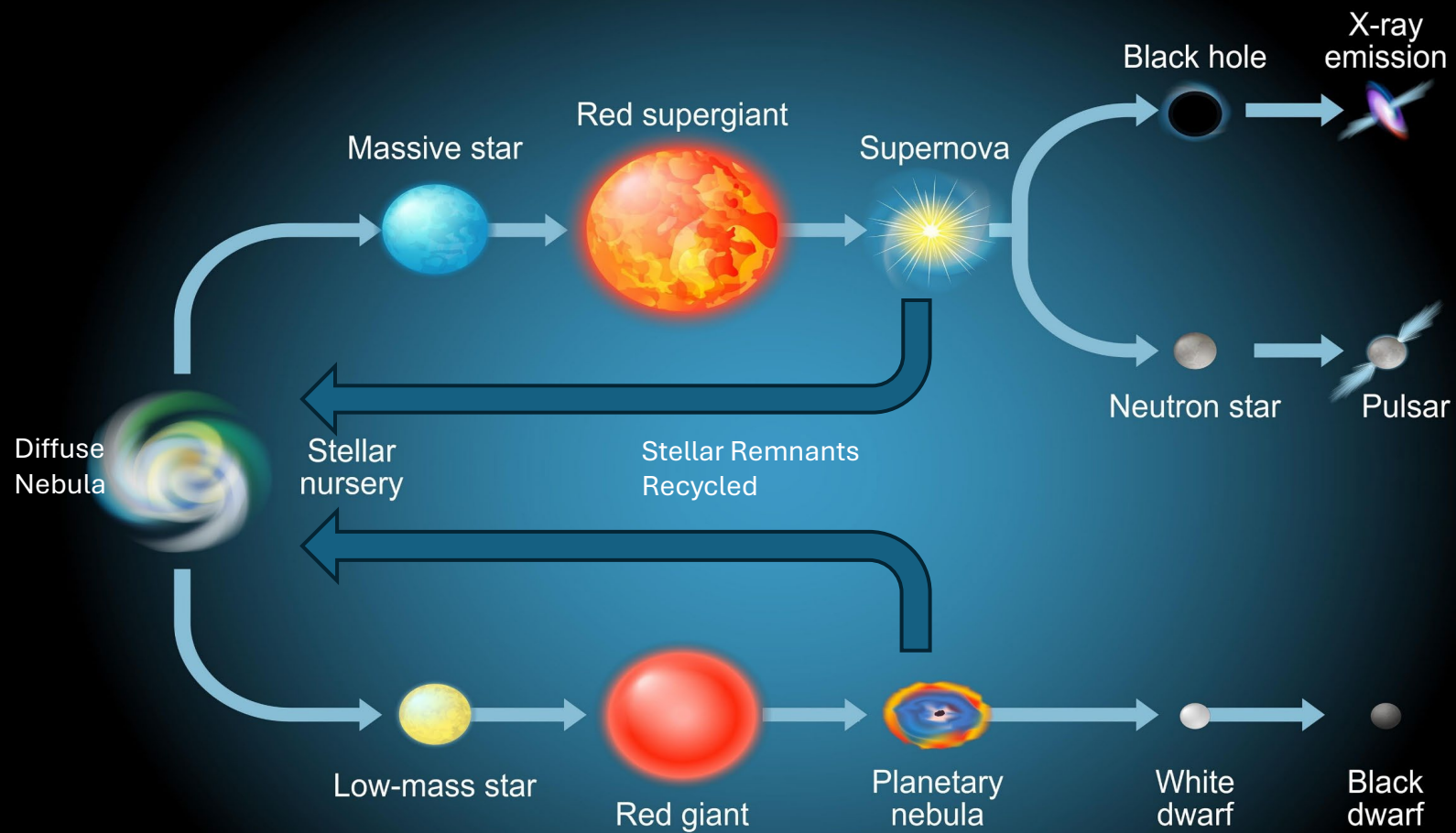
Copilot AI

Part 2:

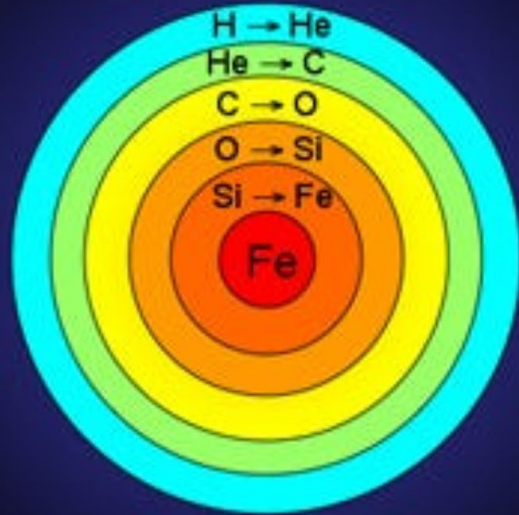
Spectacular Death: Supernova and Stellar Remnant



Stellar evolution



Stars: The Elements Factory



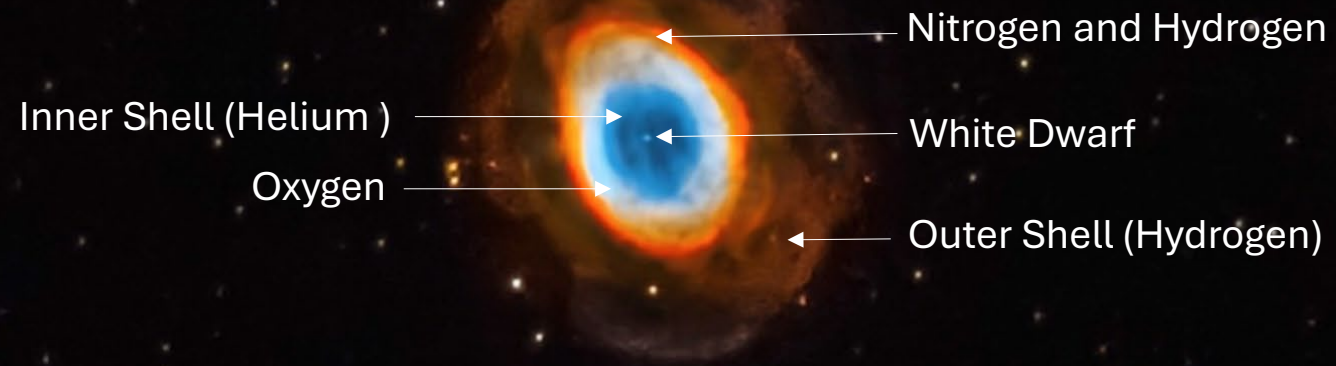
For a 25 solar mass star:

Stage	Duration
H → He	7×10^6 years
He → C	7×10^5 years
C → O	600 years
O → Si	6 months
Si → Fe	1 day
Core Collapse	1/4 second

Periodic Table of the Elements

- ~95% of Milky Way stars end fusion at C–O core → **white dwarfs**
- Merging white dwarfs → **Type 1a supernovae** → Fe-peak elements (Ni, Mn, Ti, Cr, Ca, S)
- Massive stars ($>8 M_{\odot}$) collapse iron cores → **Type II supernovae**
- Type II supernovae form most elements, including trace heavy metals
- Neutron star mergers create large amounts of gold and heavier elements

The Ring Nebula (M57): A Dying Star



The Bubble Nebula (NGC 7635)

A Supermassive Star in mid-life
– ‘O’-Star

Surrounding dense gas
cloud

Expelled outer atmosphere

The Crescent Nebula (NGC 6888)

A supermassive Star in end-life before
supernova: Wolf-Rayet (WR) Star (WR 136)

Hydrogen-alpha

Expelled outer shell

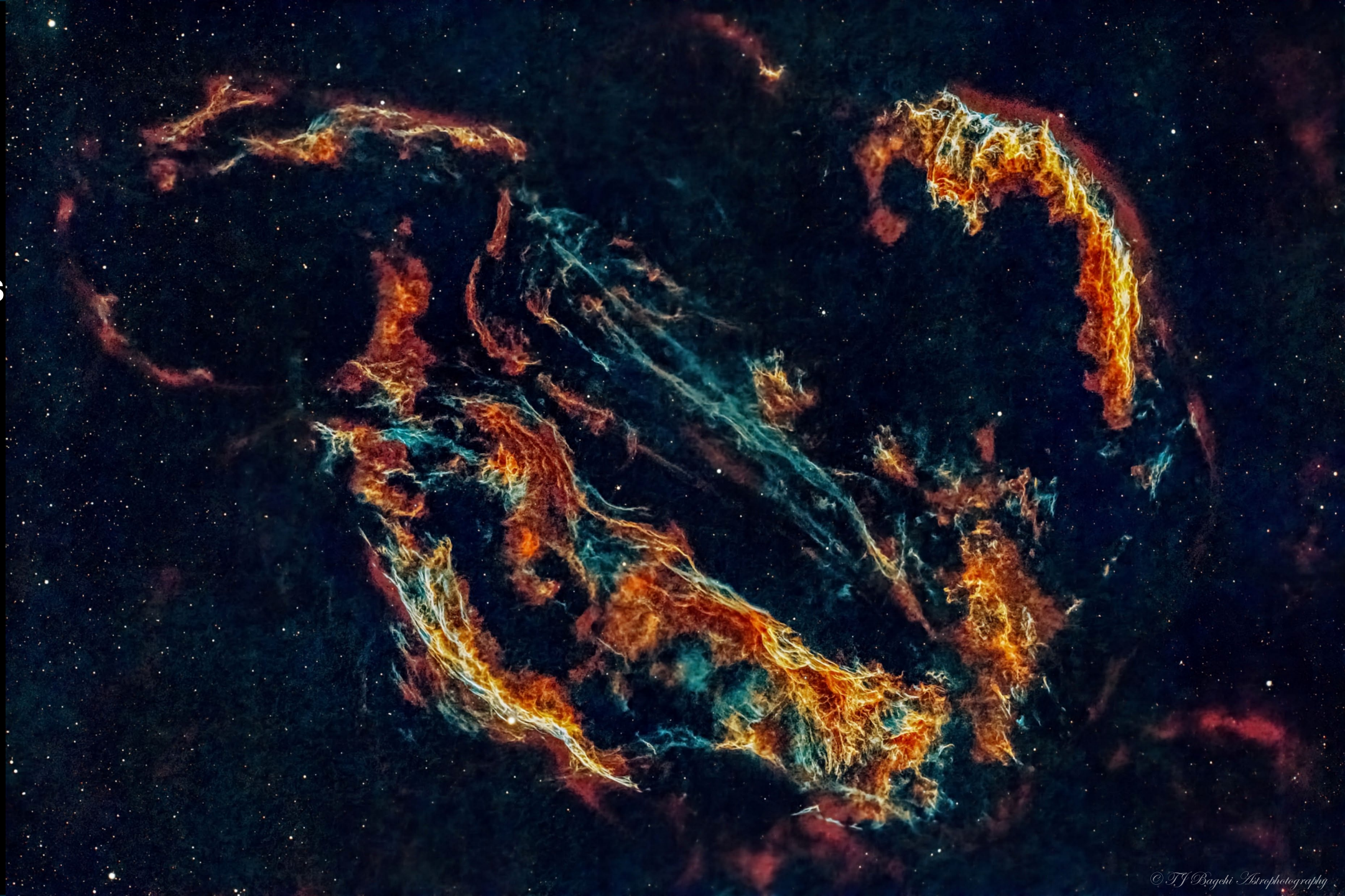
Oxygen-III

The Crab Nebula (M1): A Type II Supernova!

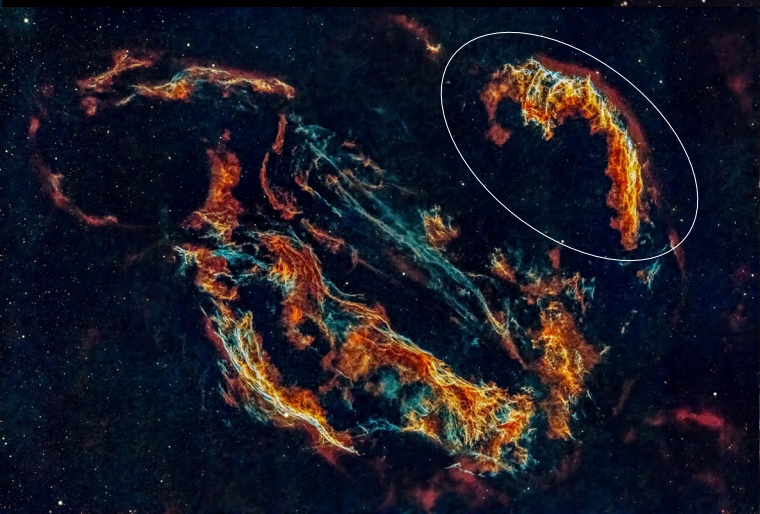


The Cygnus Loop:

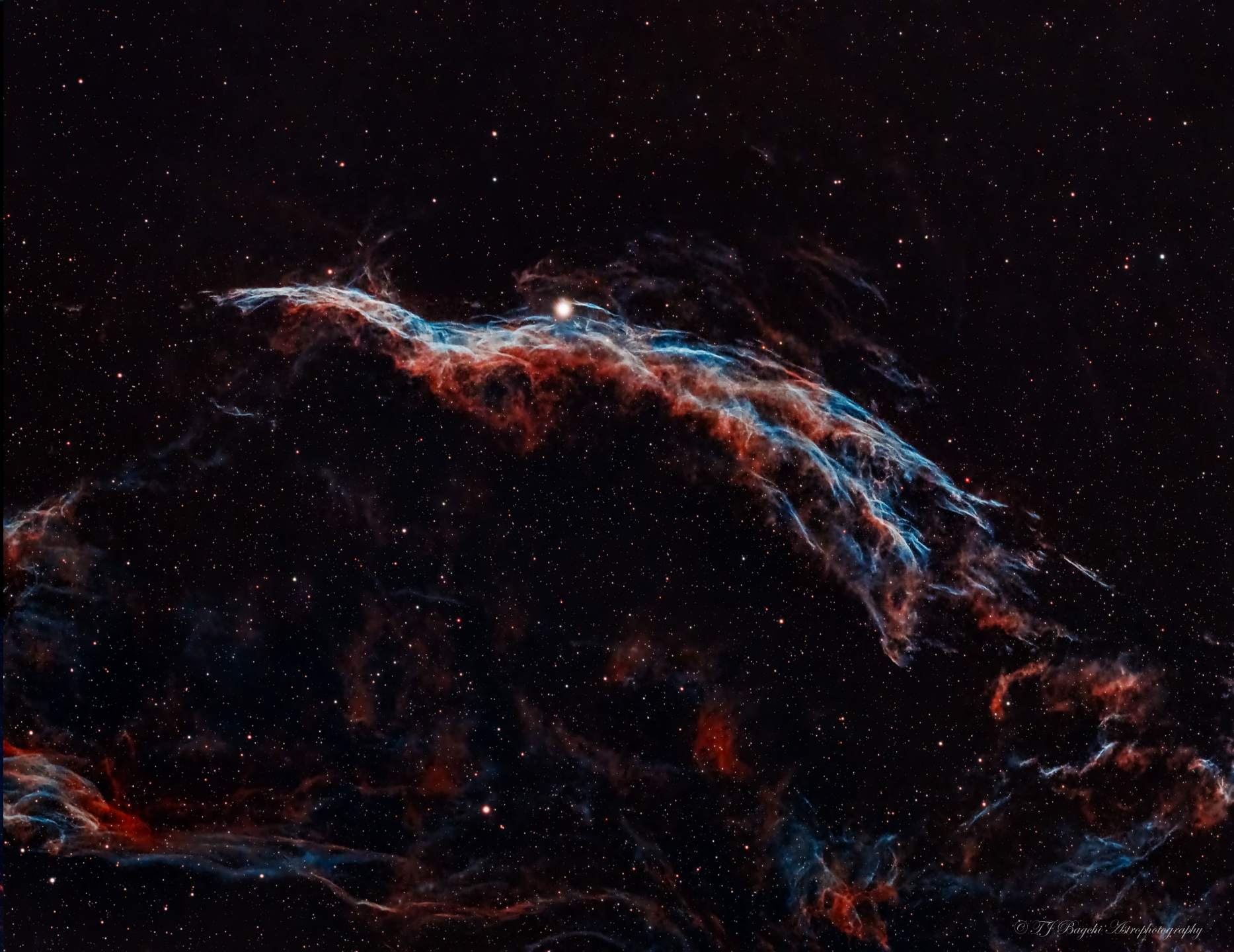
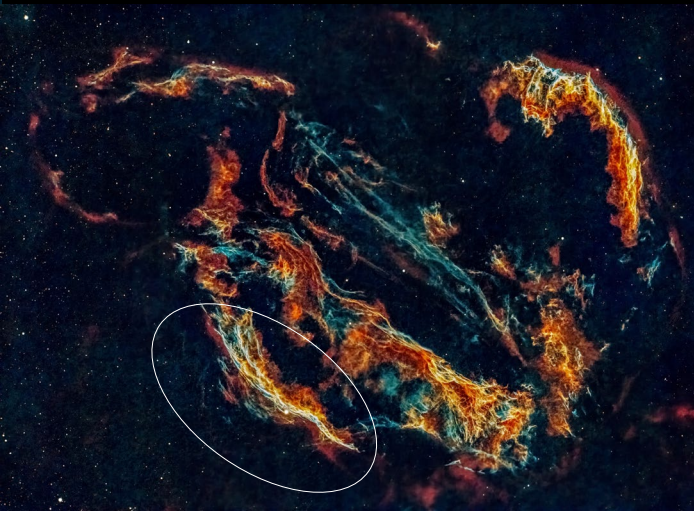
A Type II
(core-collapse)
Supernova
Remnant



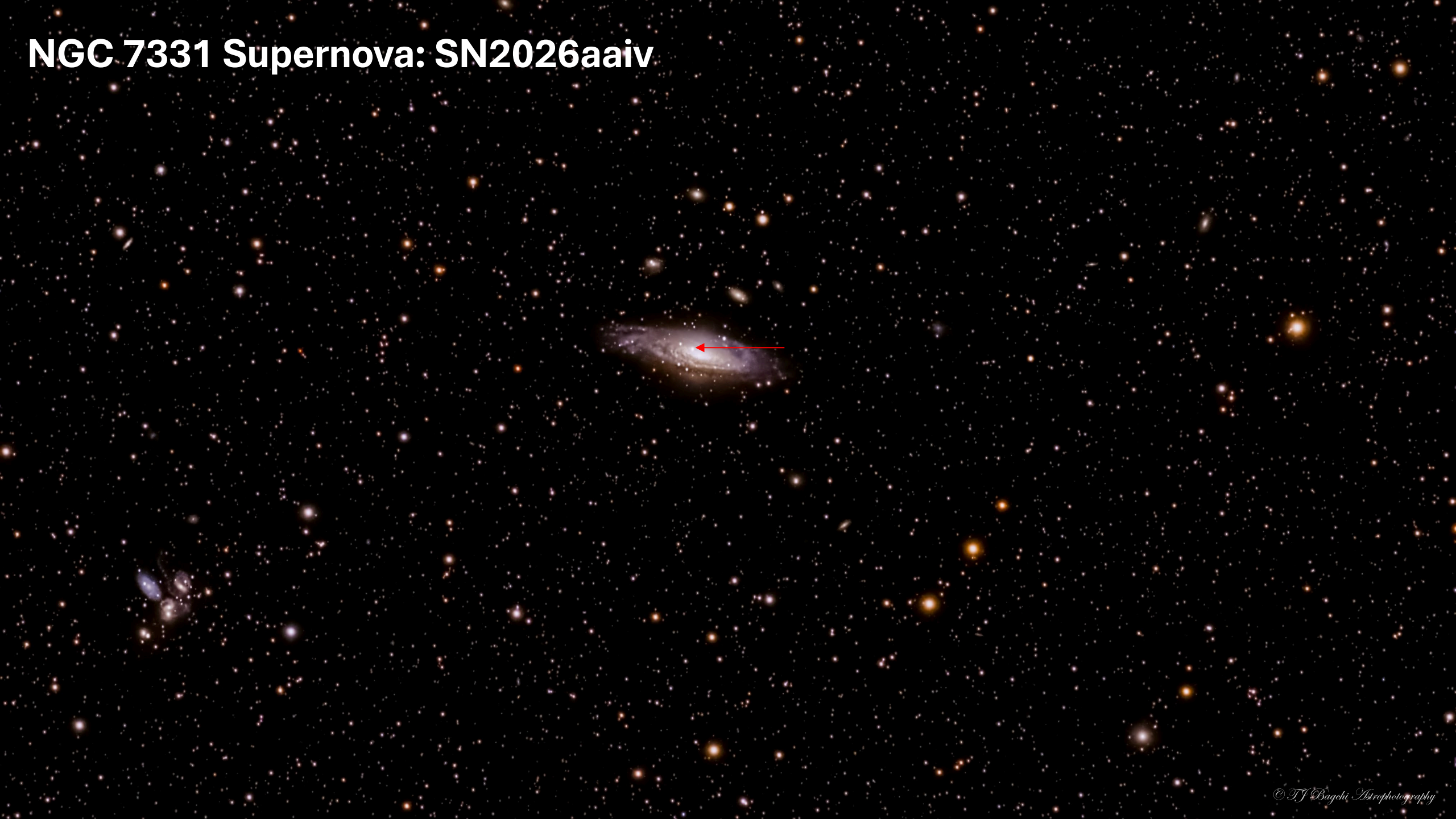
The Eastern
Veil Nebula
(Bat Nebula)
(NGC 6992)



The Western Veil
Nebula
(Witches' Broom
(NGC 6960)



NGC 7331 Supernova: SN2026aaiv

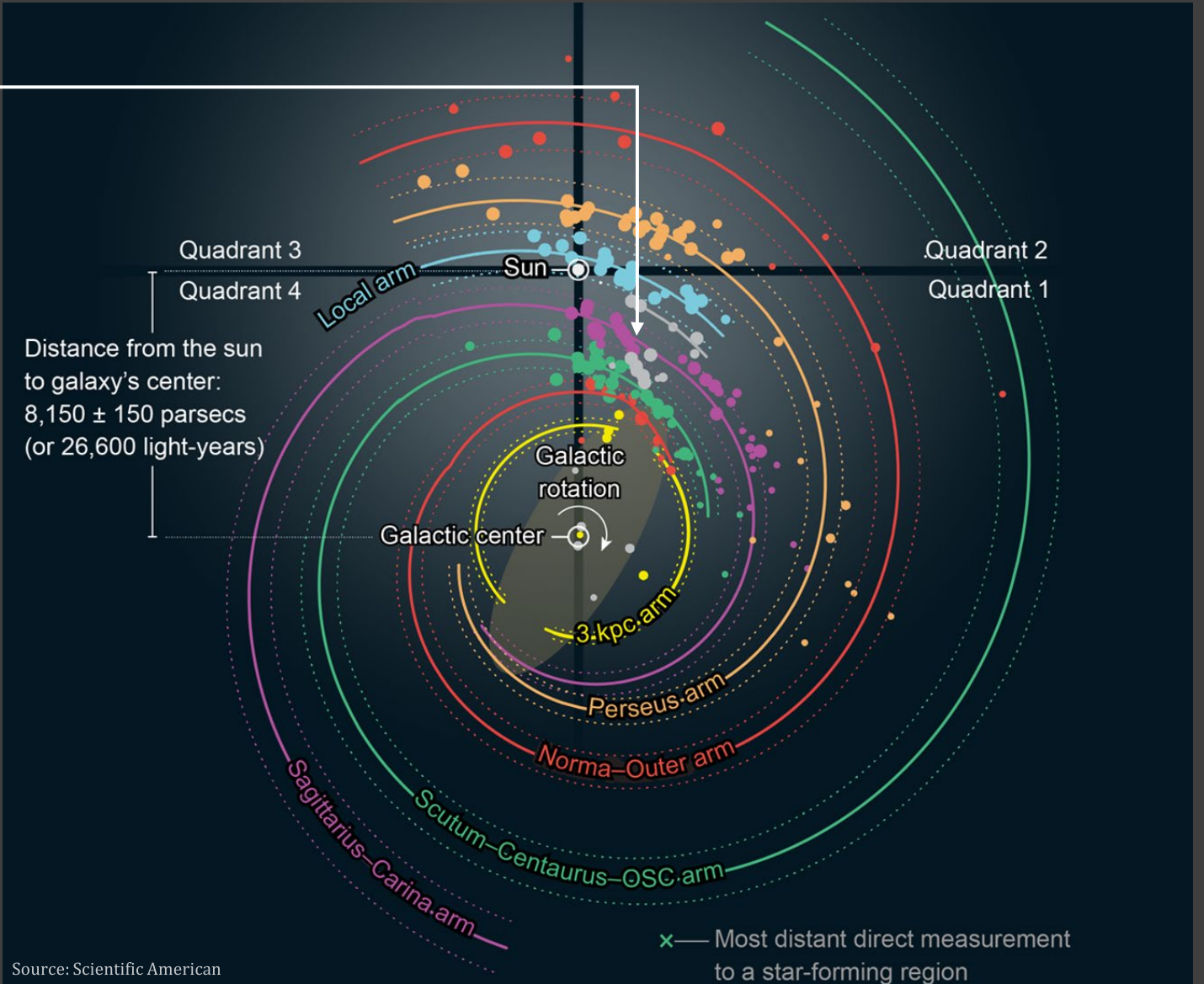


Part 3:

Galaxies, The Metropolis of Stars



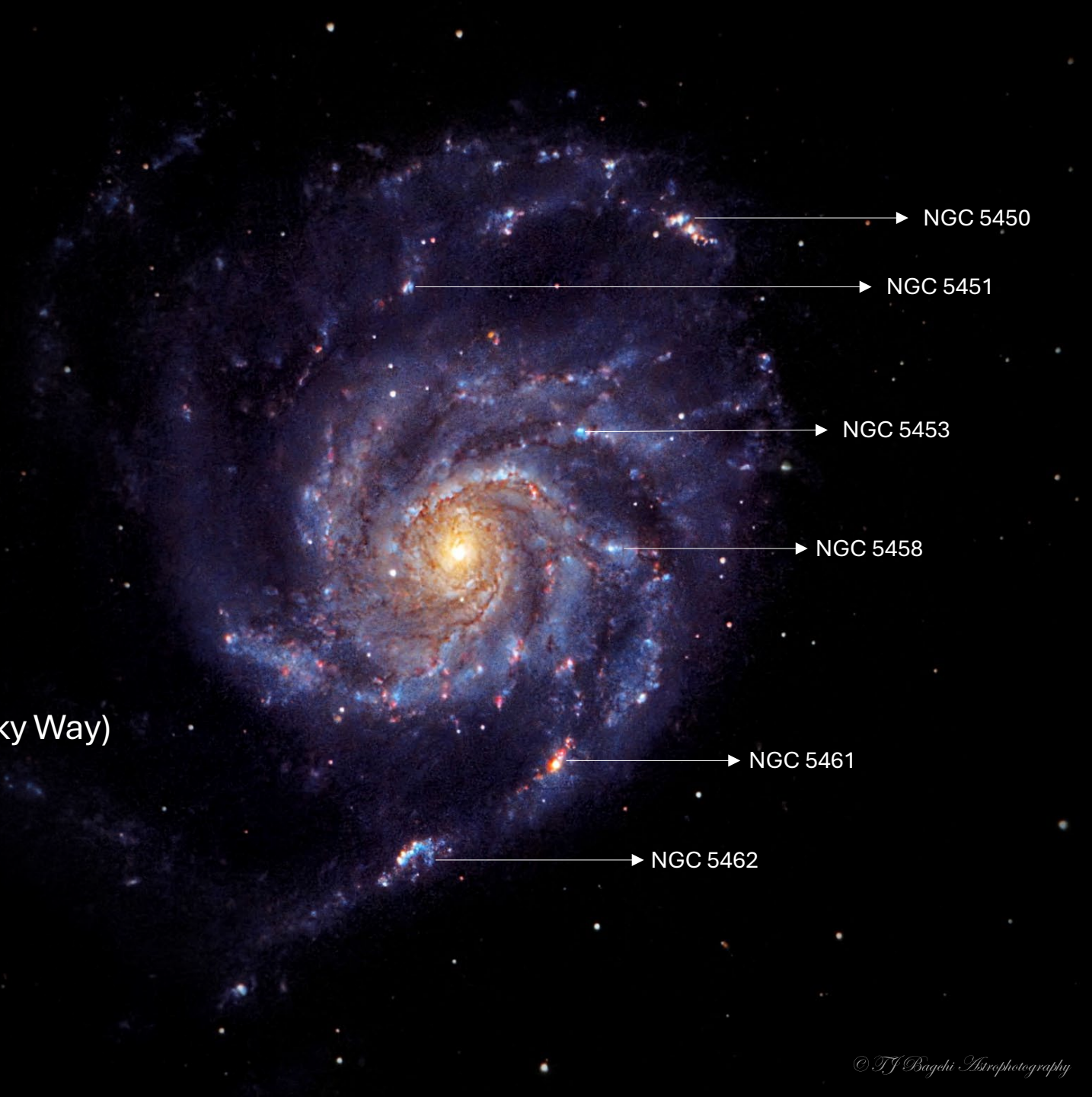
The Milky Way: Our Home in the Universe



Galaxies: A (very large) City of Stars, Nebulae, Dark Matter and Black Holes

The Pinwheel Galaxy (Messier 101):

- Large 'face-on' spiral galaxy
- 21-27 million light years away
- 170,000 light Years across (twice the size of Milky Way)
- Home of a trillion stars
- Many active star forming regions (nebula)



Andromeda: Our Galactic Neighbor



Triangulum: Another Galactic Neighbor



Galaxies: In Many Shapes and Sizes



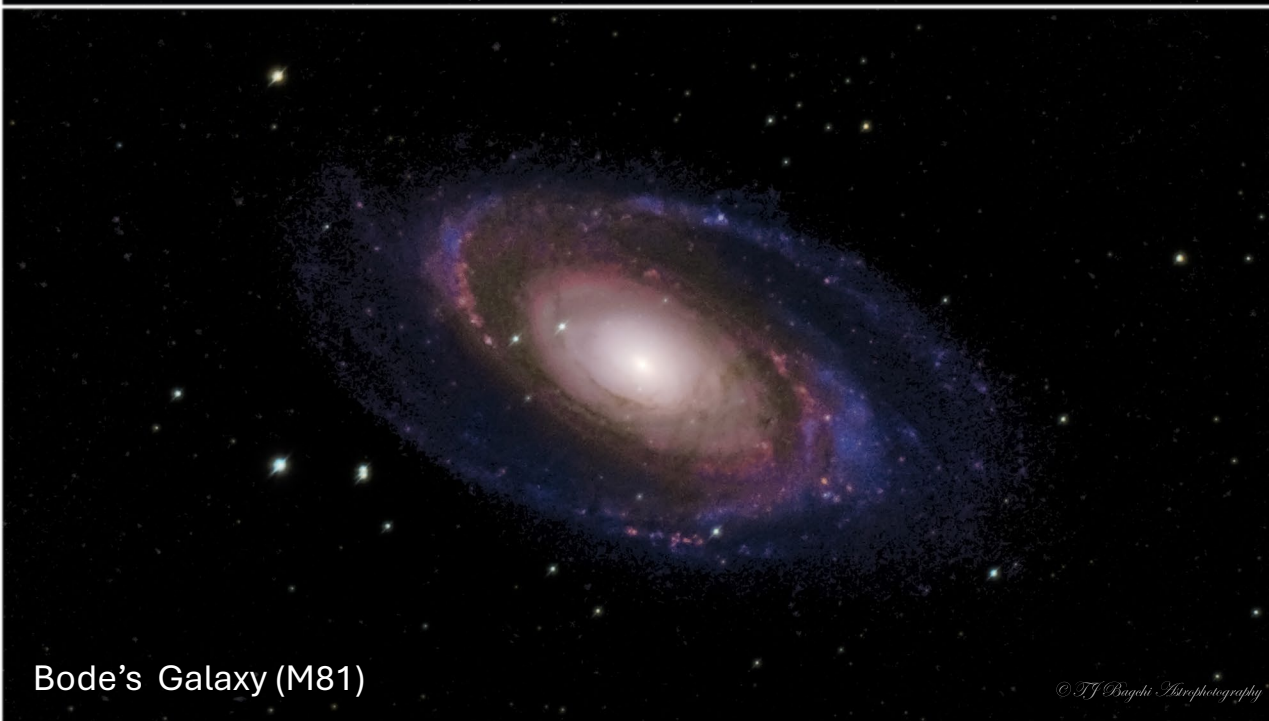
Bode's Galaxy and Cigar Galaxy (M81 & M82)

© TJ Bagchi Astrophotography



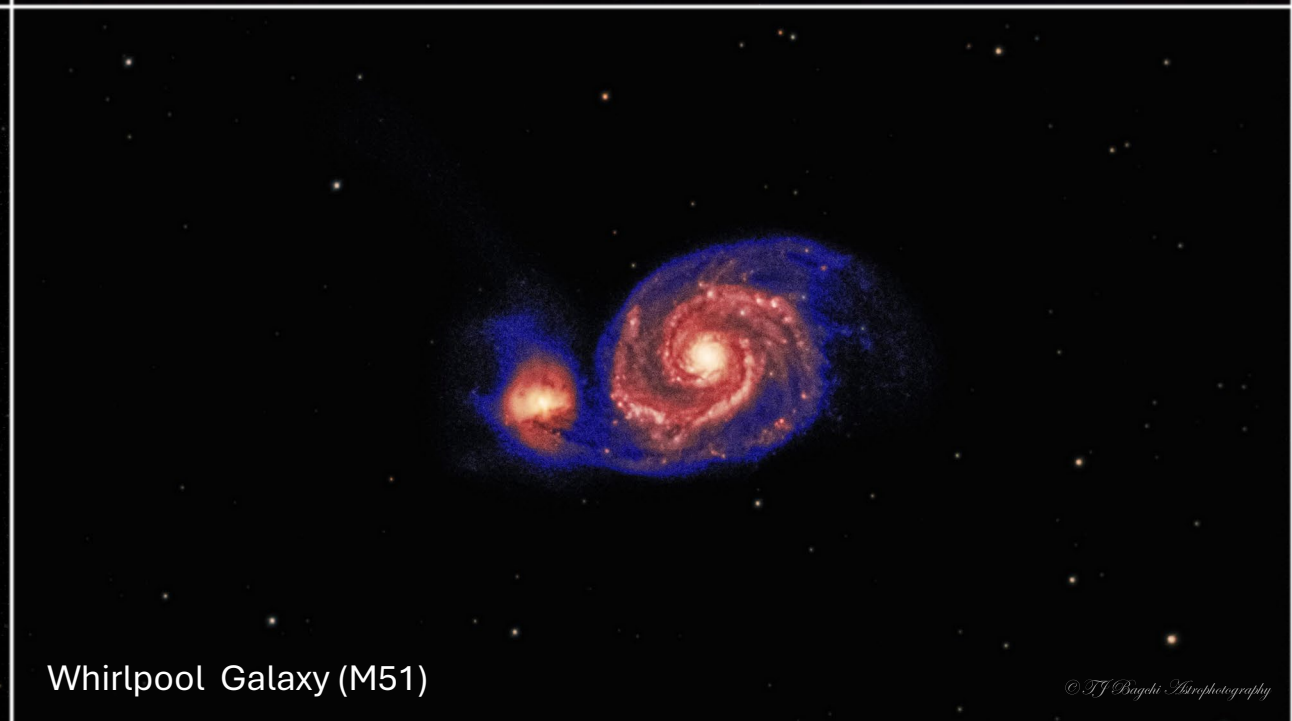
Sunflower Galaxy (M63)

© TJ Bagchi Astrophotography



Bode's Galaxy (M81)

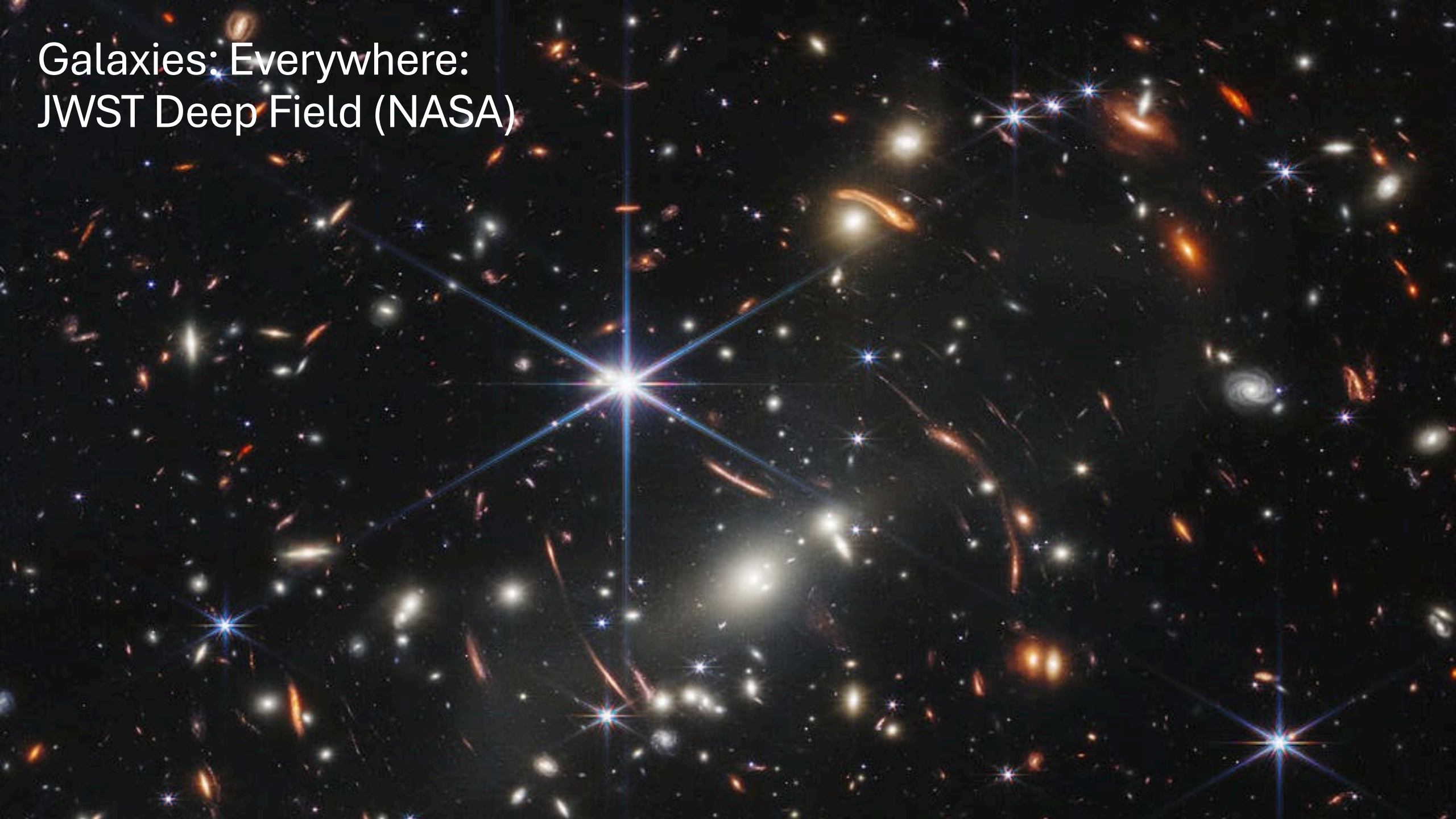
© TJ Bagchi Astrophotography



Whirlpool Galaxy (M51)

© TJ Bagchi Astrophotography

Galaxies: Everywhere:
JWST Deep Field (NASA)



Part 4:

Capturing the Light

The Science and Art of Astrophotography

**The Flaming Star Nebula
(IC 405)**

**The Tadpole Nebula
(IC 410)**

Equipment

Hardware

- Main telescope for imaging/viewing
- Small telescope for guiding
- Tracking Mount
- Tripod
- Camera
- Filters
- Controller for imaging sequence
- Reducers and Field Flatteners
- Dew Shield and Dew Heaters
- Electronic Filter Wheel (EFW)
- Electronic Automatic Focuser (EAF)
- Camera Angle Adjuster (CAA)
- Mounting Brackets and Plates
- Other Accessories
- Clear and dark sky and a lot of patience!

Software

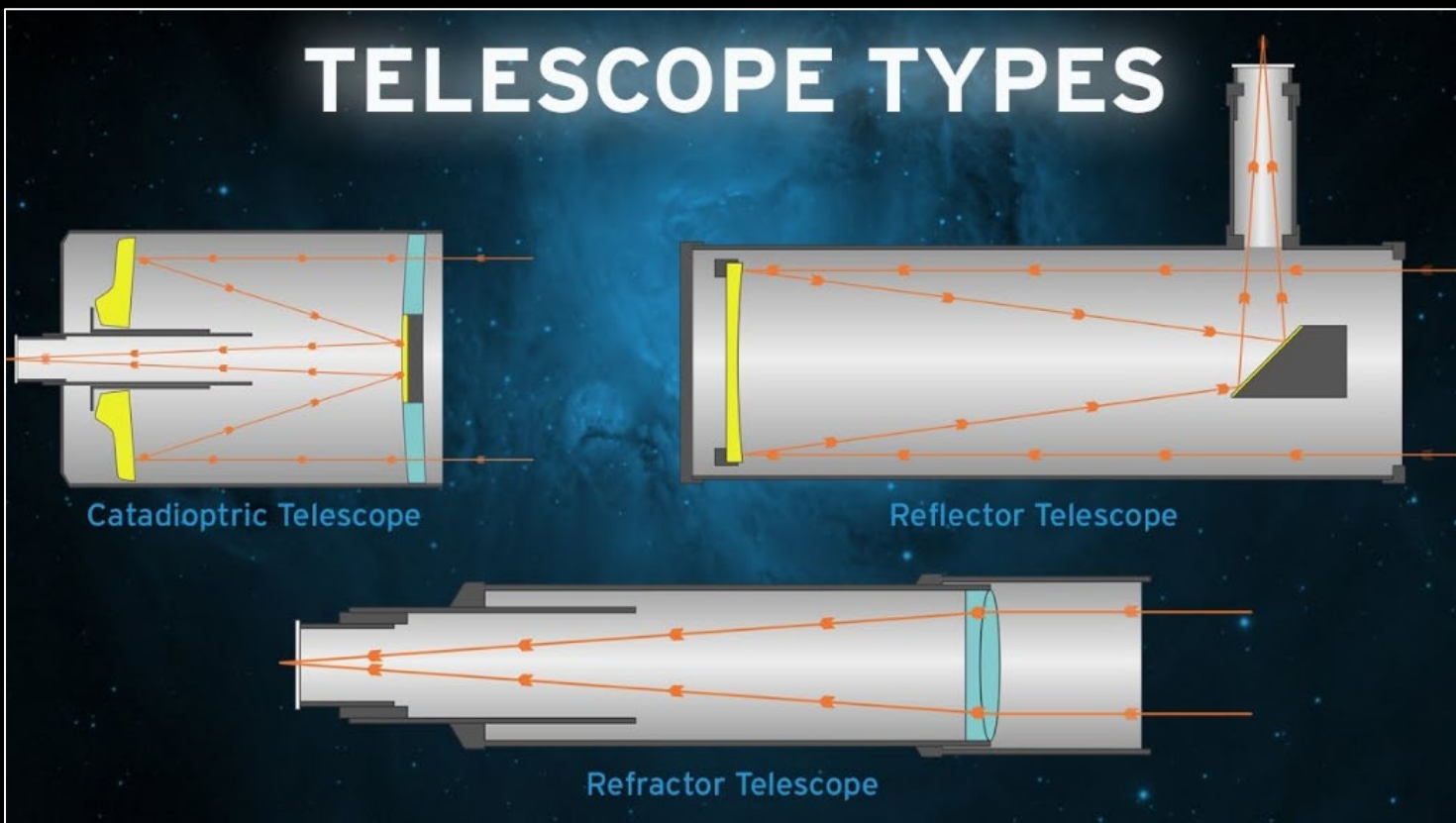
- Image Sequencing, Plate Solving (ASI Air, N.I.N.A.)
- Equipment Control (ASI Air, N.I.N.A)
- Guiding (ASI Air, PhD2)
- Image Stacking (DeepSky Stacker, Siril, Pixinsight)
- Image Pre-Processing (Siril, Pixinsight)
- Image Post-Processing (Siril, Pixinsight, Photoshop)
- Specialized software for star processing
- Specialized software for noise reduction
- Production Processing: (Photoshop)
- AI Tools: (Photoshop, Google Photo)
- Star chart and maps (Skymap, Stellarium)
- Manufacturer specific software (Celestron, Zwo)
- Internet resources for learning



Smith-Cassegrain (SCT)



TELESCOPE TYPES



Newtonian



Richey- Chretien



Dobsonian



Keck Observatory



Hubble Space Telescope



Refractor



Yerkes Observatory,
World's largest Refractor

Telescope Types and Focal Lengths in Astrophotography

- ❑ **Refractors:** 200-1200 mm , general purpose deep Sky Astrophotography. Focal Length depends on target. Also great for visual astronomy.



Rosette Nebula, 700mm Refractor

- ❑ **Smith Cassegrain (SCT):** 1500-3000 mm, Planetary imaging and small deep sky objects and close-ups.



Crescent Nebula, 2000 mm Smith-Cassegrain (SCT)

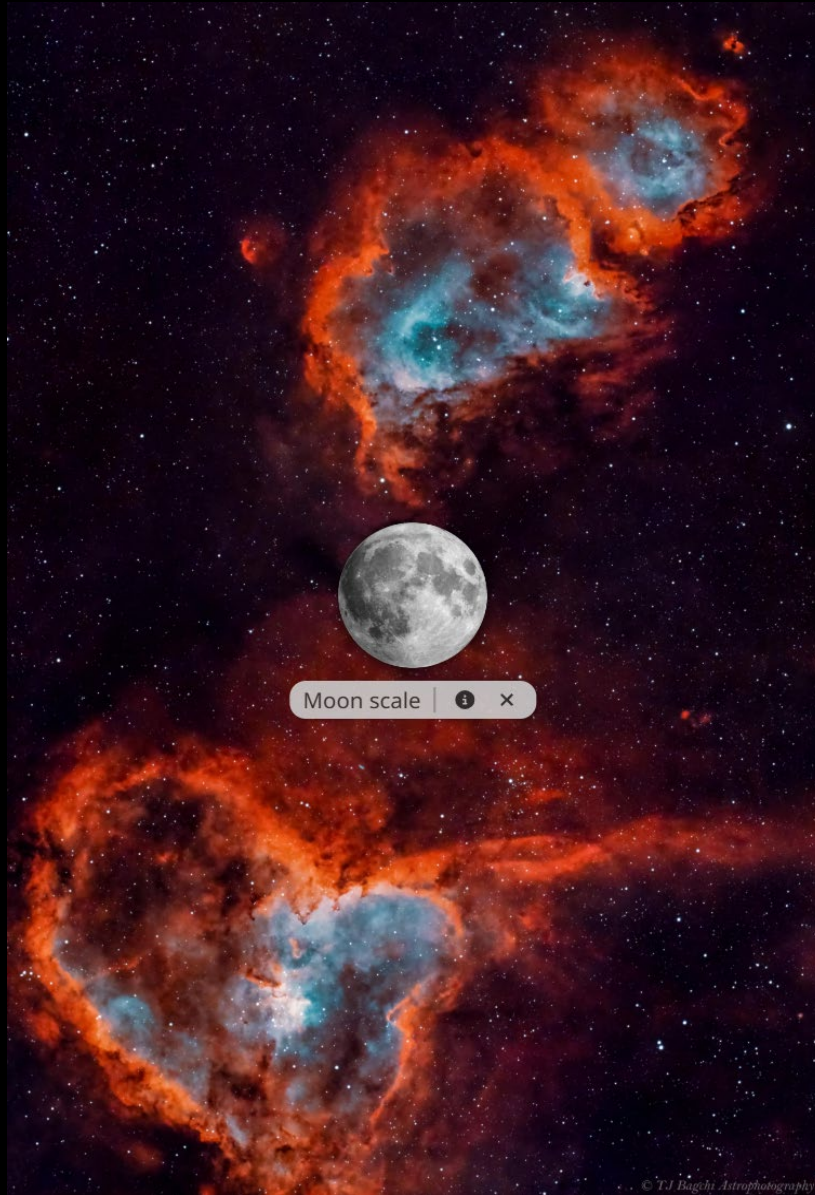
- ❑ **Newtonian:** 400-700 mm, Very fast (large aperture) scopes, ideal for faint deep sky objects.



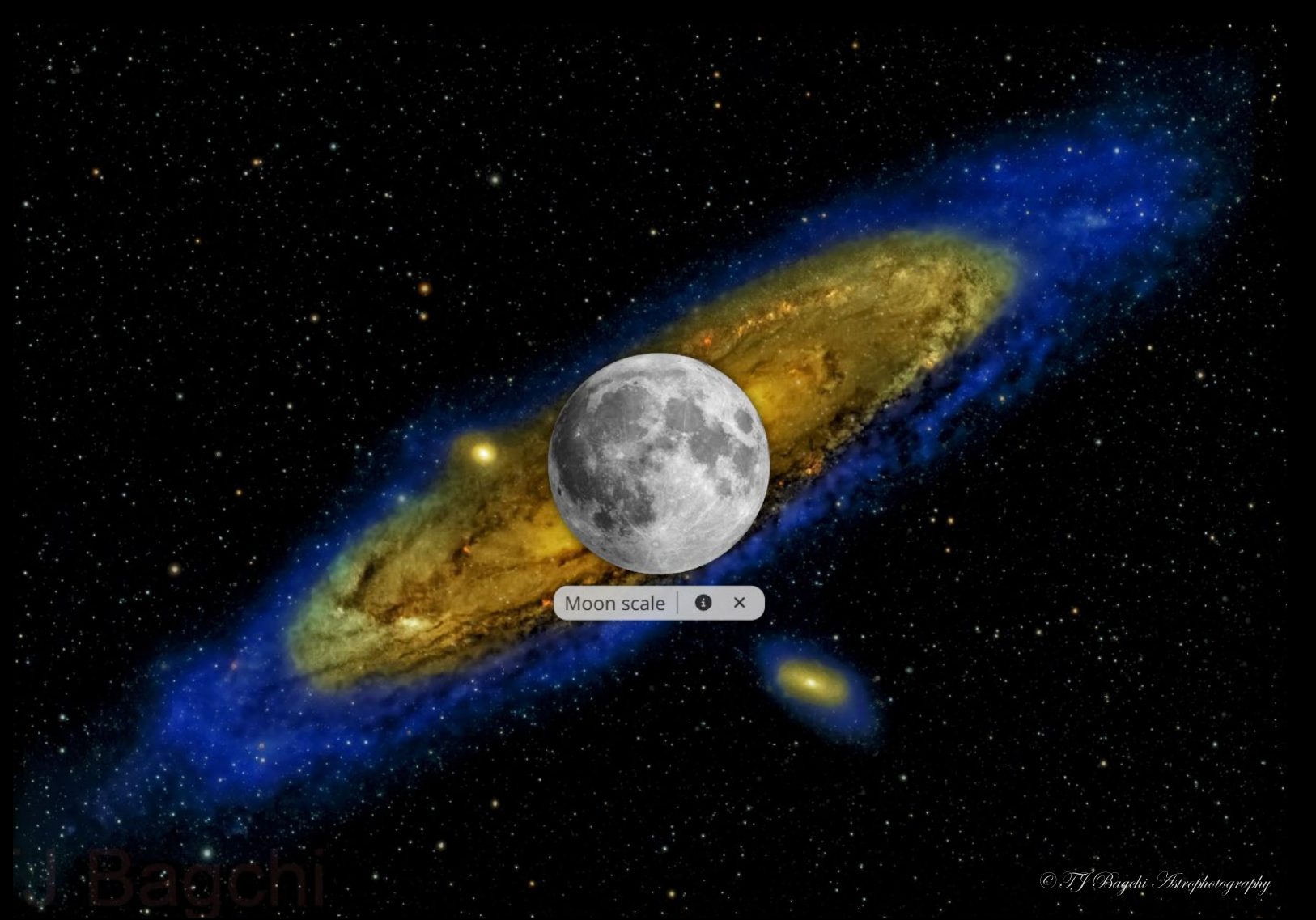
Dragon Nebula, 400 mm Newtonian

- ❑ **Dobsonian:** Large light bucket at reasonable price, ideal for visual astronomy.

Focal Length: Depends on the Subject and Composition



Heart and Soul Nebulae, 300mm Refractor



Andromeda Galaxy, 500mm Refractor

Pixel Scale, not Magnification

- ❑ Magnification is a visual astronomy concept (focal length on scope/focal length of eyepiece), not relevant in astrophotography. Astrophotography images can always be magnified digitally on the screen.
- ❑ Signal To noise ratio (SNR) and resolution are the relevant quality measure in astrophotography.
- ❑ Pixel Scale can be used for both. Pixel Scale = (size of pixel in μm /size of scope in mm) *206.3.
- ❑ Pixel scale determines how much of the sky in arcseconds one pixel can capture. Low pixel scale means high resolution but possibility of more noise. High pixel scale imply low noise but can reduce resolution.
- ❑ A pixel scale between 1-2 is considered optimum.
- ❑ A $3.76 \mu m$ pixel matched with a 700mm refractor has a pixel scale = 1.1 (good).

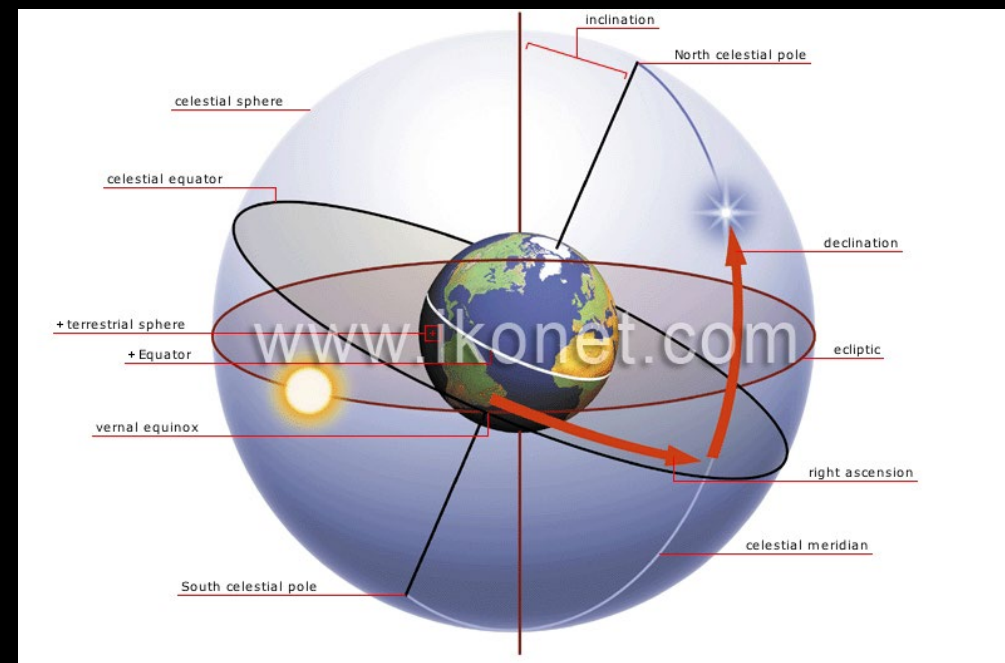
Camera

- **Dedicated astrophotography cameras:**
Purpose-built astronomy cameras are available as **One-Shot Color (OSC)** or **Monochrome** sensors.
- **DSLR option:**
DSLRs can be used for astrophotography but typically require **astro-modification** (removal of the IR-cut filter) to capture deep-sky wavelengths in the red spectrum (hydrogen, nitrogen).
- **Sensor types and pixel size:**
Pixel sizes typically range from **$\sim 1.5\text{ }\mu\text{m}$ to $9\text{ }\mu\text{m}$** .
Sensors are either **CMOS** (most consumer and pro-consumer cameras) or **CCD** (professional systems, larger pixels, higher cost).
- **Modern CMOS performance:**
Today's pro-consumer **CMOS cameras** are **highly optimized** for low noise, high sensitivity, and fast readout, making them excellent for most astrophotography projects.
- **Monochrome vs color:**
Many professional astrophotographers prefer **monochrome cameras with filters**, capturing different wavelengths separately and combining them during processing for maximum quality.
- **OSC cameras**, especially when paired with **narrowband filters**, are rapidly approaching comparable results as monochrome



Mount: The heart of the system!

- **Earth's rotation:**
Earth rotates at ~465 m/s at the equator, corresponding to 15° per hour relative to distant “fixed” stars (the sidereal rate).
- **Why tracking is needed:**
Astrophotography requires **long exposures**, which demand continuous tracking of celestial objects at the sidereal rate.
- **Equatorial mount concept:**
This is achieved by **polar aligning** one axis of the telescope mount with Earth's rotational axis and **tracking the target east–west** on the other axis.
- **Computerized equatorial mounts:**
These mounts keep the telescope precisely fixed on the target, making minute corrections using feedback from a smaller guide telescope that monitors the star field (autoguiding).
- **Celestial coordinate system:**
Astronomy uses **Declination (Dec)** — up/down, measured in degrees — and **Right Ascension (RA)** — east–west rotation, measured in hours, minutes, and seconds.
The equatorial mount **tracks along the RA axis**.
- **Alt-Az mounts:**
Altitude–Azimuth (Alt-Az) mounts are well suited for visual observing but cause field rotation in long-exposure astrophotography. Dobsonian telescopes use Alt-Az mounts.



Putting it all together



Processing and Production



Astro-Image Processing

Behind the Scenes

Color Palette: The Art

The Elephant's Trunk
Nebula in SHO (IC 1396)

Emission lines:

Ionized atoms emit light at **specific wavelengths**, producing characteristic colors:

- **Hydrogen (H α)**: Red — 656.3 nm
- **Oxygen (O III)**: Greenish-blue — 500.7 & 495.9 nm
- **Nitrogen (N II)**: Purple-red — 658.3 nm
- **Helium**: Deep blue-violet — 447 nm
- **Sulfur (S II)**: Deep red — 671.6 nm

Color mapping flexibility:

These emission lines **do not have to be displayed in their natural colors** and can be mapped to different colors during processing.

False-color imaging:

NASA popularized **false-color palettes** with Hubble Space Telescope images to enhance visual appeal and reveal subtle structures not easily seen in natural color.

Hubble Palette (SHO):

A common mapping where: **Sulfur** → Red, **Hydrogen** → Green, **Oxygen** → Blue (SHO mapped to RGB)

Other popular palettes:

Additional mapping schemes include **HOO**, **HSO**, and **FORAX** (dynamic combinations); emphasizing different physical features.

Role of monochrome cameras:

Monochrome sensors capture emission data in **black and white**, allowing flexible assignment to any color palette during processing.

Image processing software:

Tools such as **Siril** and **PixInsight** can separate individual emission channels when **narrowband filters** are used, enabling fully user-defined color mapping

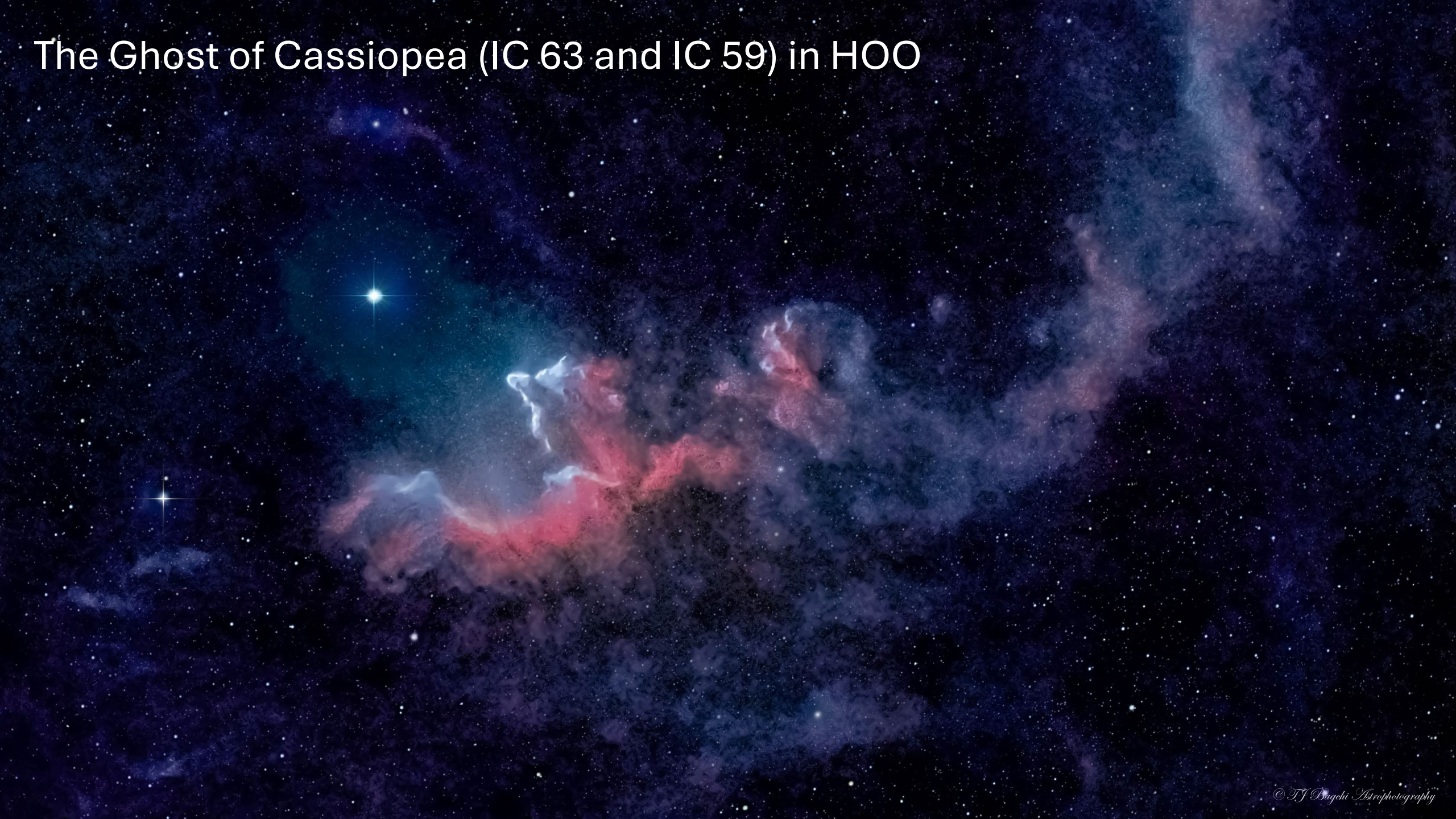
The Jellyfish
Nebula (IC 443)

SHO

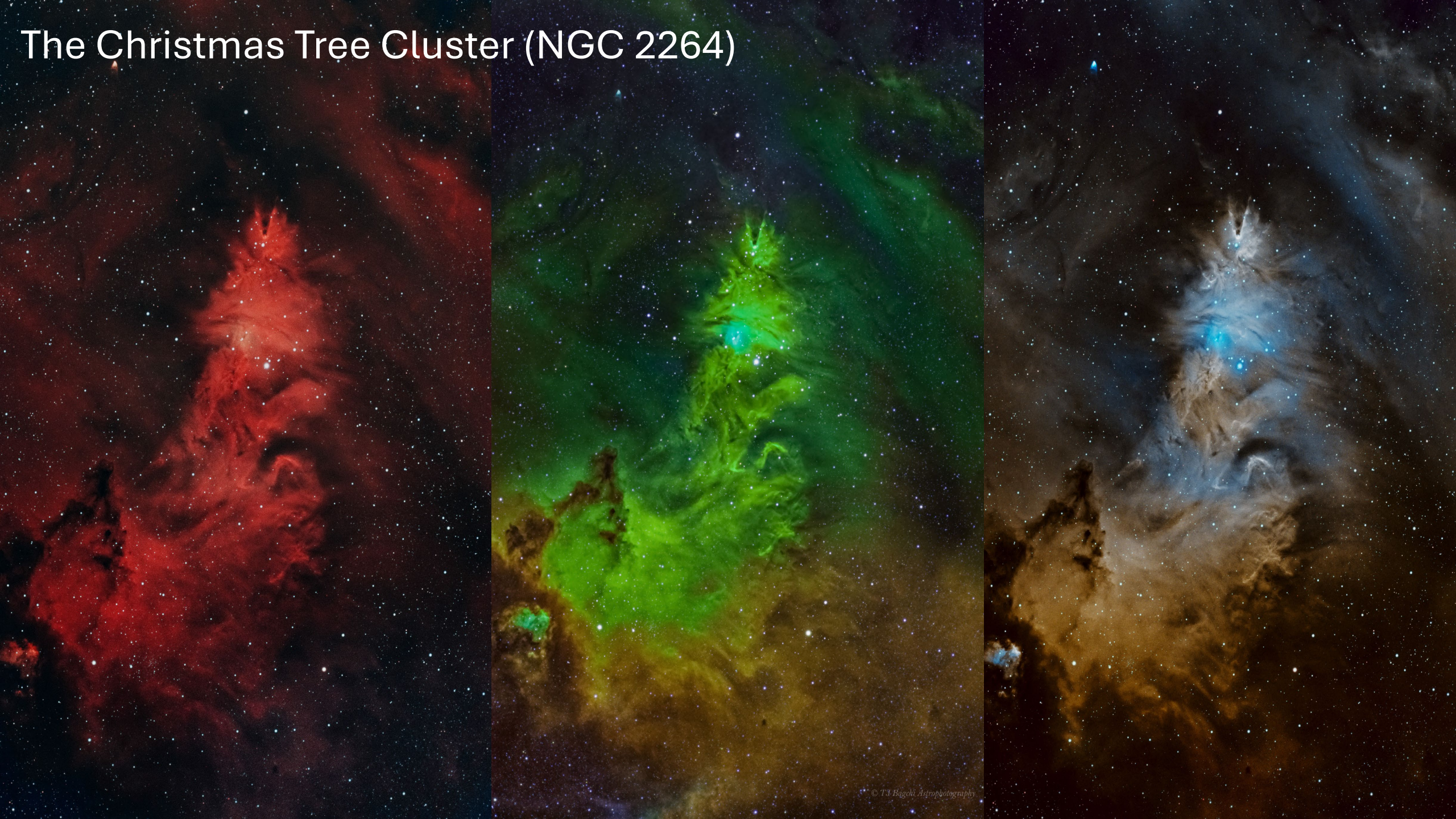
RGB



The Ghost of Cassiopea (IC 63 and IC 59) in HOO



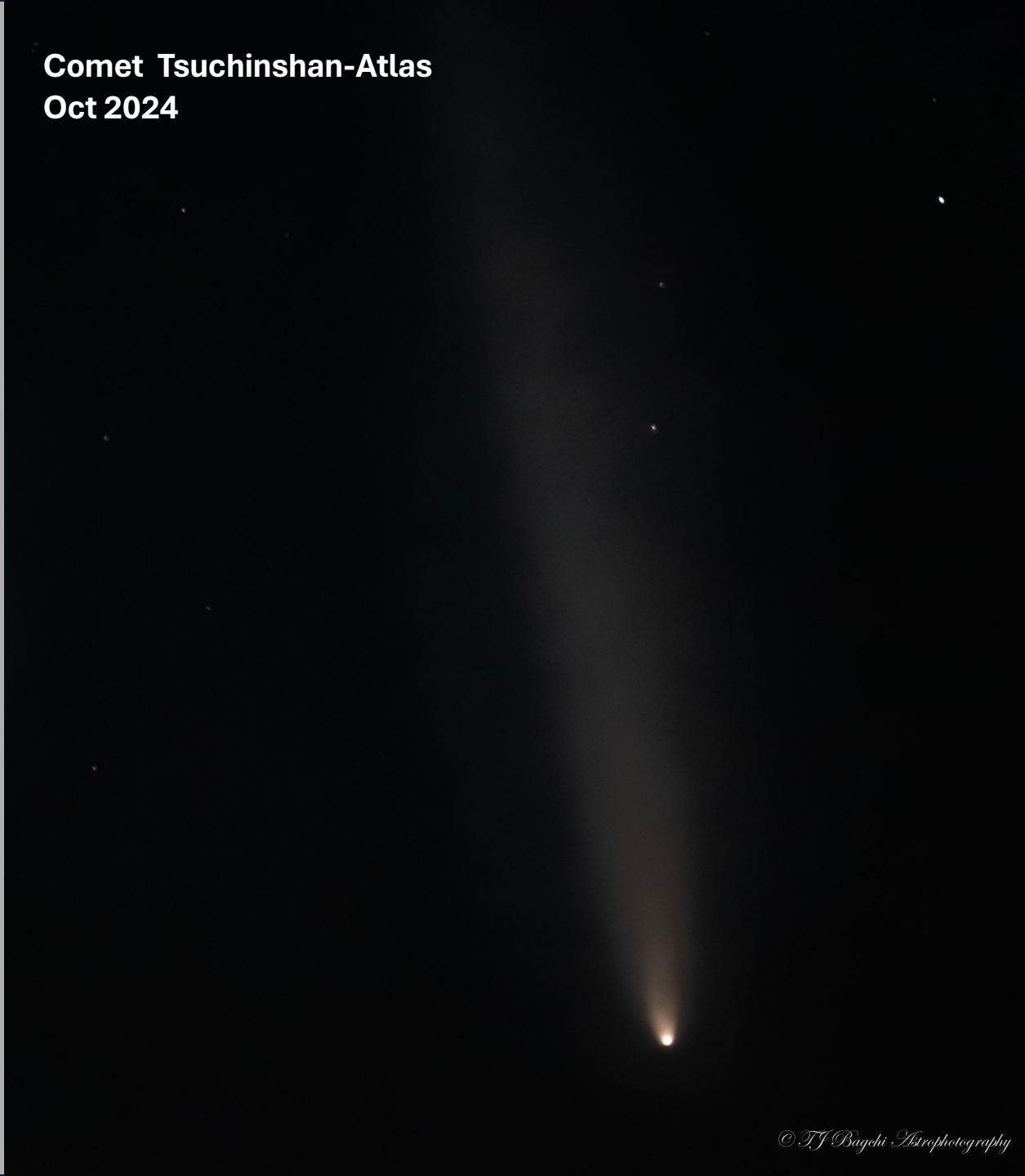
The Christmas Tree Cluster (NGC 2264)

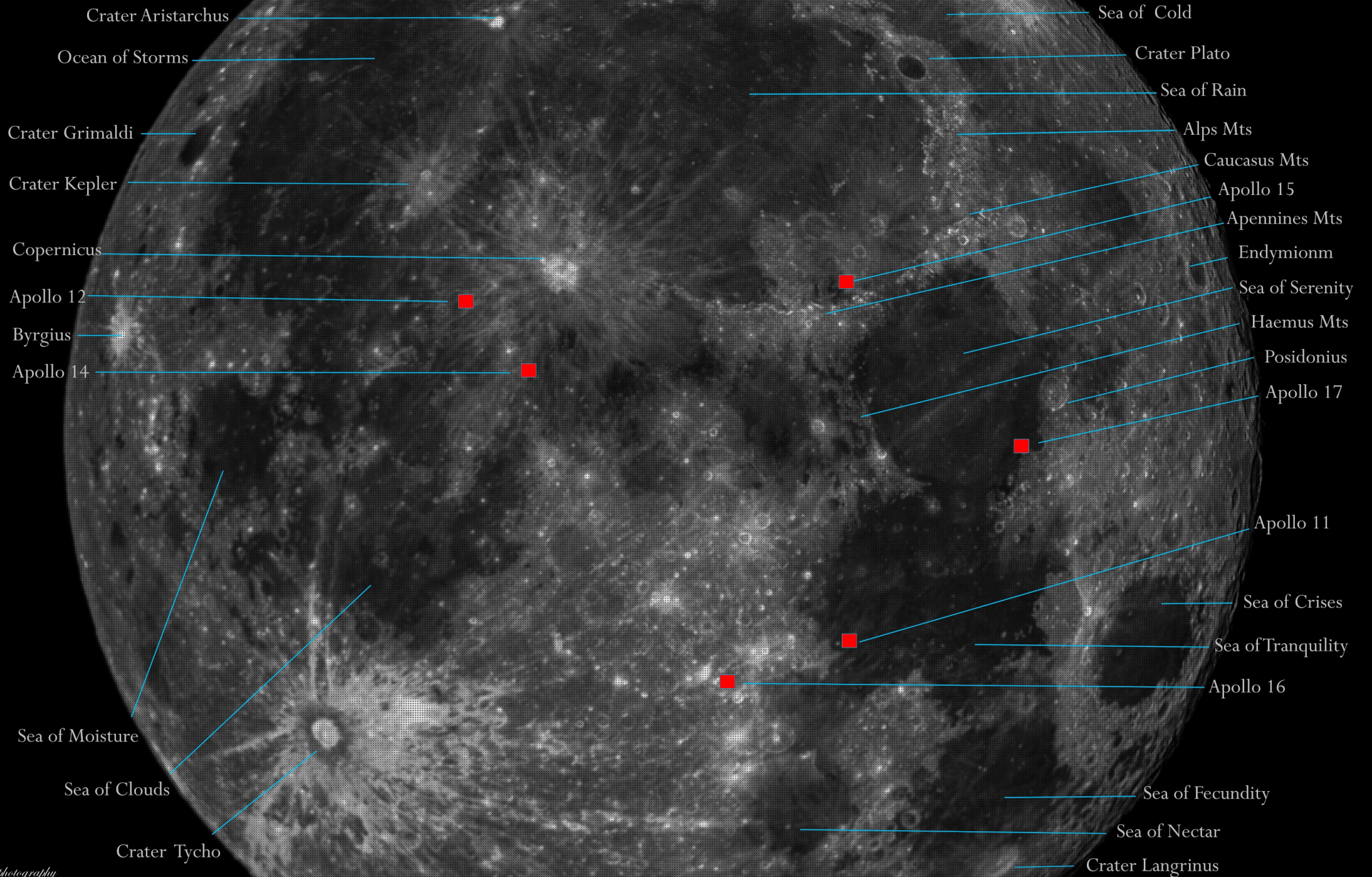


Comet Tsuchinshan-Atlas
Oct 2024

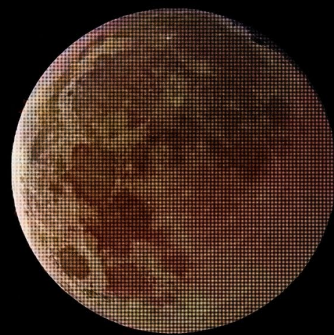
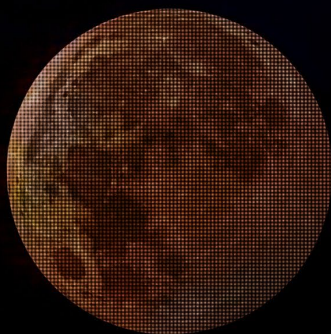
Epilogue:

**A Comet, the Moon
the Sun and an
Aurora**





Total Lunar Eclipse
Mar 14, 2025
Spring TX



Total Solar Eclipse Apr 8, 2024

Mckinney TX





Aurora Borealis
March 2026, Yellowknife Canada