
Create in the moment
Story Jazz

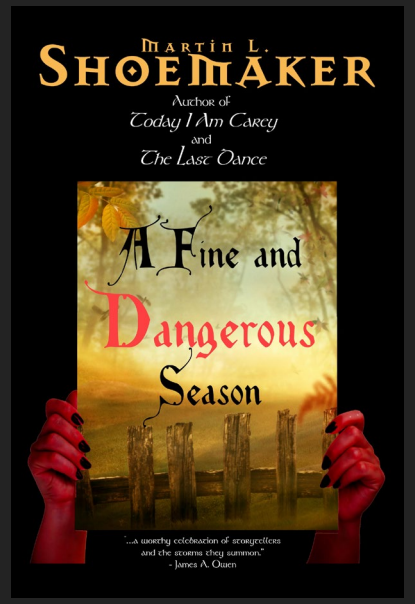
What's Up There?

Things to See in Space

Martin L. Shoemaker

Martin@Shoemaker.Space

Music: "Saxophone Song" by Mircea Iancu



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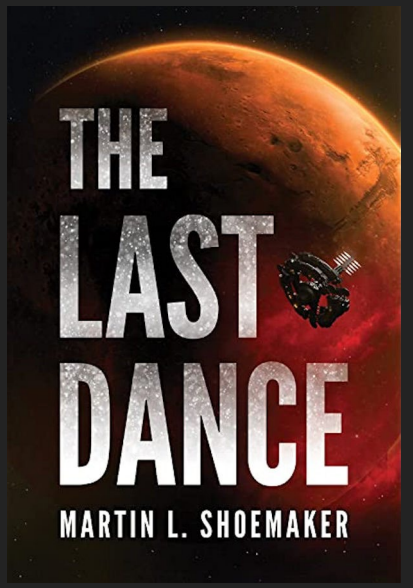
Some of My Books



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If This is the Last Slide We See…

My slides are available online.
http://Shoemaker.Space/WhatsUpThere.pdf

Your questions aren’t.

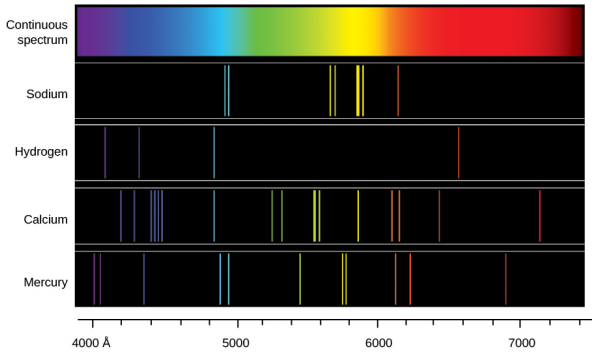
You’re more important than me,
and your questions are more important than my slides.

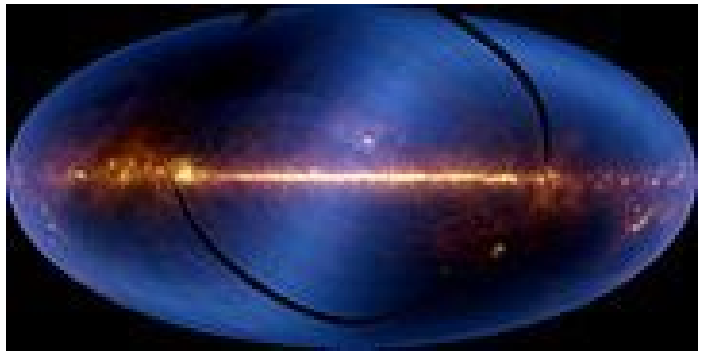
Ask! Object! Disagree! Participate!
Please!

Why Do We Look Up?

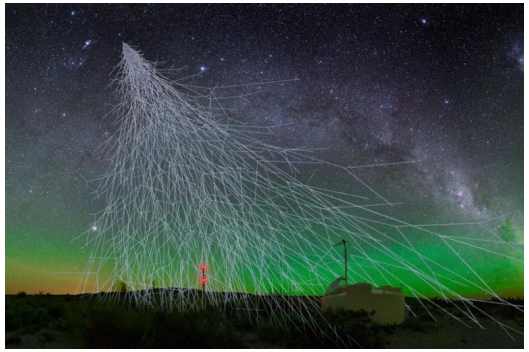
Why Do We Look Up?

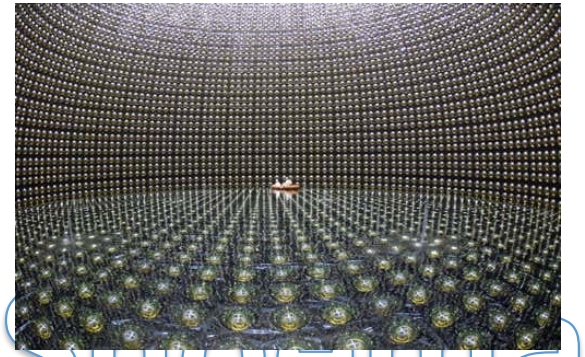
- The universe is pretty!
- The universe is awesome!
- The universe is inspiring!
- The universe is scary!
- The universe is educational!
- The universe is a frontier!
- The universe is a clock!
- The universe is a calendar!

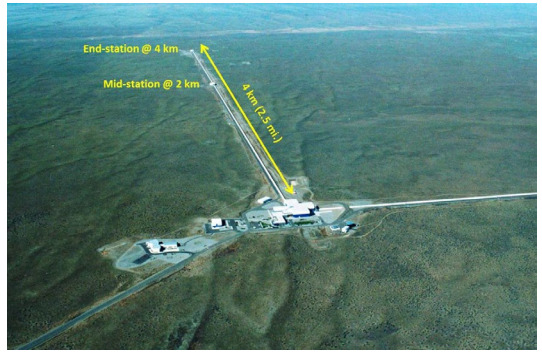


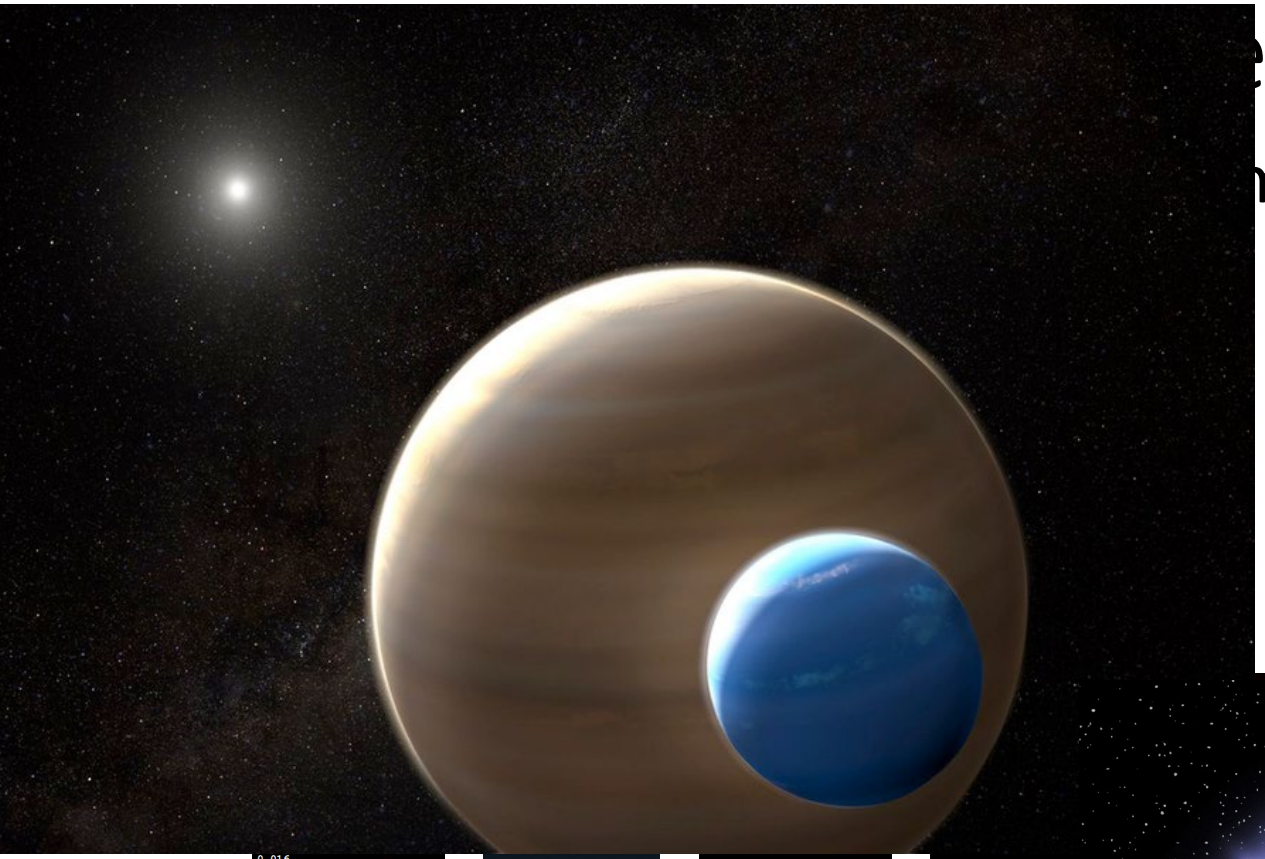


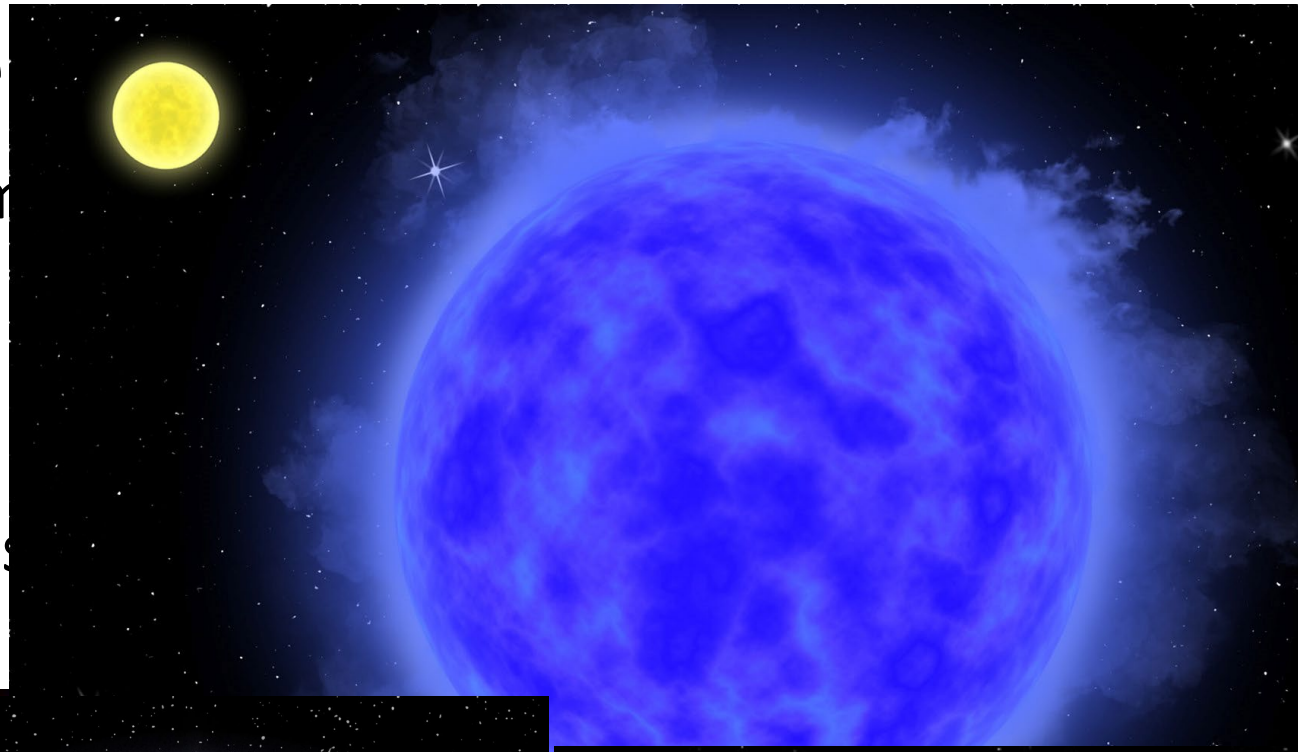
How Do We Look Up?

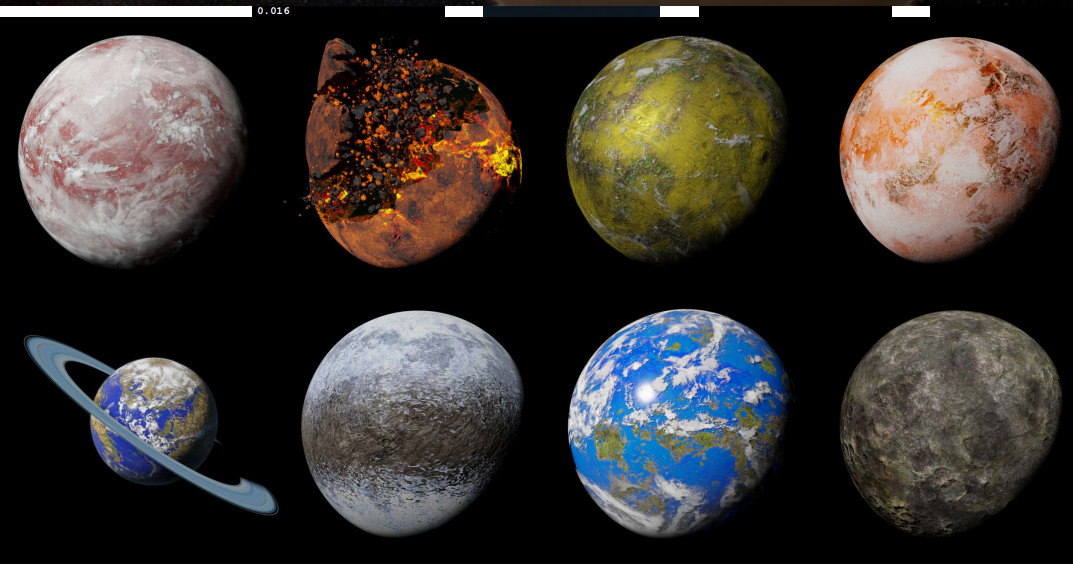


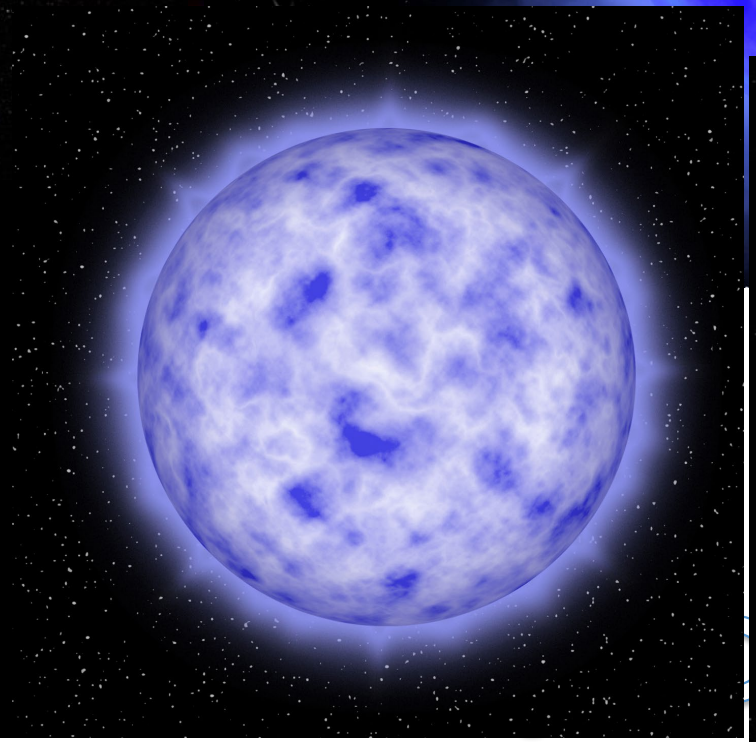


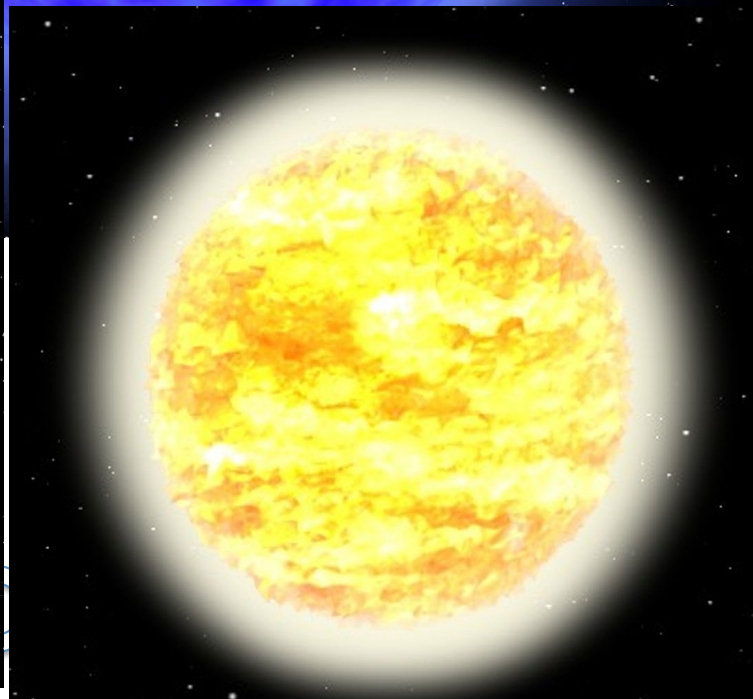








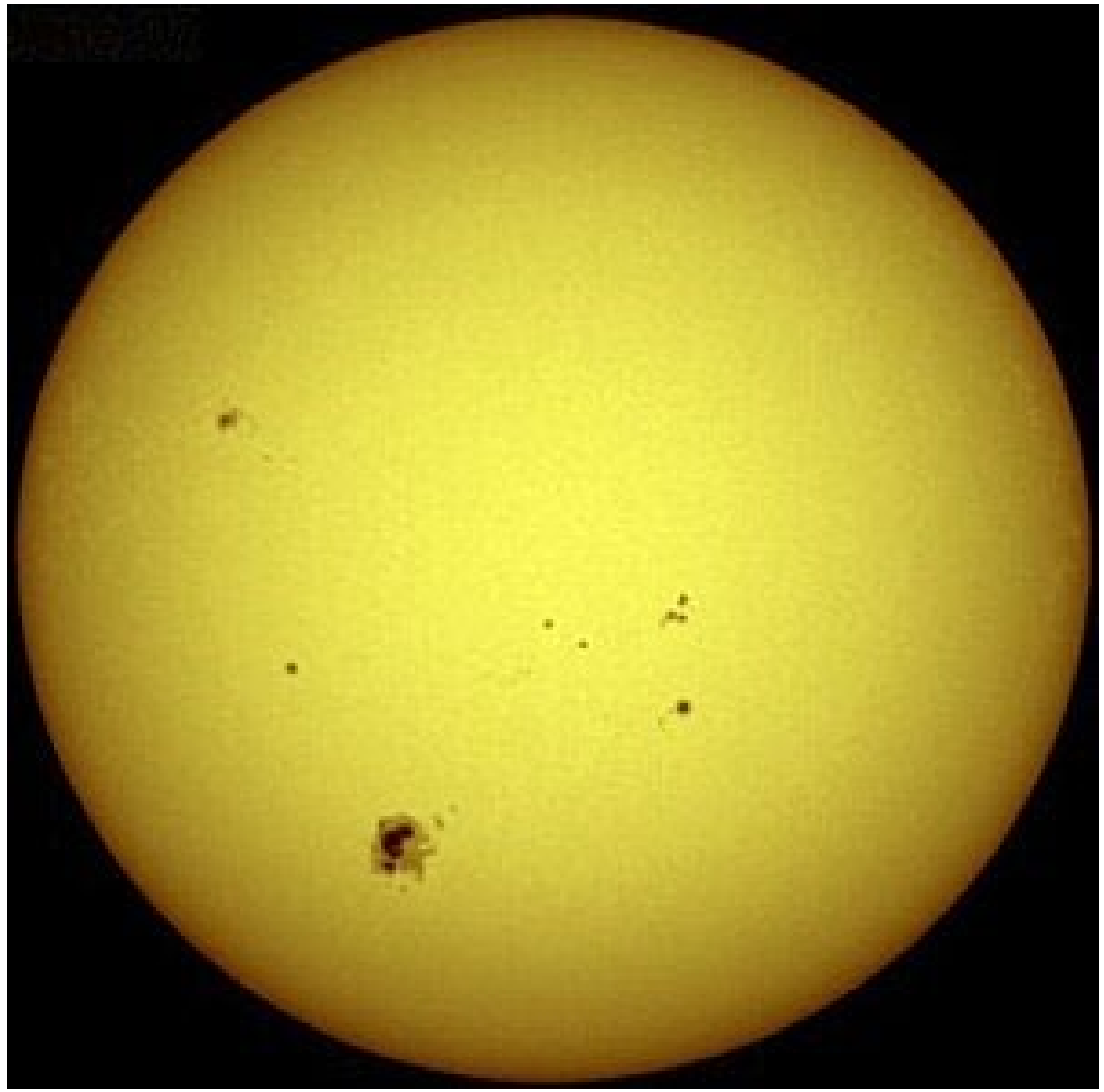




That Big Yellow Thing in the Sky

The Sun, a.k.a. Sol

- Nearest star.
- 93 million miles/150 million km/1 Astronmical Unit (AU).
- 1.39 million km across (109 Earths).
- 1.3 million Earths in volume.
- 5,700-5 million degrees Kelvin at surface.
- Sunspots.
- Solar flares.
- The Solar Wind.
- Coronal Mass Ejections (CMEs).



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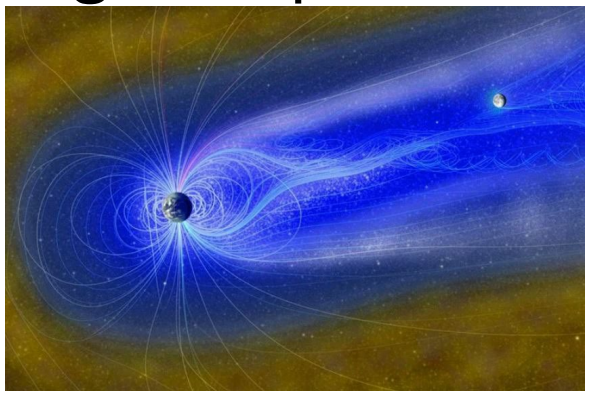
Earth and Our Atmosphere

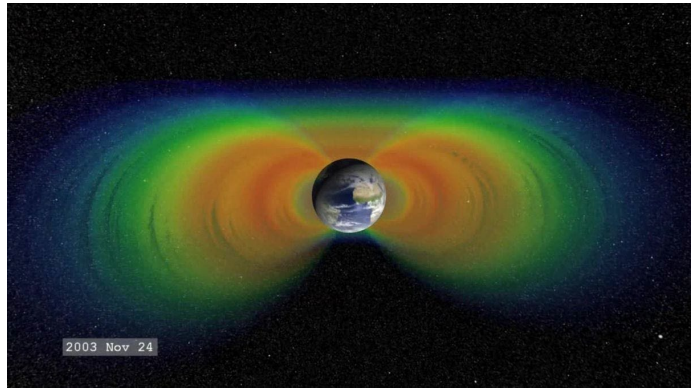
- Meteors.

- Auroras.

- Magnetosphere.



- Van Allen Radiation Belts.



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LEO: Low Earth Orbit

- 200-1,600 km
- Travel time: 8 to 9 minutes.
  - But then why does it take so long to reach the ISS??
- Light Speed: 0.005 seconds.

Geosynchronous

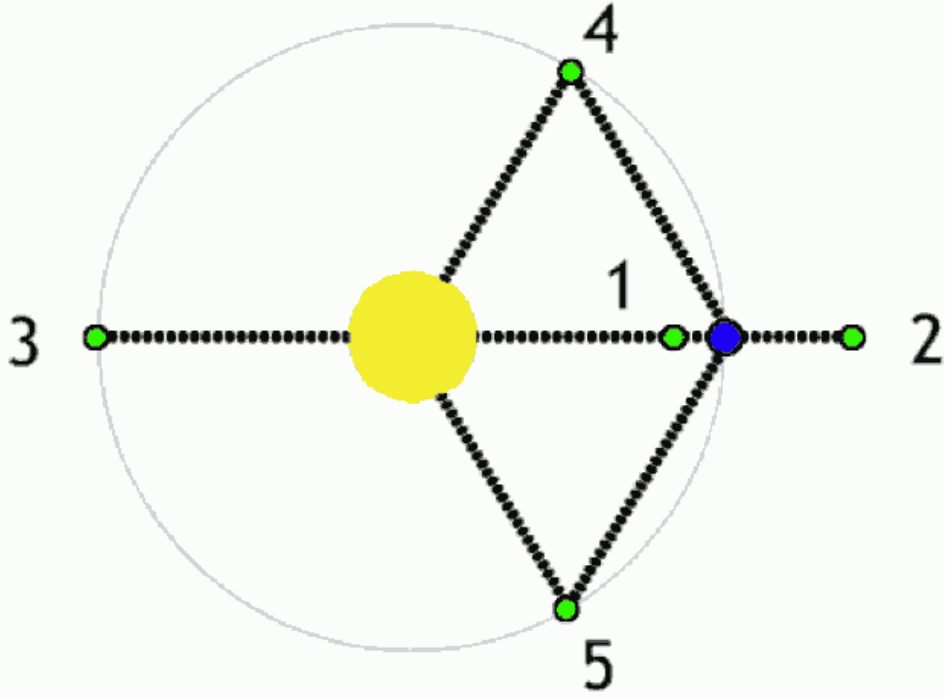
- 35,786 km
- Travel time: 5.25 hours
- Light Speed: 0.12 seconds

The Moon

- a.k.a. Luna.
- 384,399 km from Earth.
- Travel time: 3 days
- Light speed: 1.255 seconds
- Our only natural satellite.
- Radius: 1,737.4 km (0.2727 Earth radius).
- Orbital period: 29.53 days.

Lagrange points

- Gravitationally stable points.
  - 1, 2, 3: Semi-stable.
  - 4, 5: Fully stable.
- Dust clouds in 4 and 5.
- Asteroids **<u>may</u>** cluster in these.



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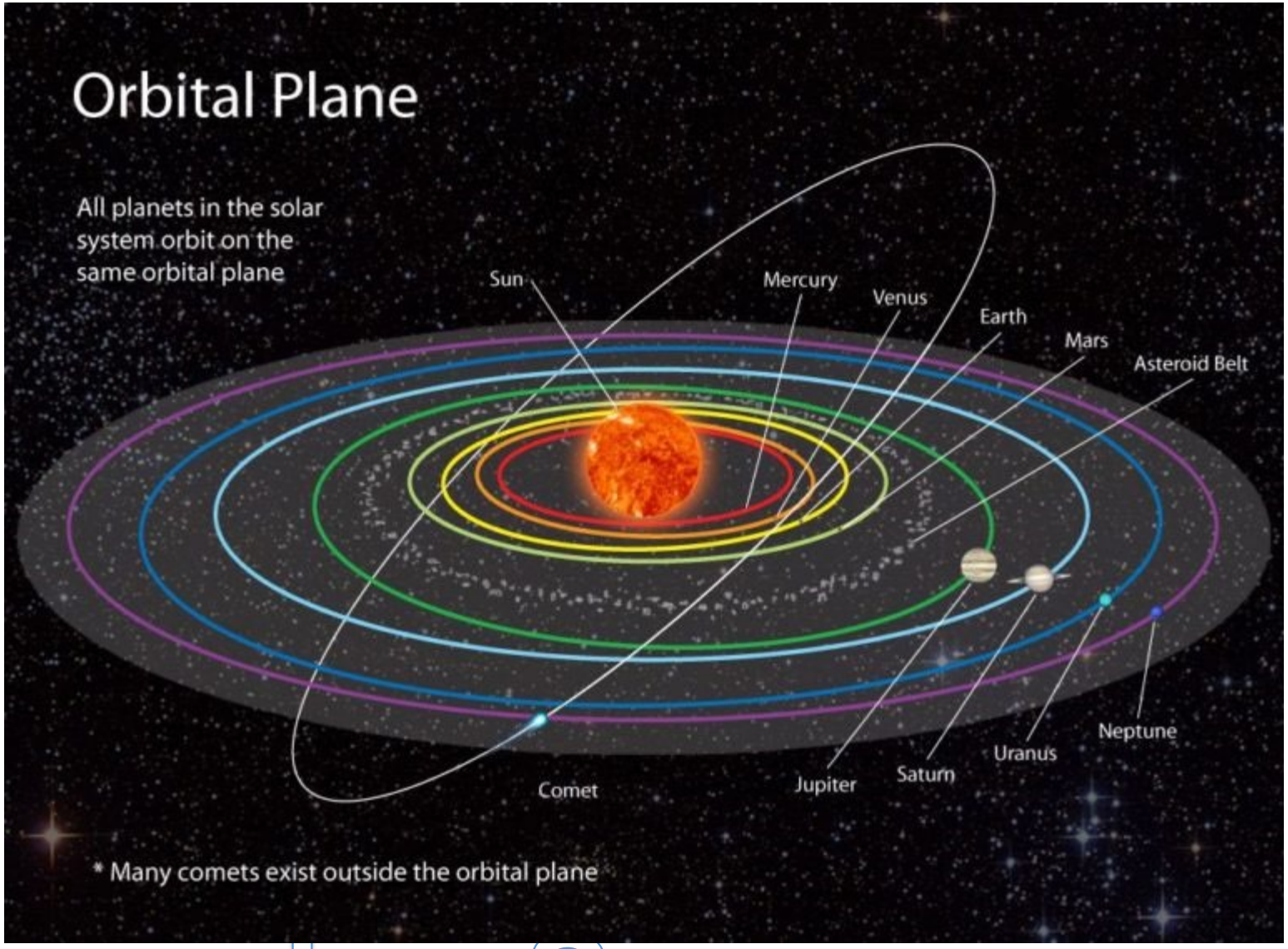
Planets

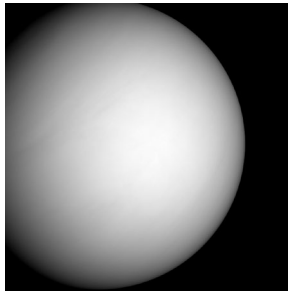
- Large bodies.
  - Rocky spheres.
  - Gas Giants.
  - Ice Giants.
- Orbit the Sun.



The Inner Planets

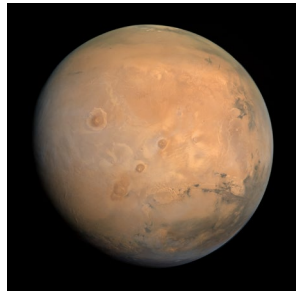
- Mercury
  - 0.387 AUs from Sun.
  - 0.382 times Earth radius.
  - “Year”: 87.97 days.
  - Temp: -193 C to 427 C.

- Venus
  - 0.723 AUs from Sun.
  - 0.950 times Earth radius.
  - “Year”: 224.7 days.
  - Temp: 464 C.



- Earth
  - 1 AU from Sun.
  - Radius: 6,371 km.
  - Year: 365.25 days.
  - Temp: -89.2 C to 56.7 C.

- Mars
  - 1.523 AU from Sun.
  - Radius: 3,389.5 km.
  - “Year”: 686.98 days.
  - Temp: -110 C to 35 C.
  - 2 moons: Deimos and Phobos.



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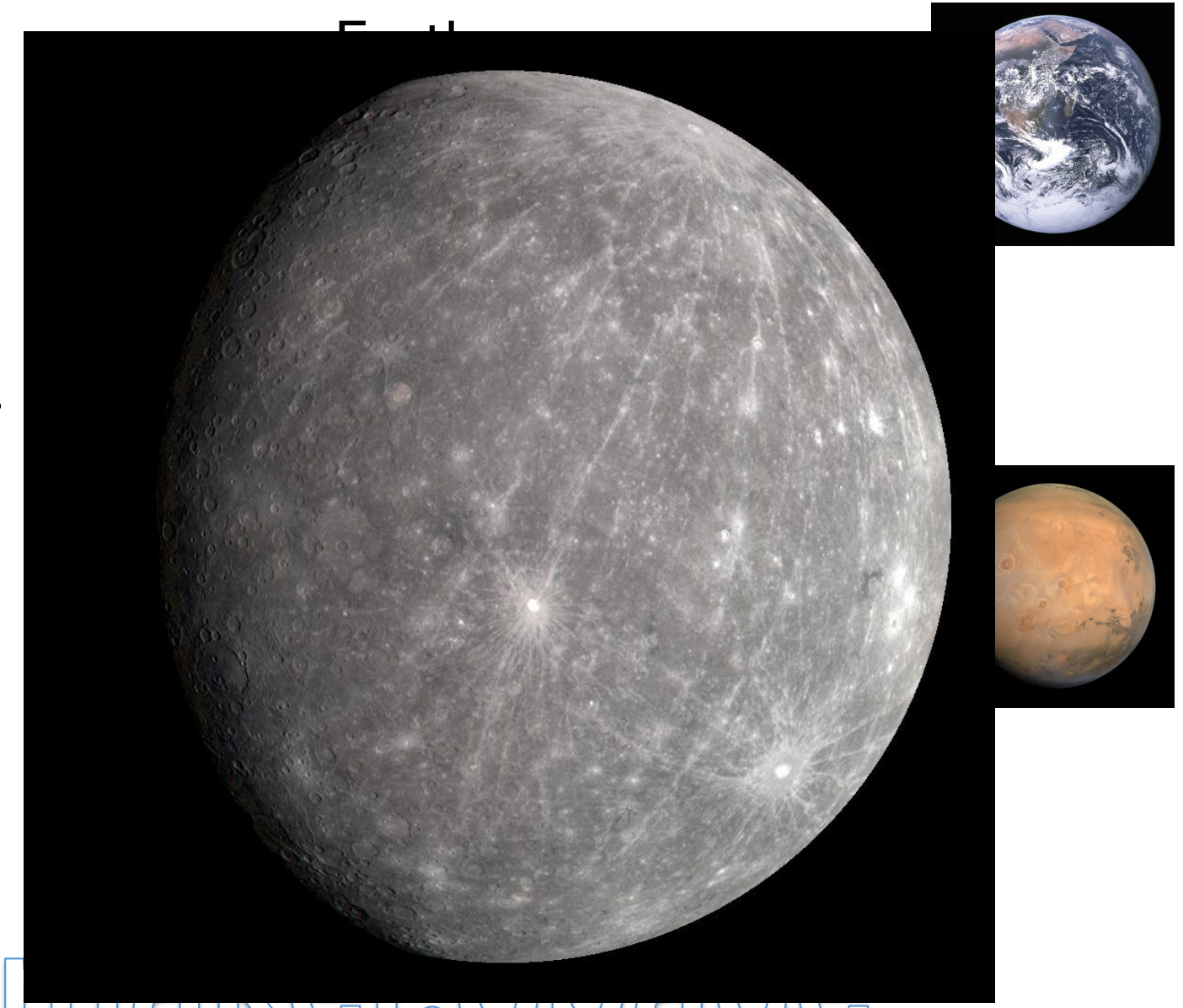

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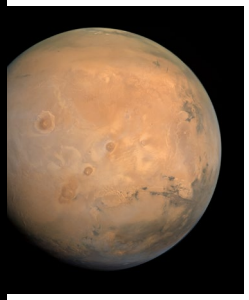

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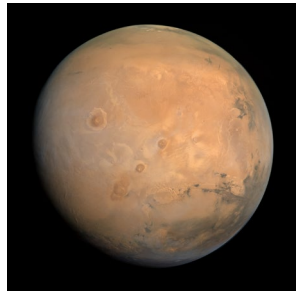

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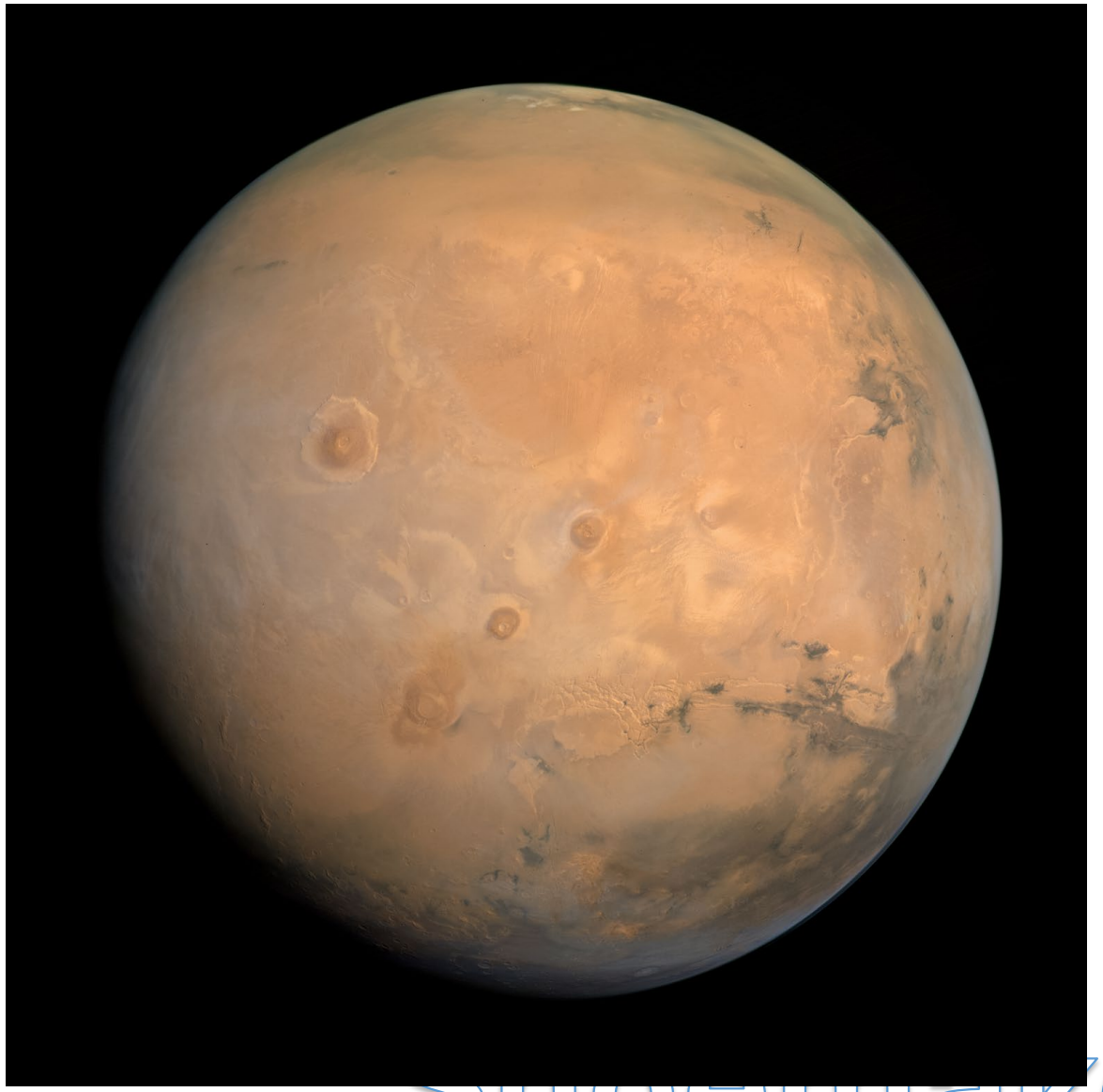

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Asteroid Belt

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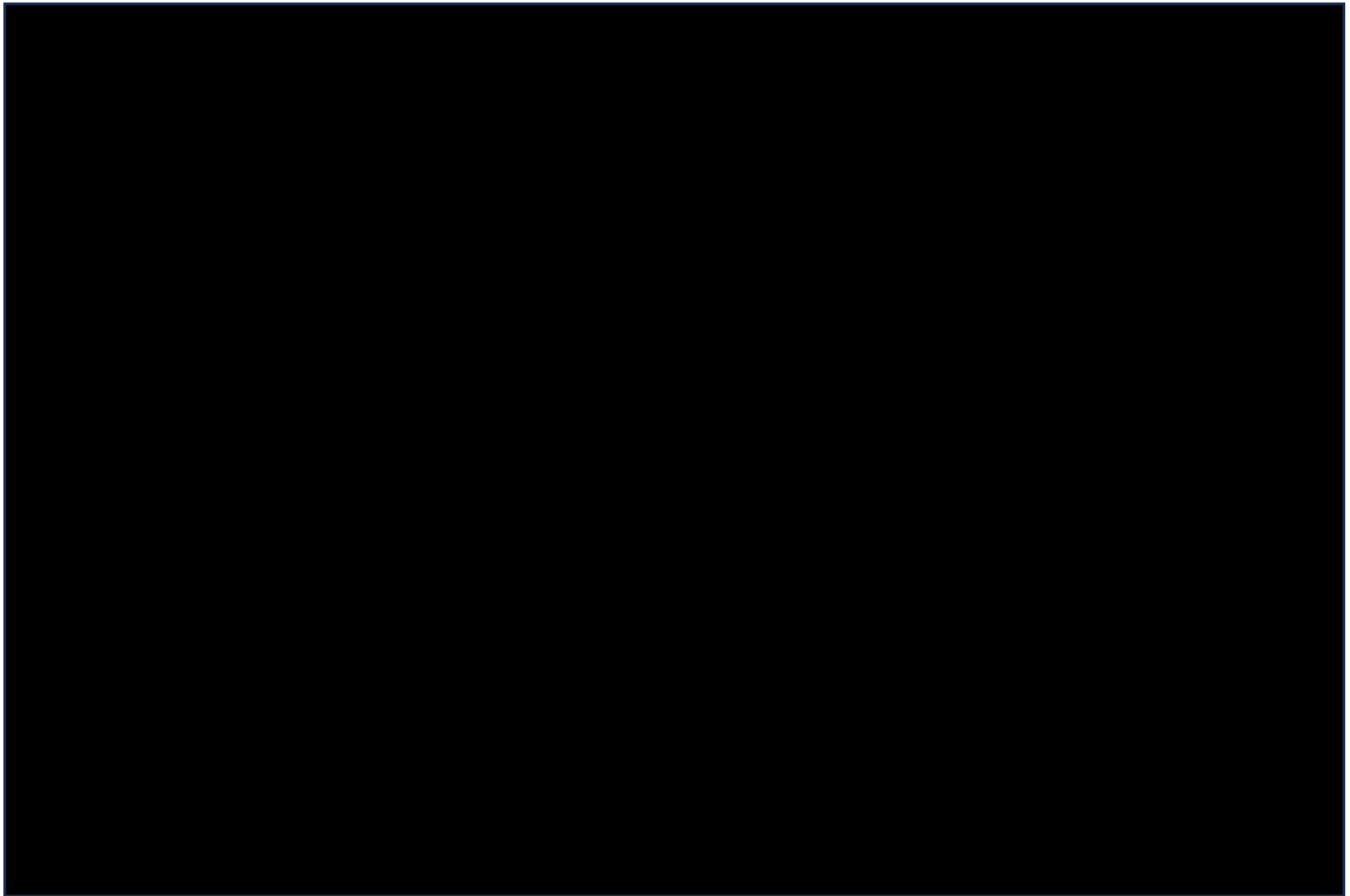
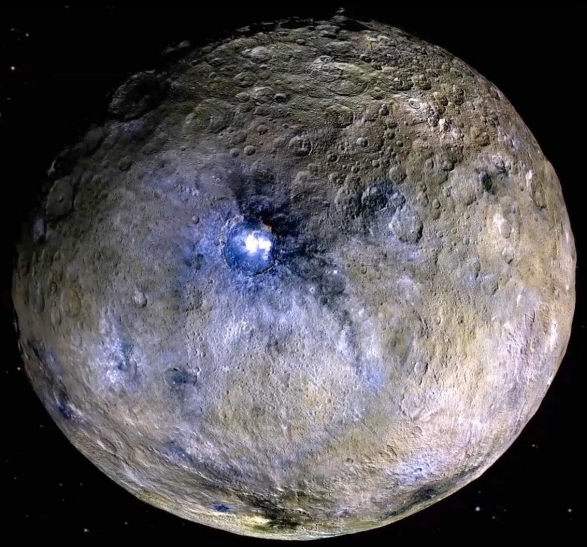


Asteroid Belt

- Sizes range from dust to dwarf planets.
  - Smallest detectable: 10 meters.
  - Largest detectable: 940 km.
- Average separation: 965,000 km.
  - 2.5 times the distance from the Earth to the Moon.

Asteroid Belt

- Ceres.
  - First known and largest asteroid.
  - Radius: 469.7 km.
  - “Year”: 1,680 days.

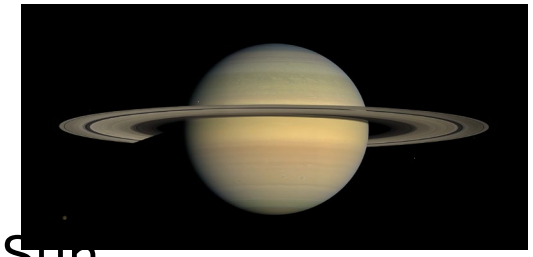


- Vesta
  - Second-largest asteroid.
  - Radius: 262 km.
  - “Year”: 1,325.86 days.

The Outer Planets

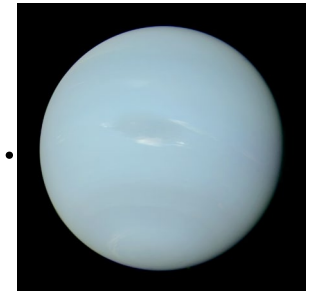
- Jupiter
  - Gas Giant.
  - 5.2 AUs from Sun.
  - 10.97 times Earth radius.
  - “Year”: 4,332.59 days.
  - Temp: 165 K.
  - 97+ moons

- Saturn
  - Gas Giant.
  - Amazing rings.
    8 major.
  - 9.5826 AUs from Sun.
  - 9.1402 times Earth radius.
  - “Year”: 10,775.70 days.
  - Temp: 134 K.
  - 274+ moons.



- Uranus
  - Ice Giant.
  - 19.191 AU from Sun.
  - Radius: 4 times Earth radius.
  - “Year”: 30,688.5 days.
  - Temp: 76 K.
  - 28+ moons.

- Neptune
  - Ice Giant.
  - 30.7 AU from Sun.
  - Radius: 3.8 times Earth radius.
  - “Year”: 686.98 days.
  - Temp: 72 K.
  - 16+ moons.
  - Axial Tilt: 28.32°.



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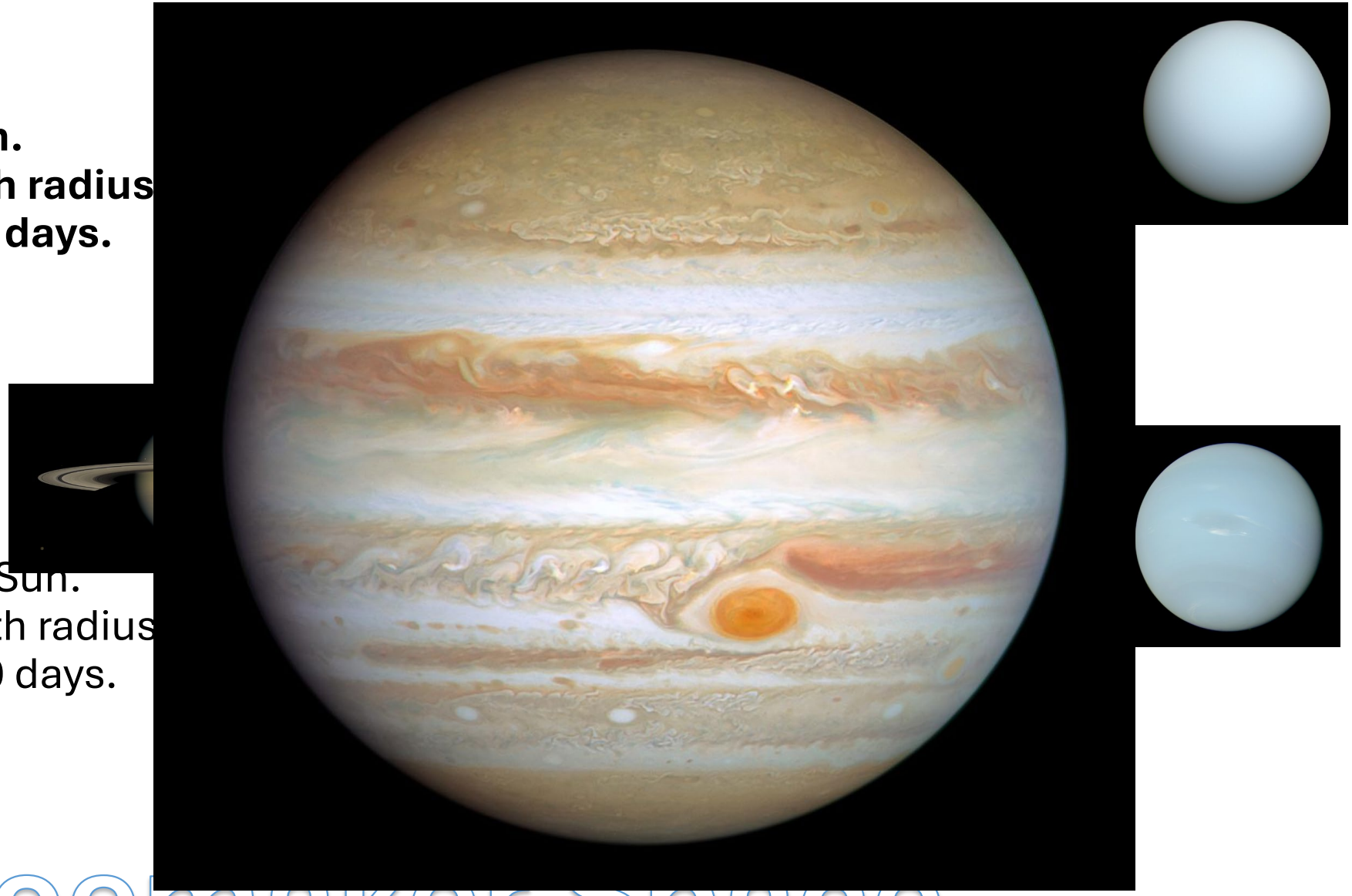

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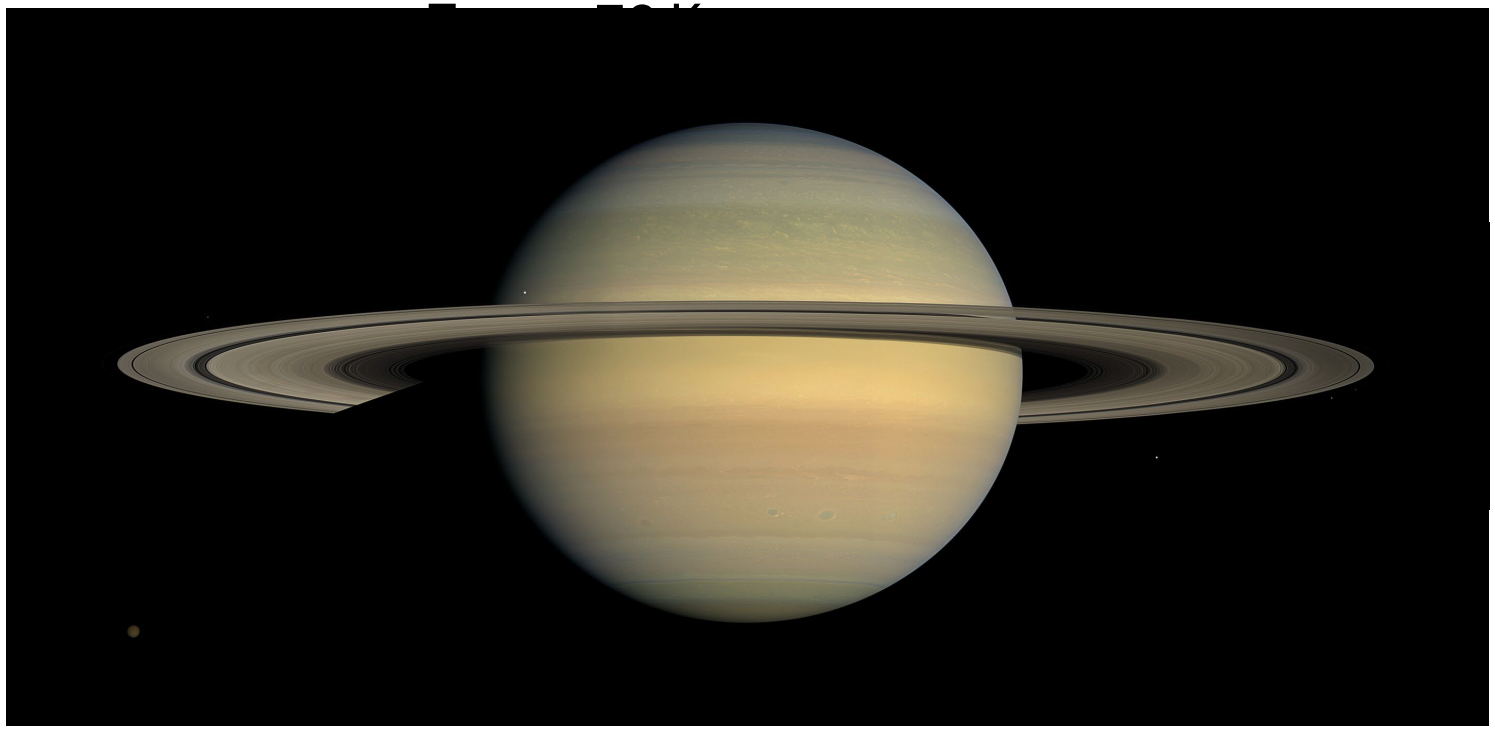

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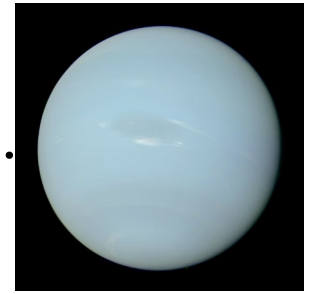

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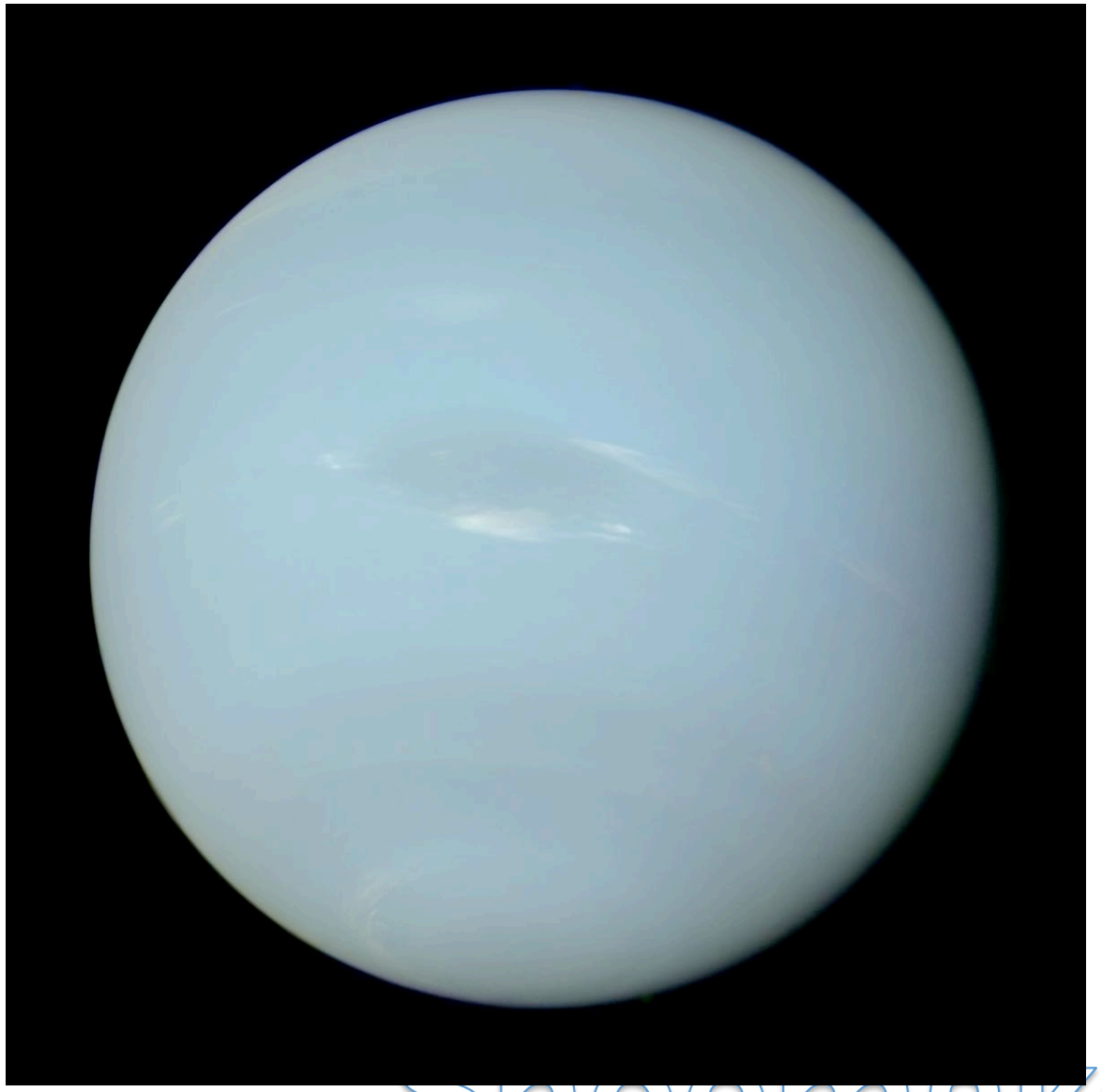

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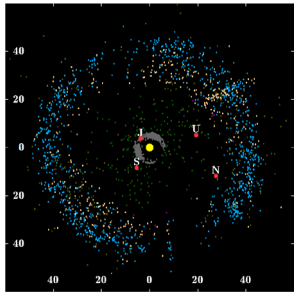
Beyond the Outer Planets

- Pluto
  - “Dwarf Planet”.
  - 39.482 AUs from Sun.
  - 0.1868 times Earth radius.
  - “Year”: 90,560 days.
  - Temp: 66 K.
  - 1 moon.

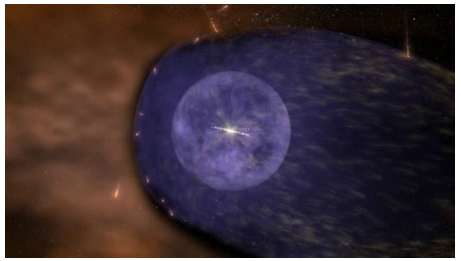
- Kuiper Belt.
  - Another asteroid belt.
  - More icy than rocky.
  - Dwarf planets.
  - Comets.



- Oort Cloud.

- Comets.
  - “Slush balls”.
  - Nucleus.
  - Coma.
  - Tail.
  - Can approach the Sun in an elliptical orbit.

- Heliopause.
  - The edge of the Solar wind.
  - The start of other stellar winds.
  - 121 AUs from Sun.



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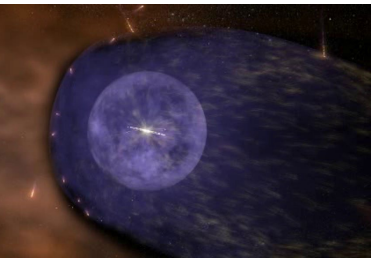

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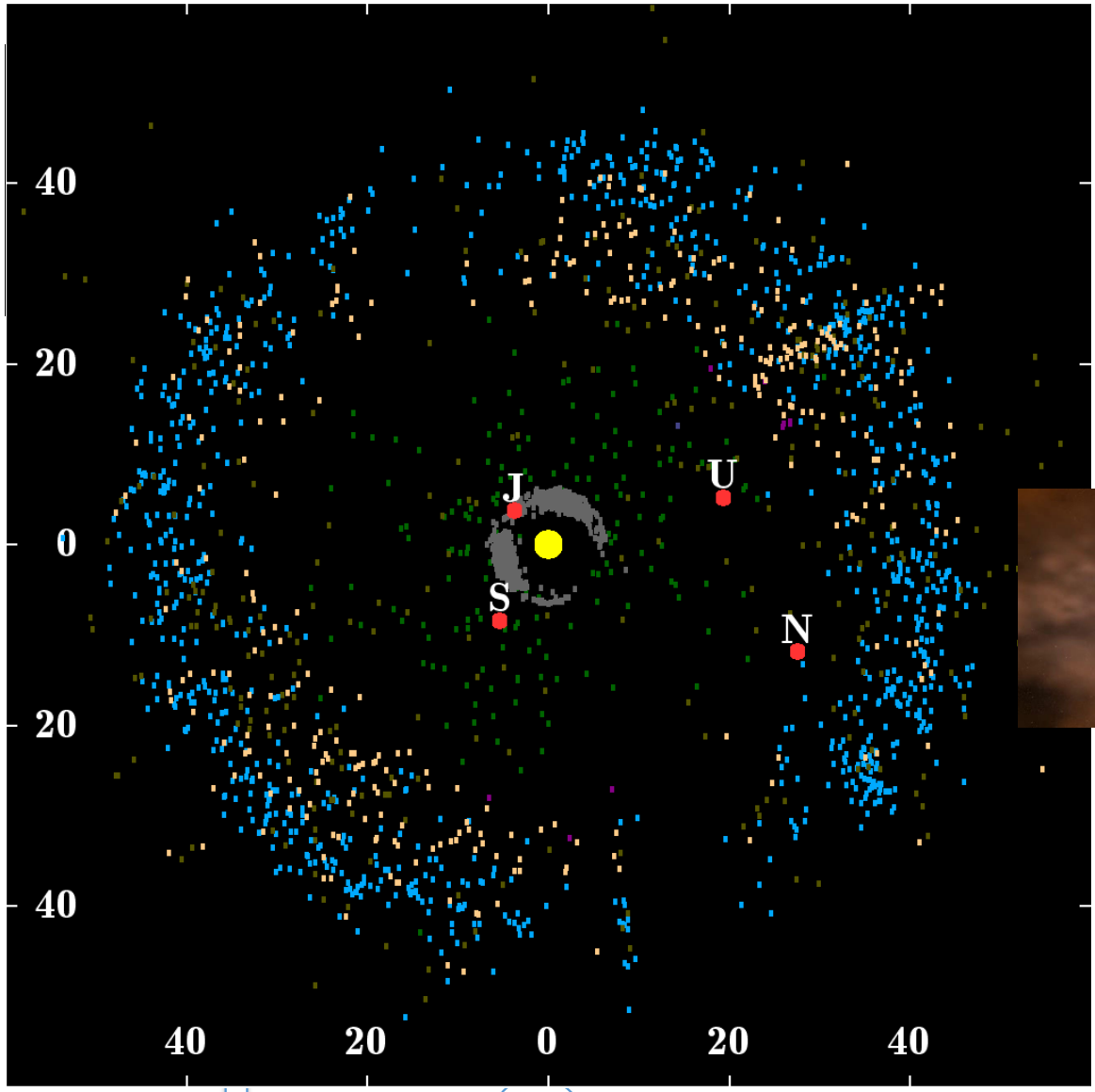

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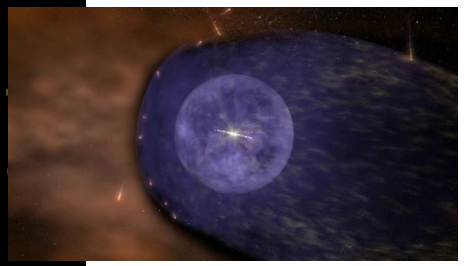

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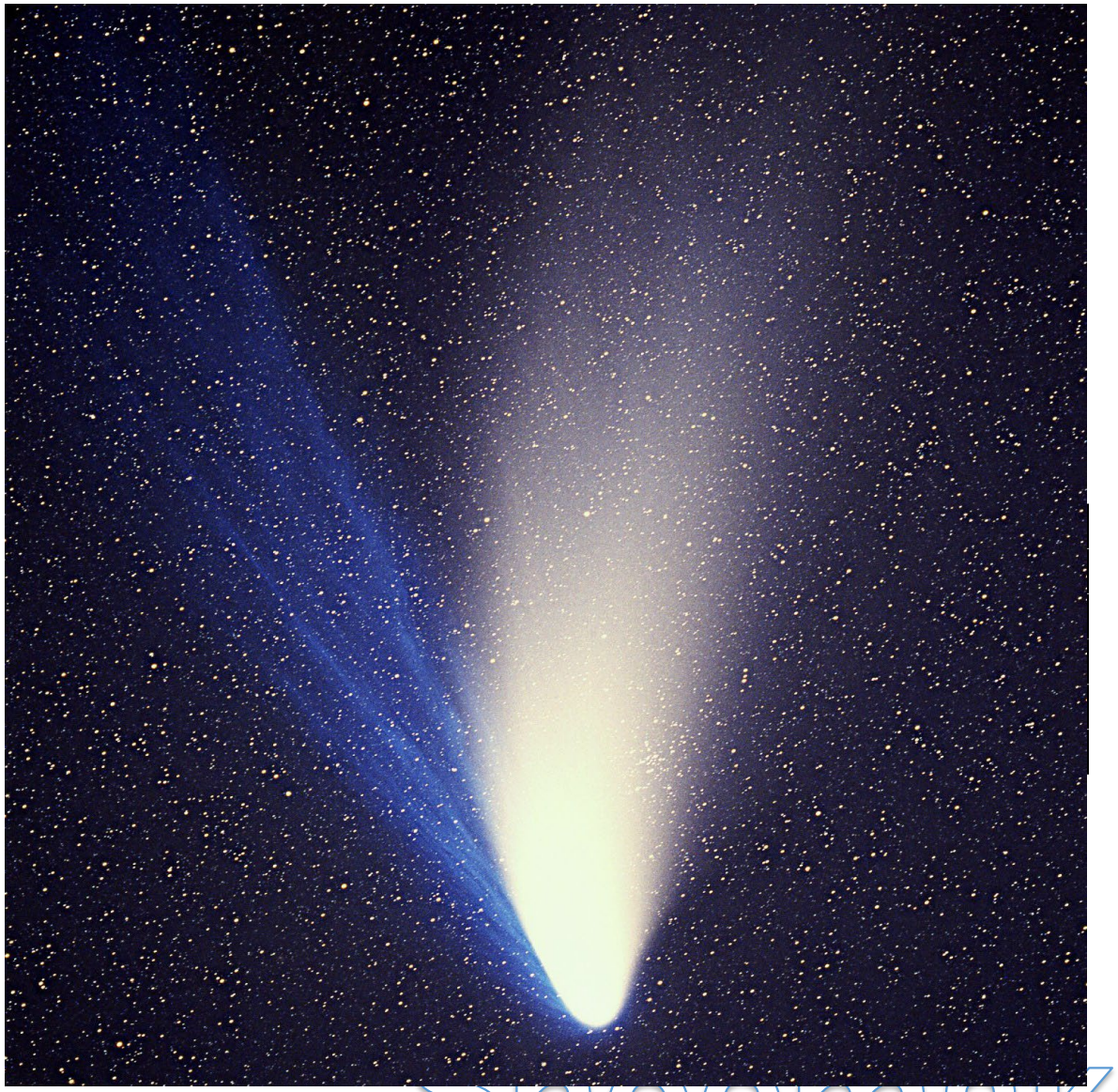

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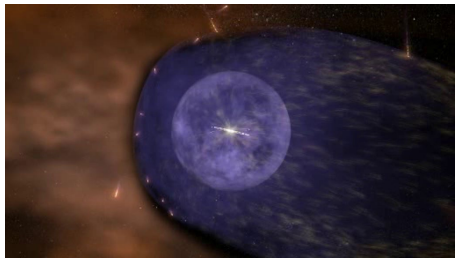
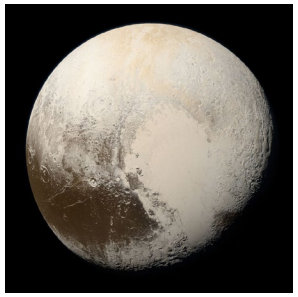
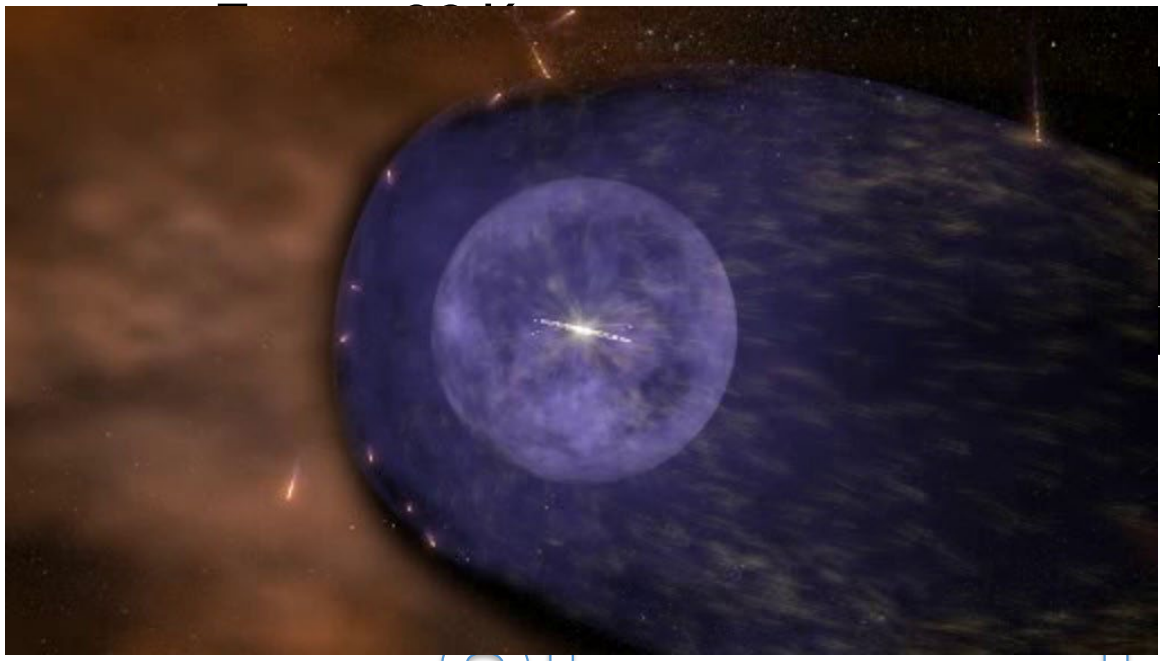


Beyond the Outer Planets

- Pluto
  - “Dwarf Planet”.
  - 39.482 AUs from Sun.
  - 0.1868 times Earth radius.
  - “Year”: 90,560 days.





- Comets.
  - “Slush balls”.
  - Nucleus.
  - Coma.
  - Tail.
  - Can approach the Sun in an elliptical orbit.

- **Heliopause.**
  - **The edge of the Solar wind.**
  - **The start of other stellar winds.**
  - **121 AUs from Sun.**

Stars and Stellar Evolution

- Protostars. Very young stars forming from the gravitational collapse of a molecular cloud.
- Yellow Dwarfs, Medium-sized stars that steadily fuse hydrogen to helium in their cores, maintaining equilibrium for about 10 billion years.
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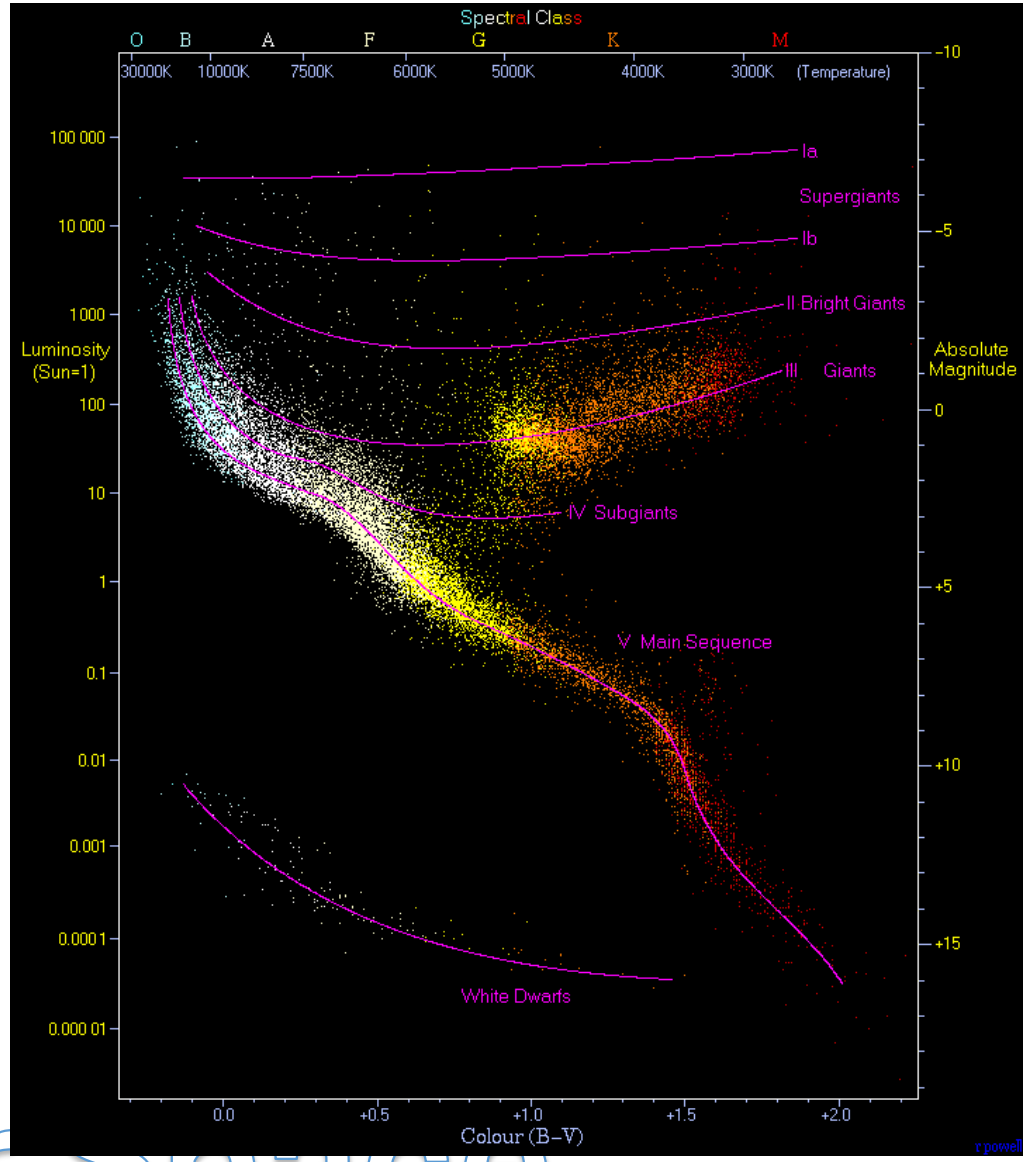

Hertzsprung–Russell diagram

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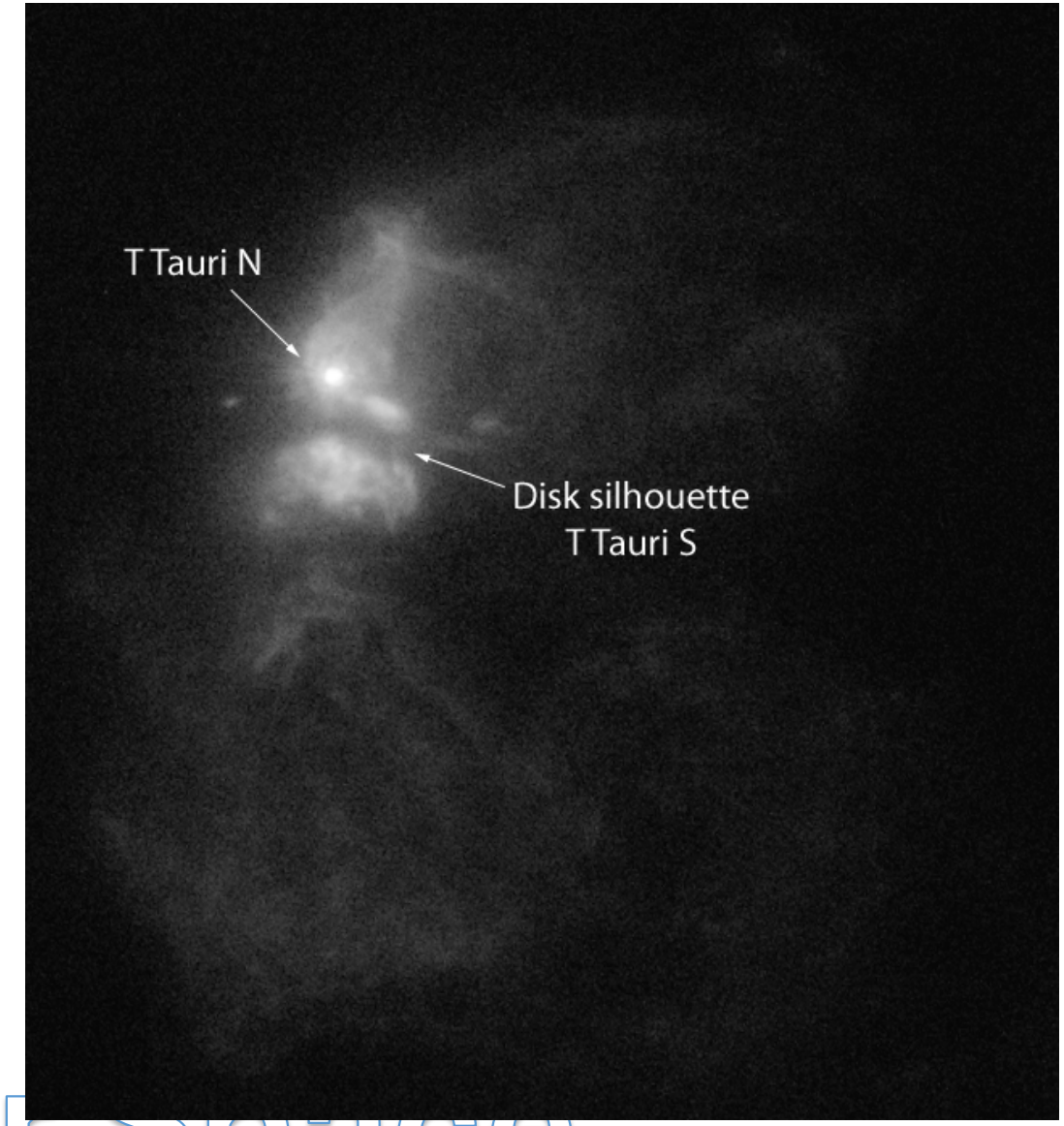

T Tauri System: The Birth of Protostars

Stars and Stellar Evolution: Yellow Dwarfs

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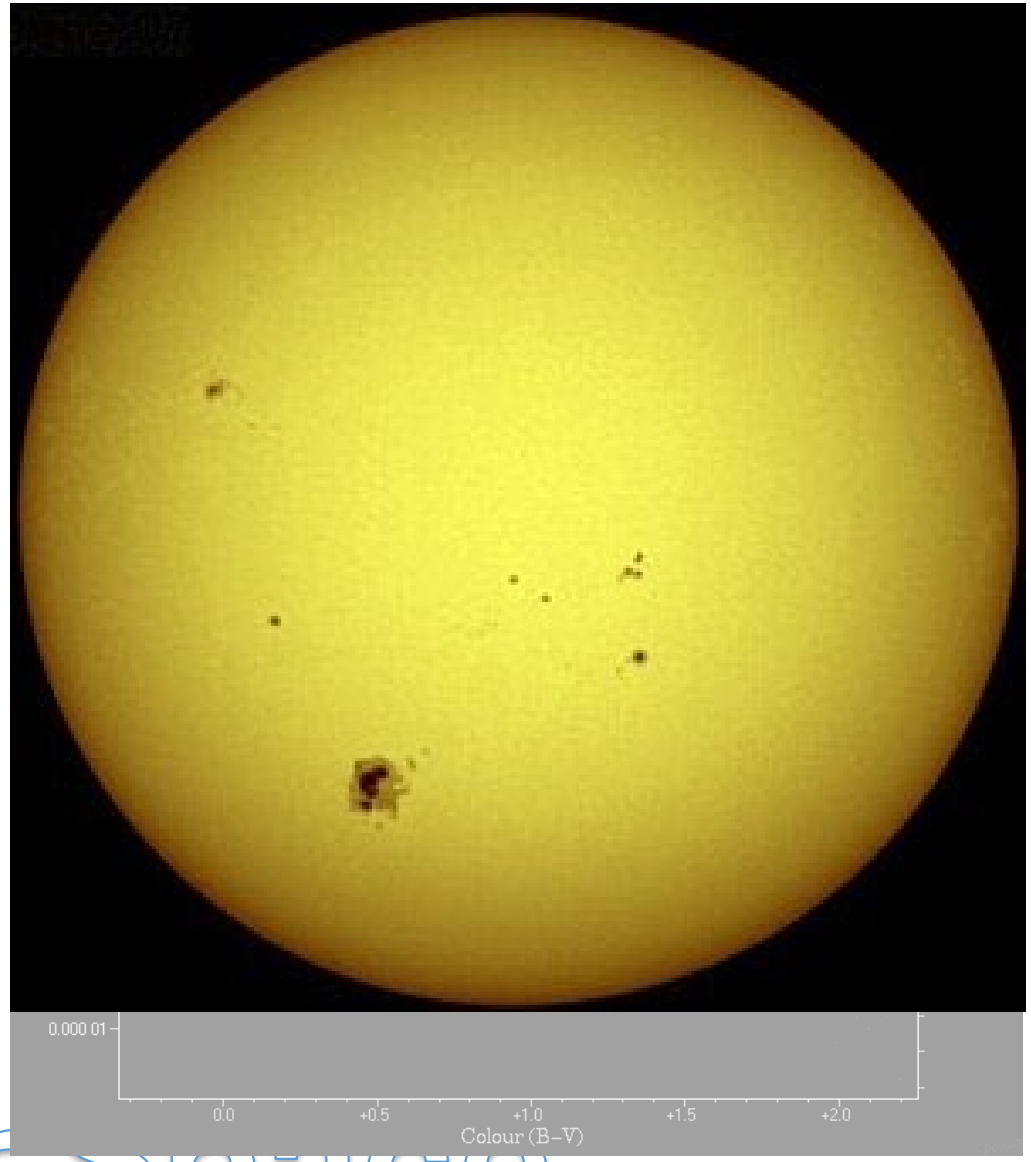

The Sun: A Yellow Dwarf

Stars and Stellar Evolution: Red Giants

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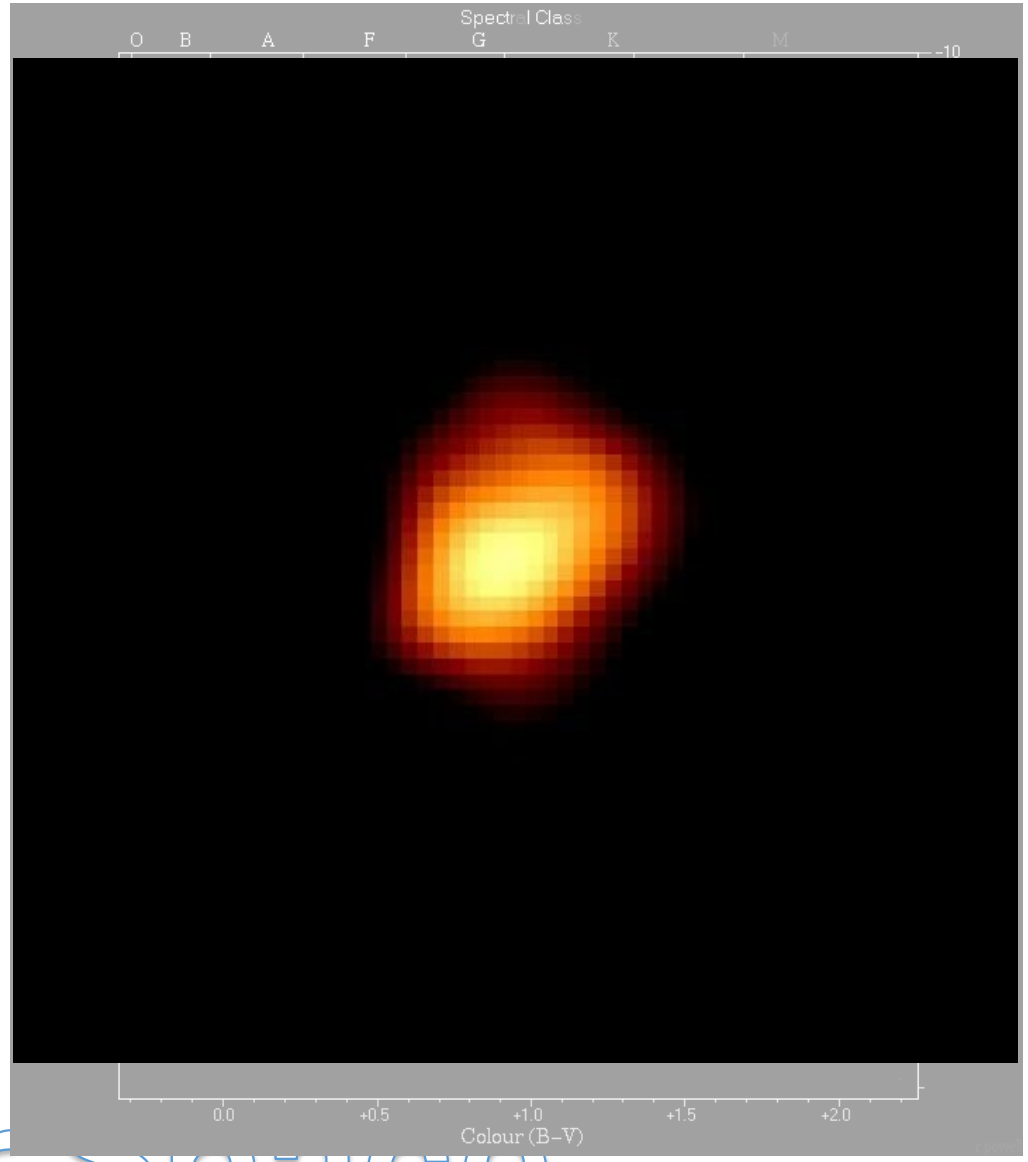

Arcturus: A Reg Giant

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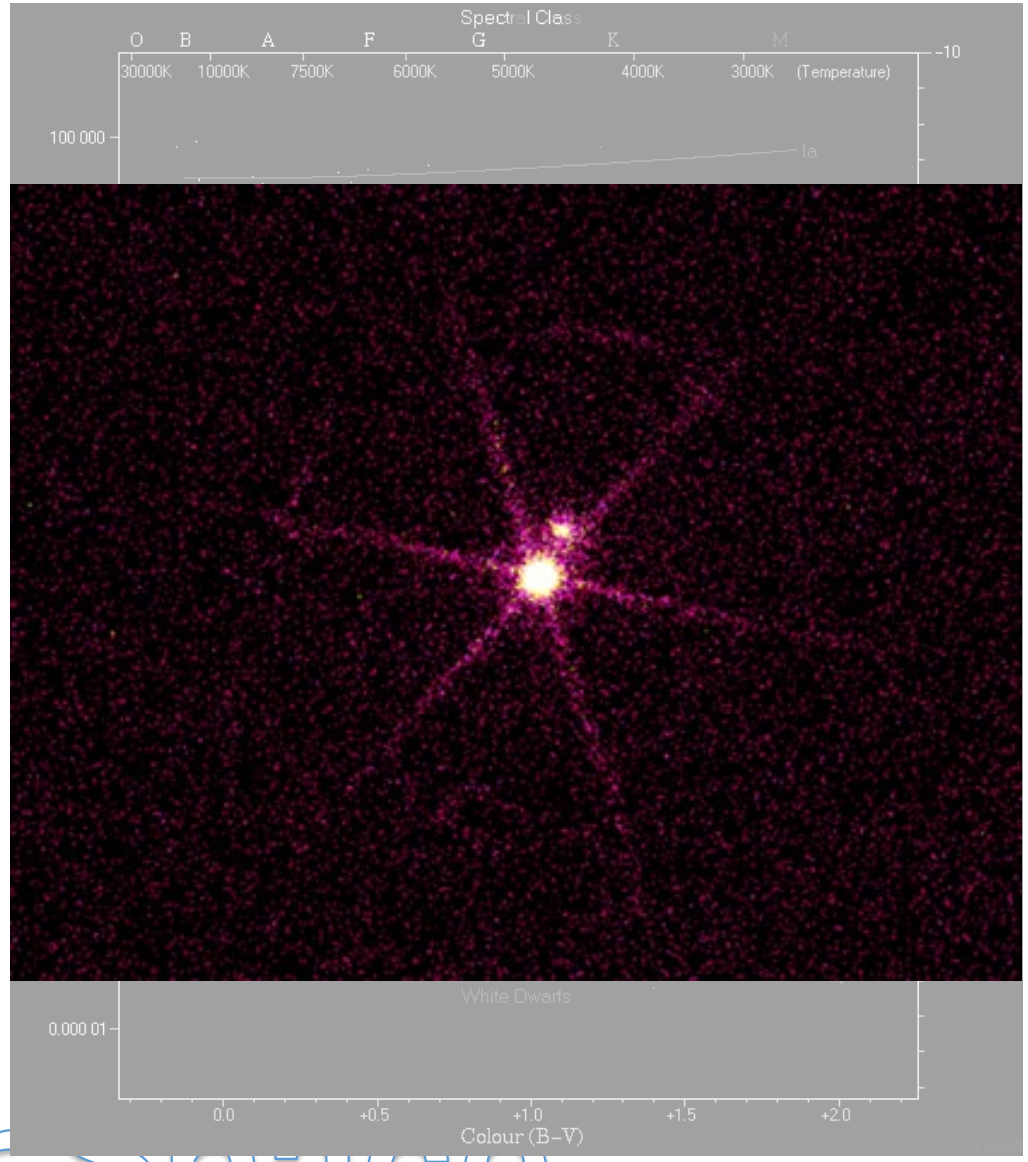

Sirius B: A White Dwarf (with Sirius A)

Stars and Stellar Evolution: Red Dwarfs

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Proxima Centauri: A Red Dwarf

Stars and Stellar Evolution: Blue Main-Sequence

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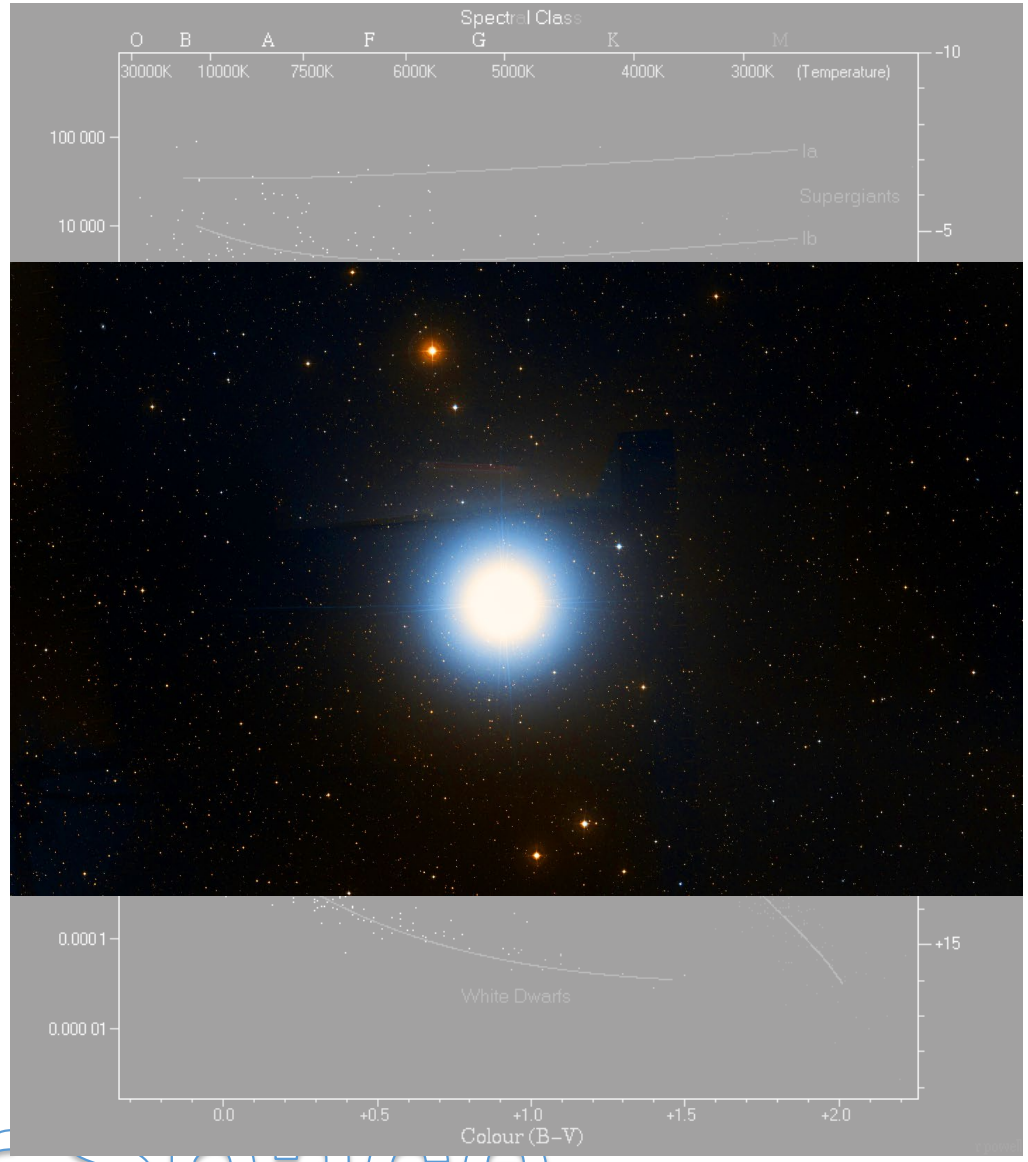

Spica: A Blue Main Sequence Star

Stars and Stellar Evolution: Blue Supergiant

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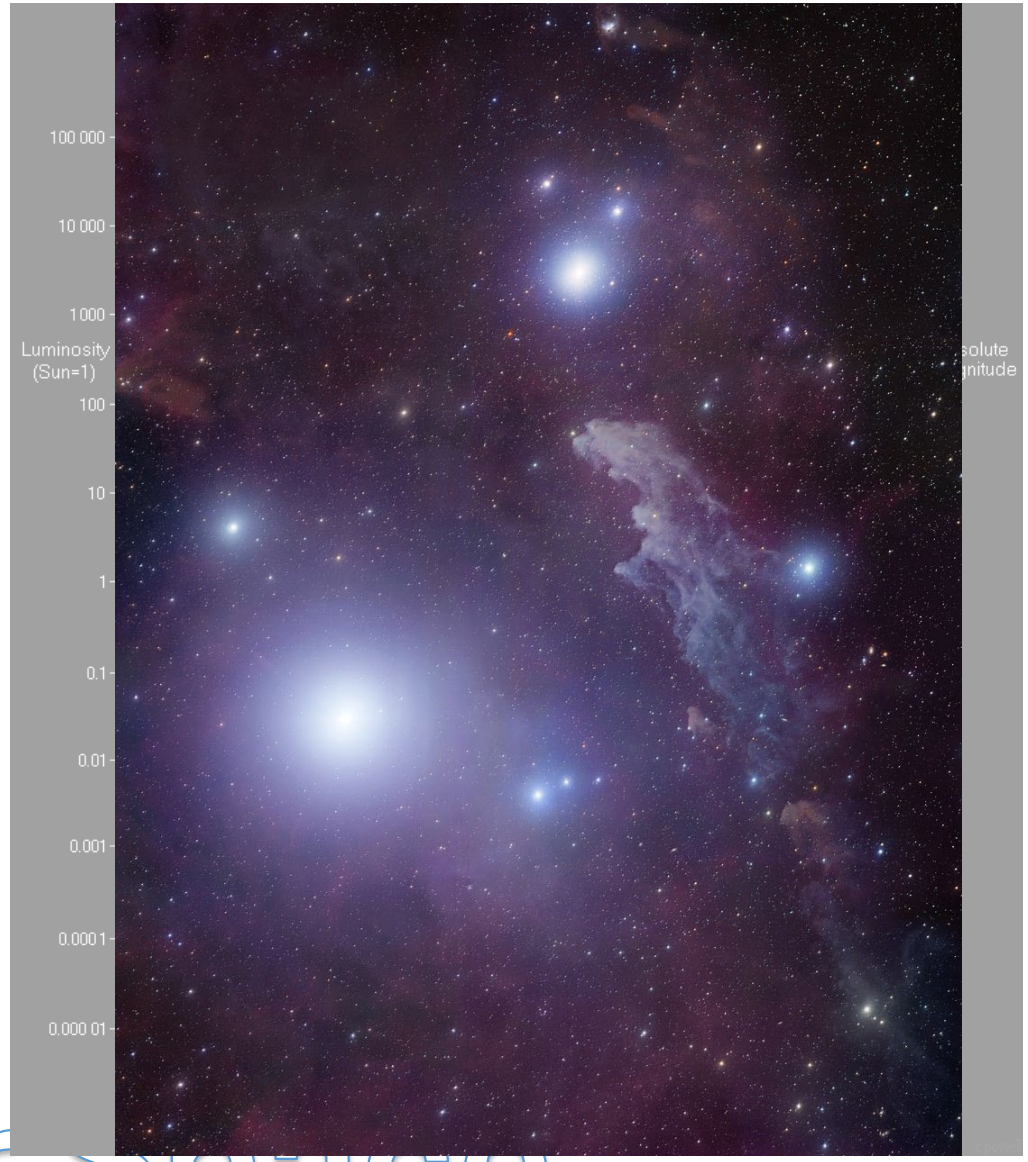

Rigel: A Blue Supergiant

Stars and Stellar Evolution: Red Supergiant

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Betelgeuse: A Red Supergiant

Stars and Stellar Evolution: Supernova

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SN 1994D: A supernova within galaxy NGC 4526

Stars and Stellar Evolution: Neutron Stars/Pulsars

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Echo of a Pulsar in the Crab Nebula

Stars and Stellar Evolution: Black Holes

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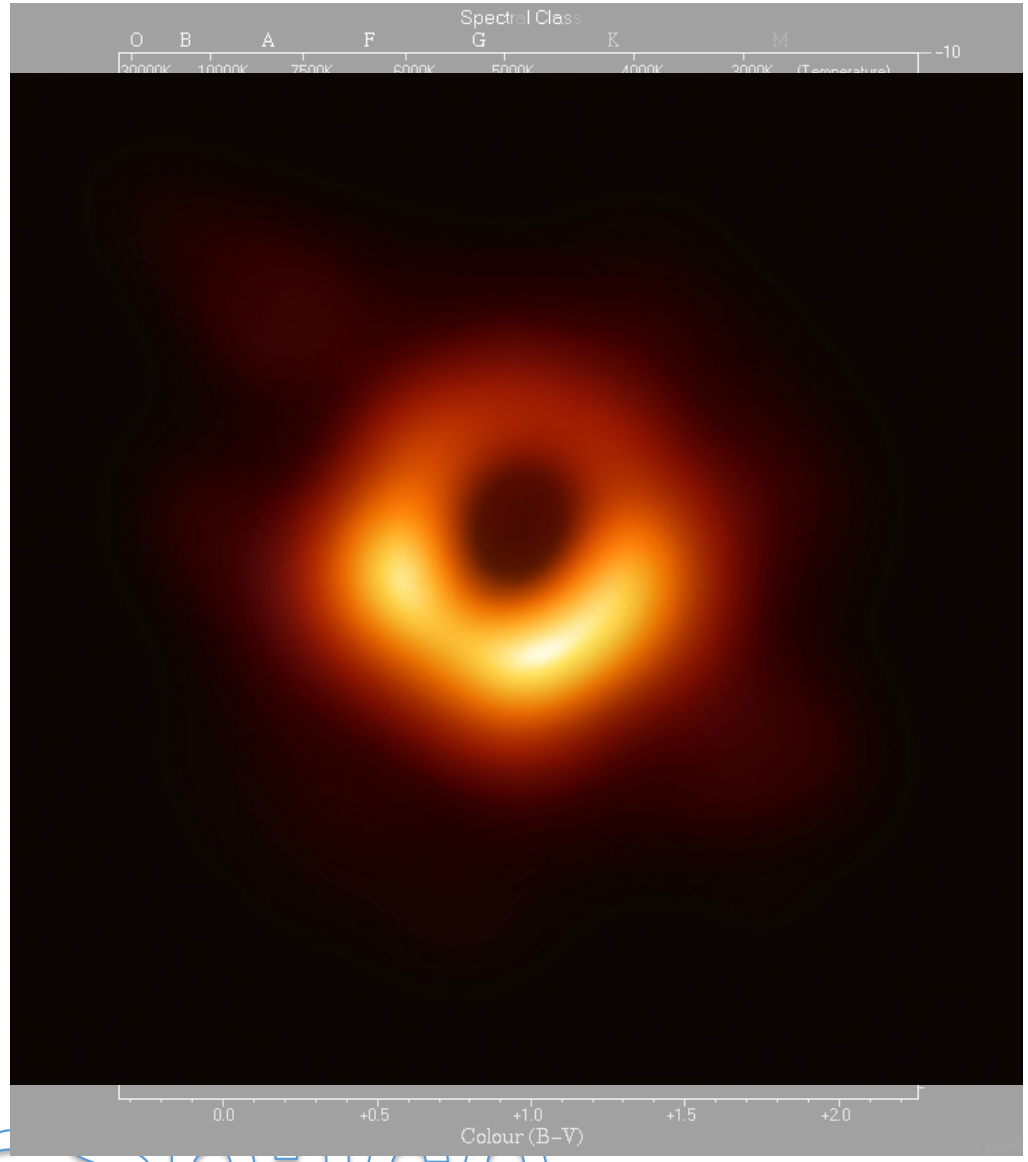

Messier 87: A supermassive black hole

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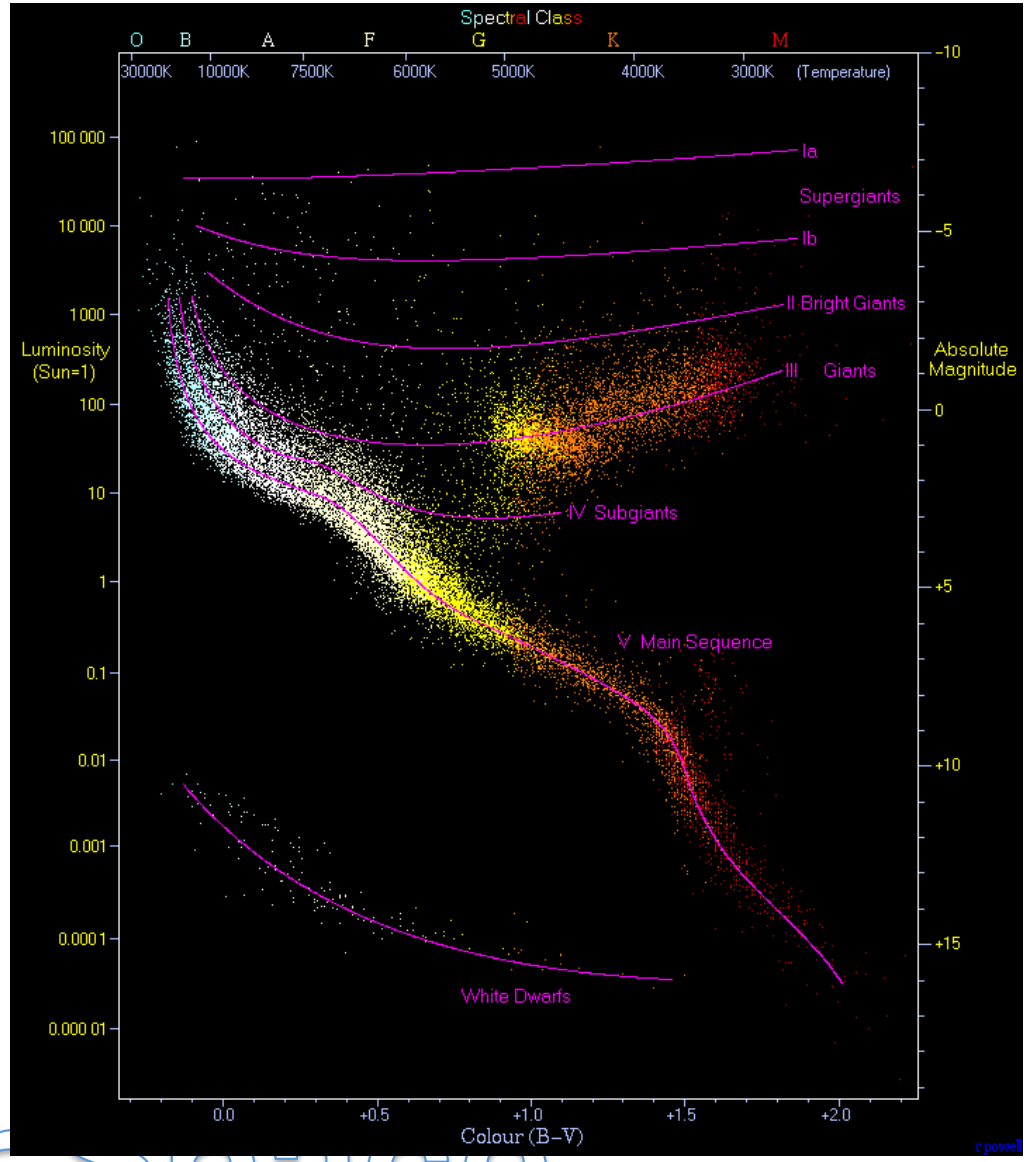
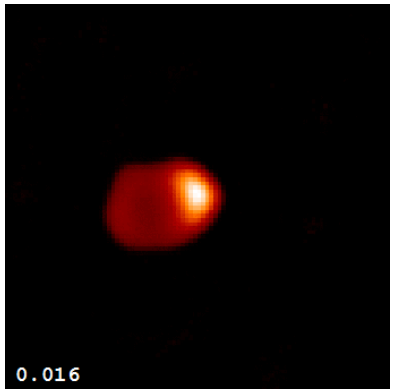
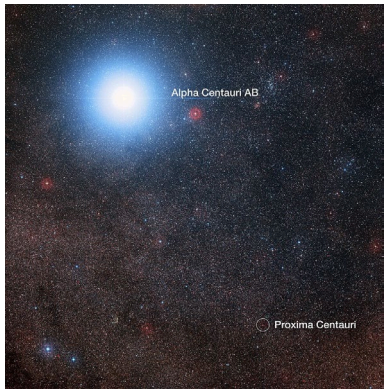


Hertzsprung–Russell diagram

Stellar Groups

- Binary Stars.
- Trinary Stars.
- Star Clusters.
- Constellations.





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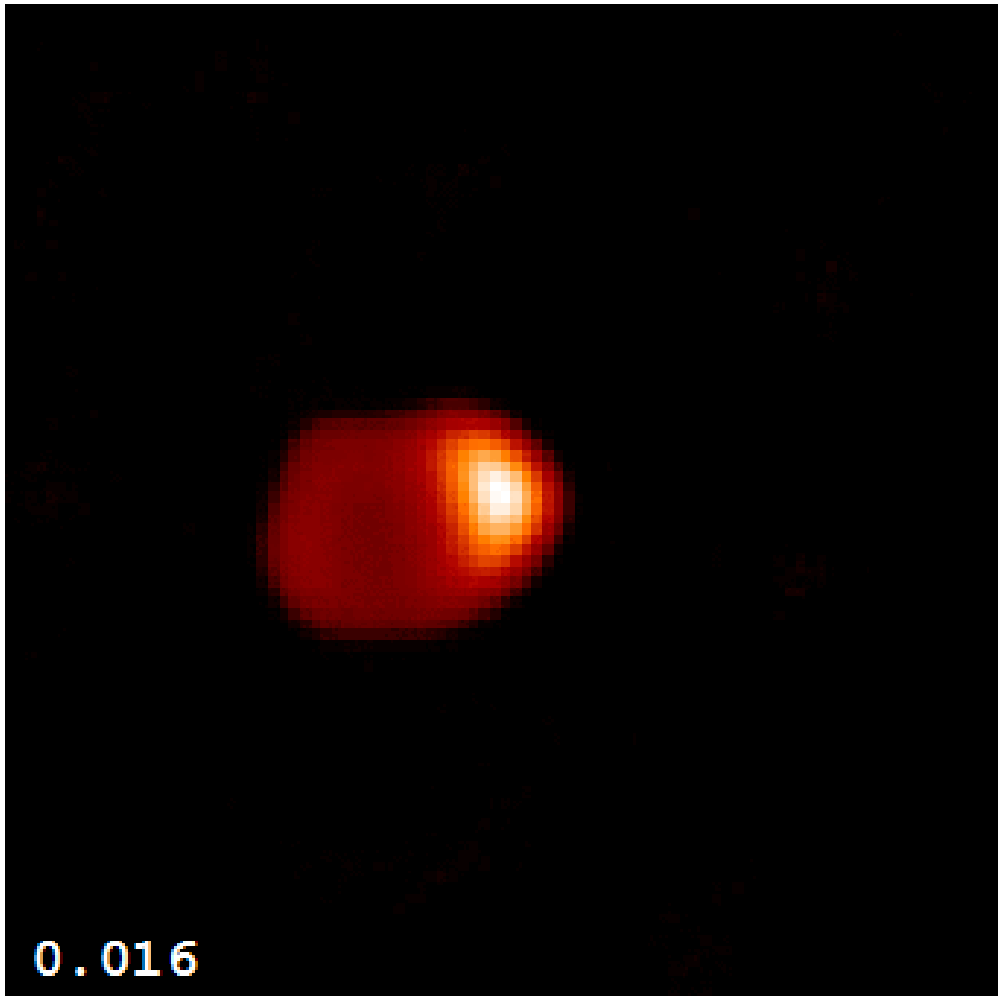

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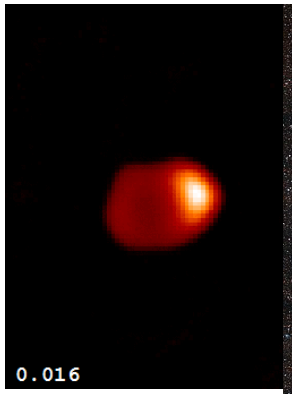

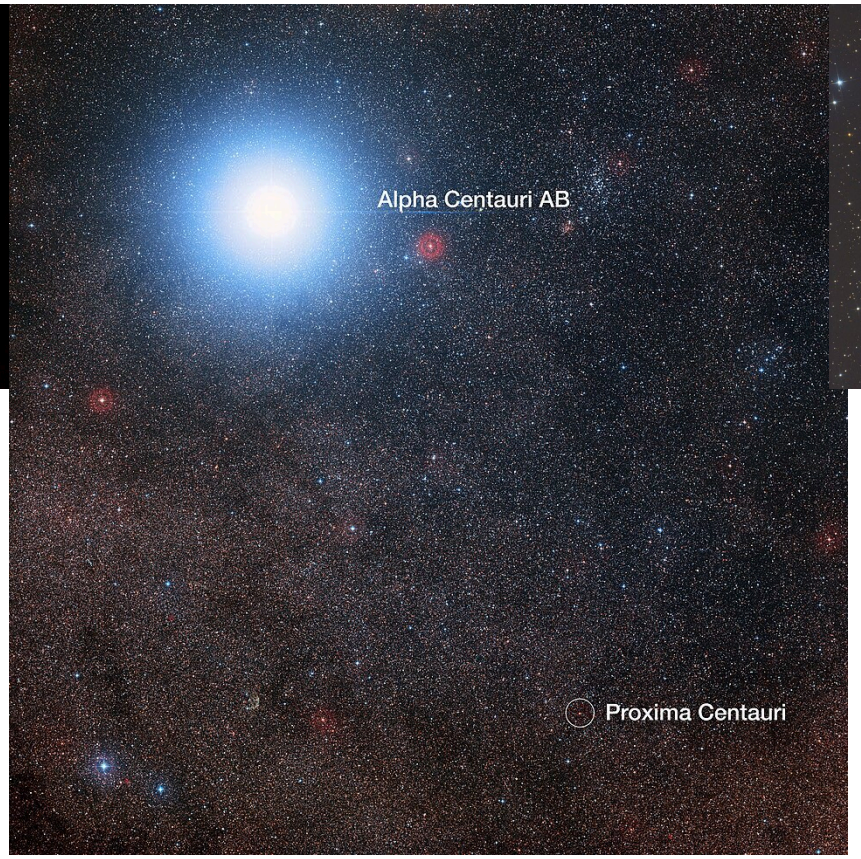

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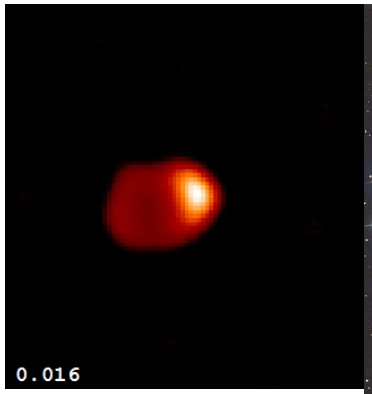
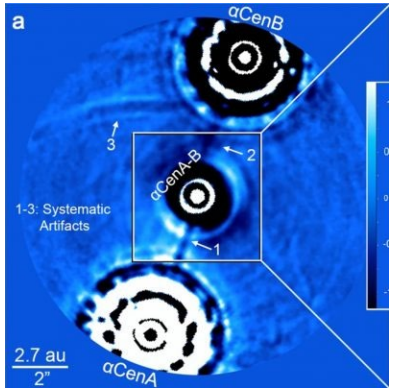
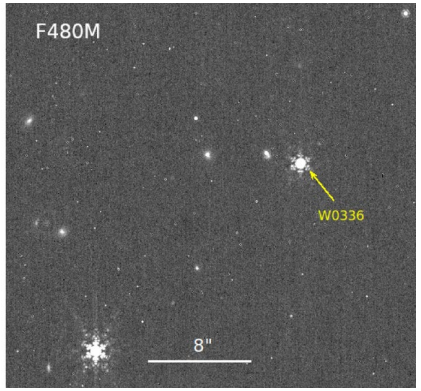
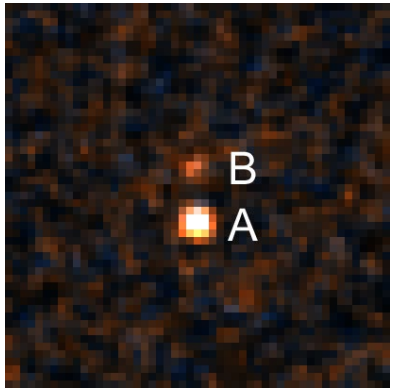


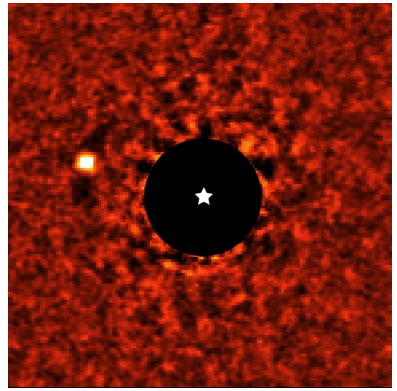
Exoplanets

- Planets orbiting other stars.
- Detection methods:
  - Direct imaging.
  - Transit method.
  - Radial velocity method (Doppler shift).
  - Timing variation.









Shoemaker.Space

Nebulae: Clouds of Dust and Gas

- Emission Nebulae
  - Clouds of ionized gas.
  - Lit up by nearby radiation like a neon sign.

- Reflection Nebulae
  - Clouds of gas (not ionized).
  - Reflect the light from nearby stars.

- Dark Nebulae
  - Clouds of dust and gas.
  - Block the light from nearby stars.

- Planetary Nebulae
  - Gas thrown off as stars settle in as Red Dwarfs.

- Supernova Remnants
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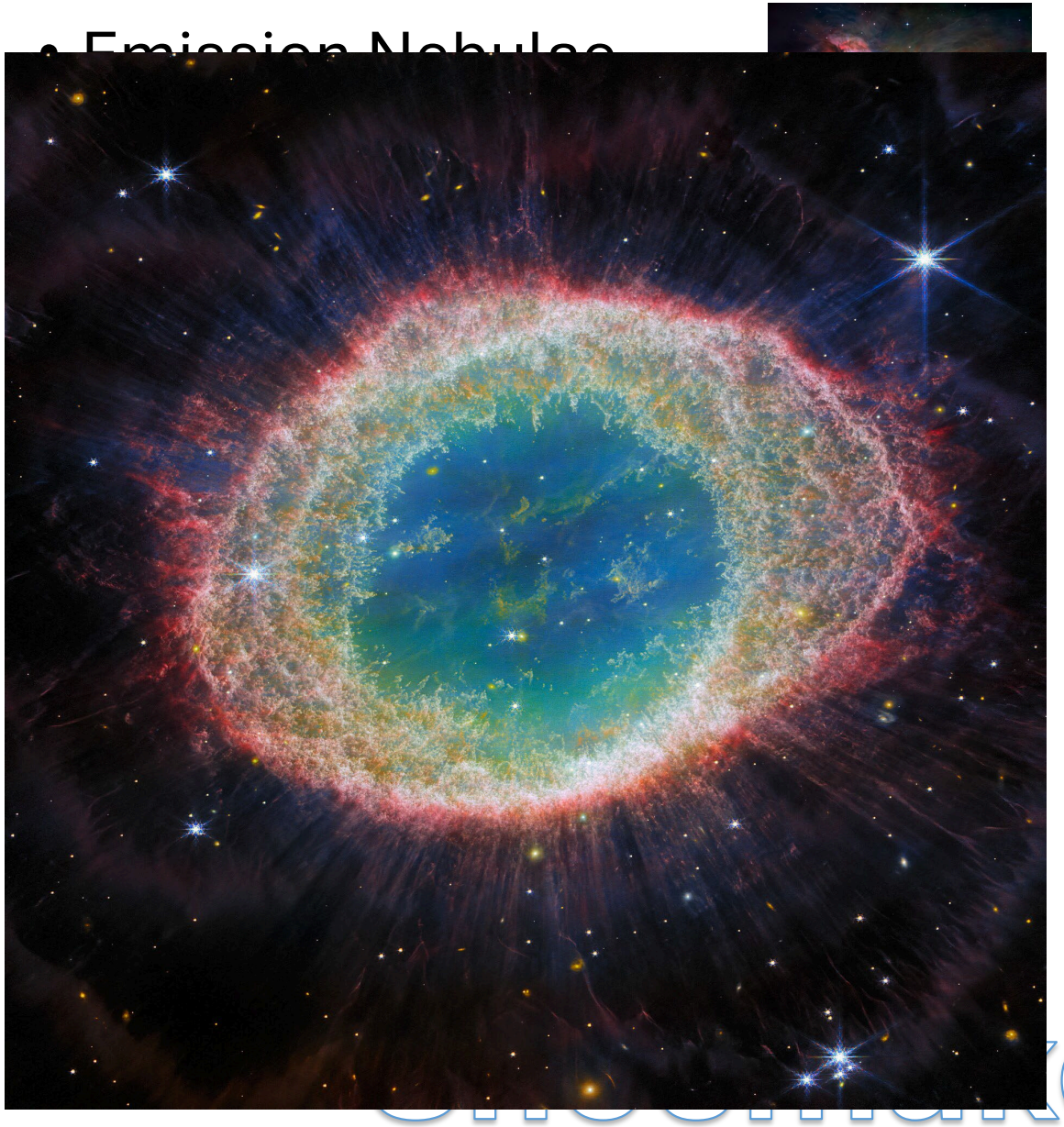

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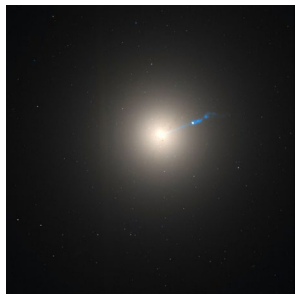
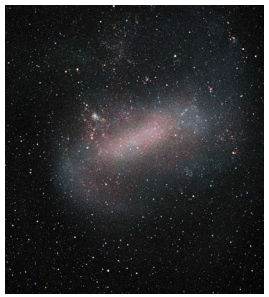
Galaxies

- Clusters of stars.
  - As few as 60. As many as 100 *trillion*.
  - As small as 20 light years. As large as 6 million light years.
- Many have a supermassive black hole at the center, and a quasar.
- Three general types.
  - Spirals.
  - Ellipticals.
  - Irregular.

Galaxies

- Clusters of star
  - As few as 60. A
  - As small as 20
- Many have a su
- Three general ty
  - **Spirals.**
  - Ellipticals.
  - Irregular.

Galaxies

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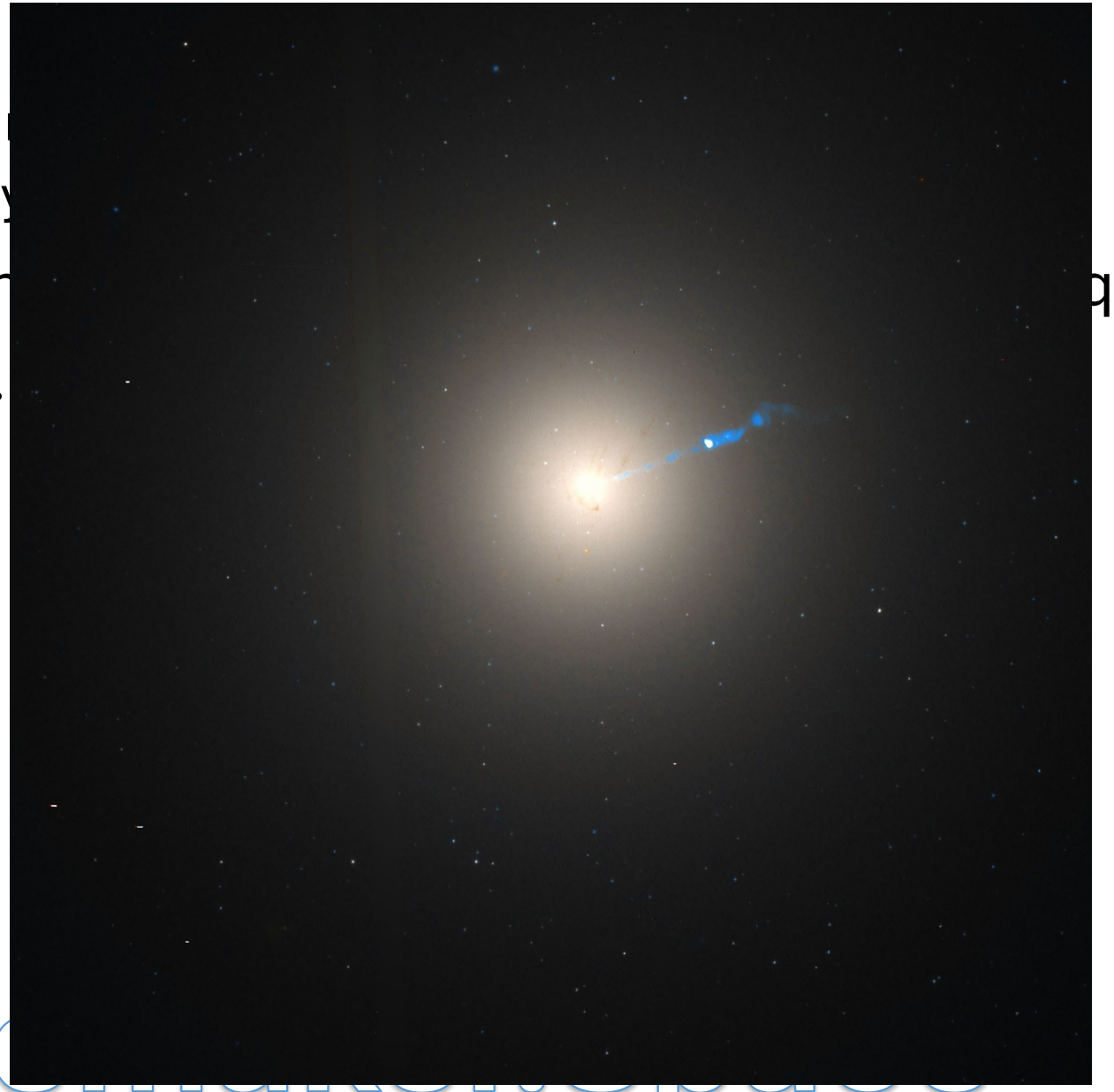
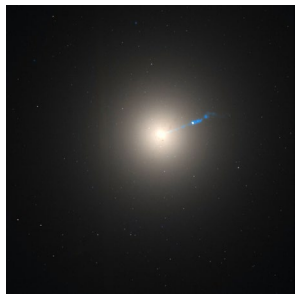


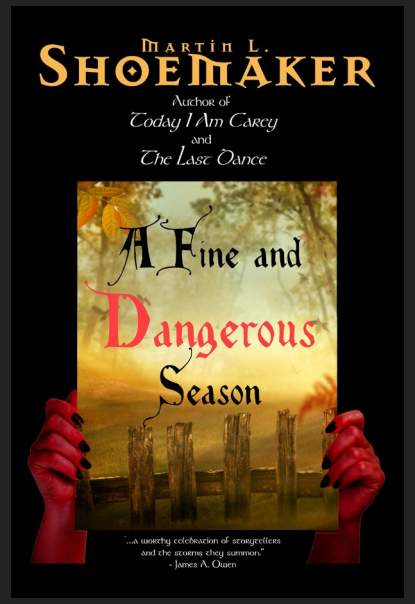
Galaxies

- Clusters of stars.
  - As few as 60. As many as 100 *trilli*
  - As small as 20 light years. As large
- Many have a supermassive blac
- Three general types.
  - Spirals.
  - Ellipticals.
  - **Irregular.**



The Scope of Space

https://www.youtube.com/watch?v=5zlcWdTs2-s



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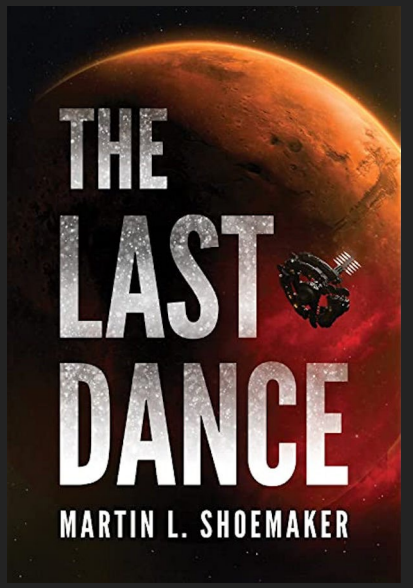
Some of My Books



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What's Up There?

Things to See in Space

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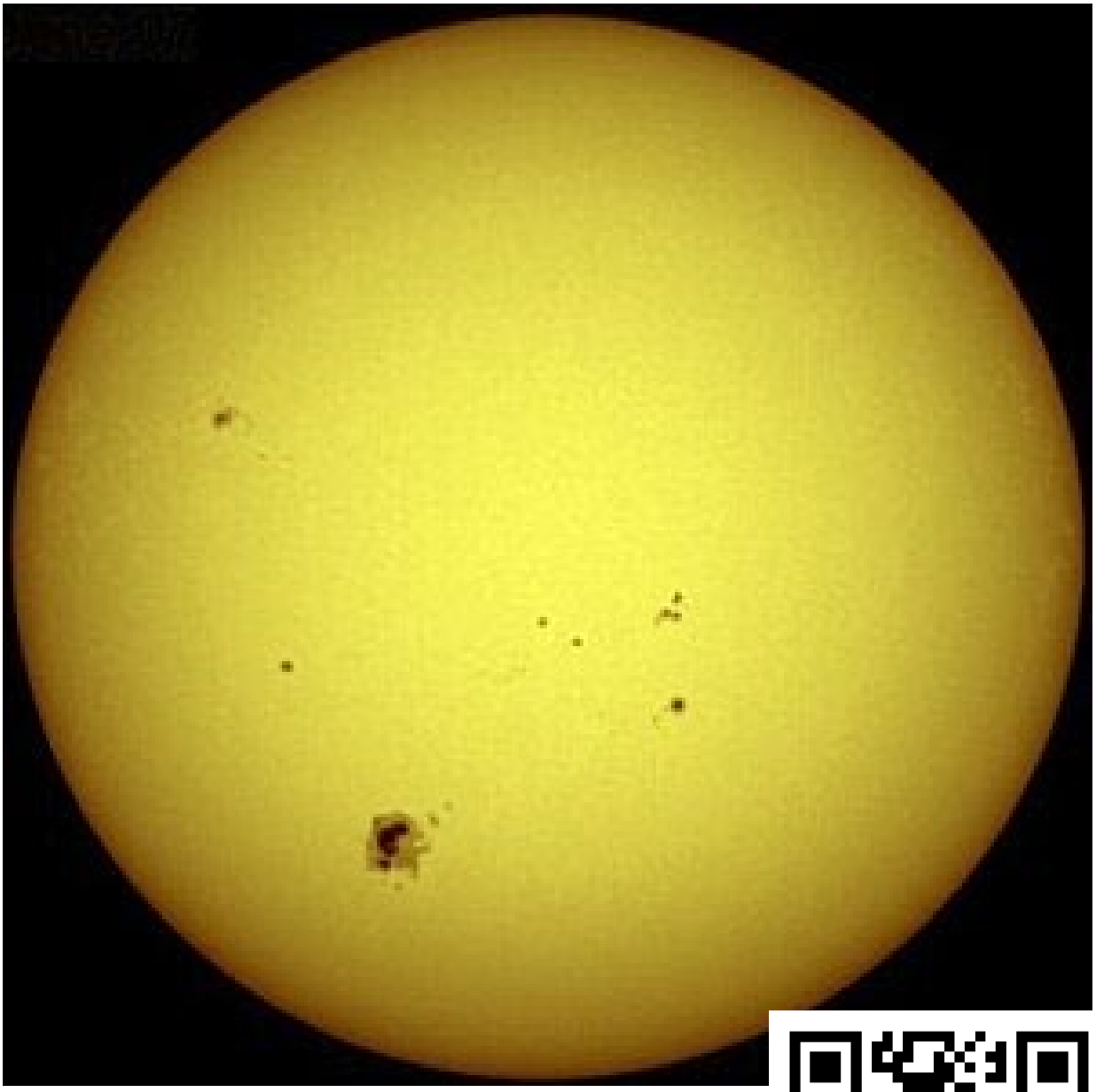
Martin@Shoemaker.Space

Music: "Saxophone Song" by Mircea Iancu

What's Up There?

The Sun: The Nearest Star



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1 1 https://science.nasa.gov/sun/

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What's Up There?

Meteors

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2 https://science.nasa.gov/solar-system/meteors-meteorites/

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What's Up There?

Auroras

3 https://www.nasa.gov/science-research/heliophysics/auroras/

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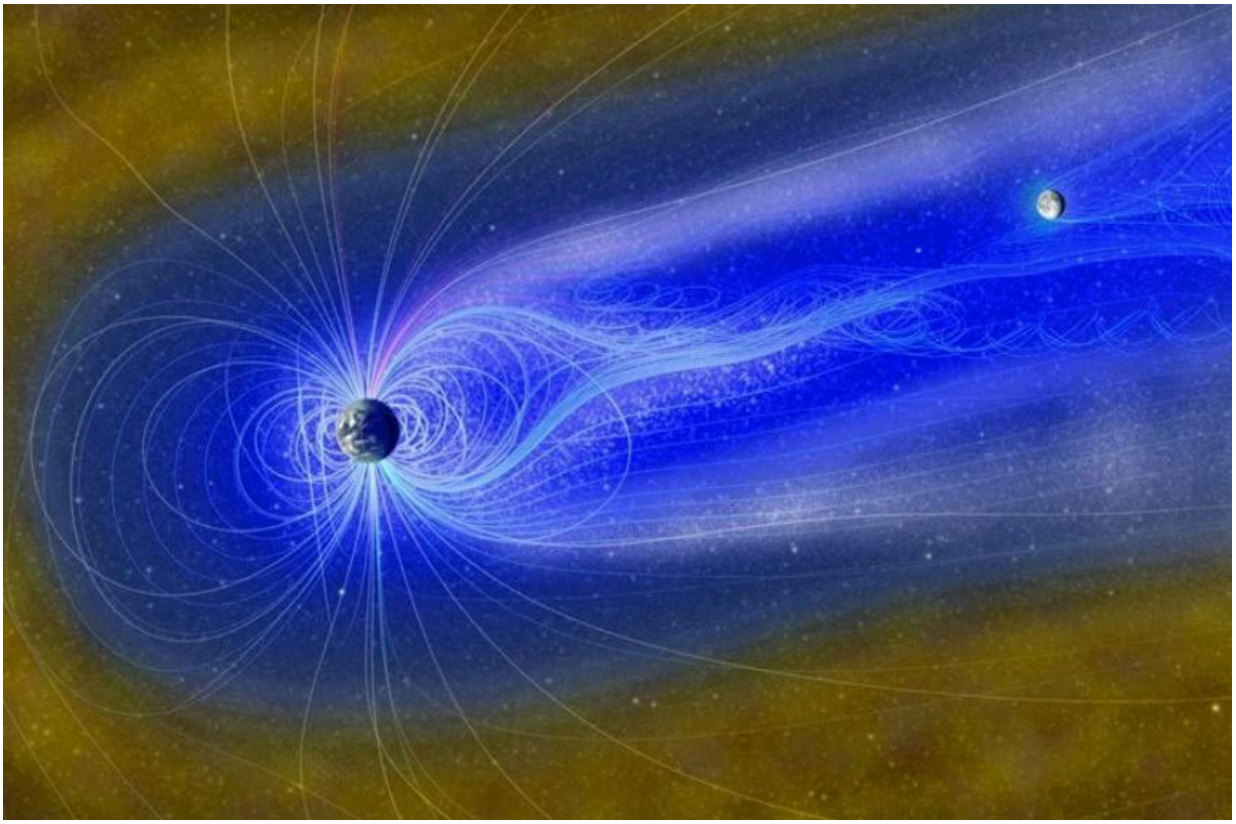
Magnetosphere



4 https://science.nasa.gov/heliophysics/focus-areas/magnetosphere-ionosphere/

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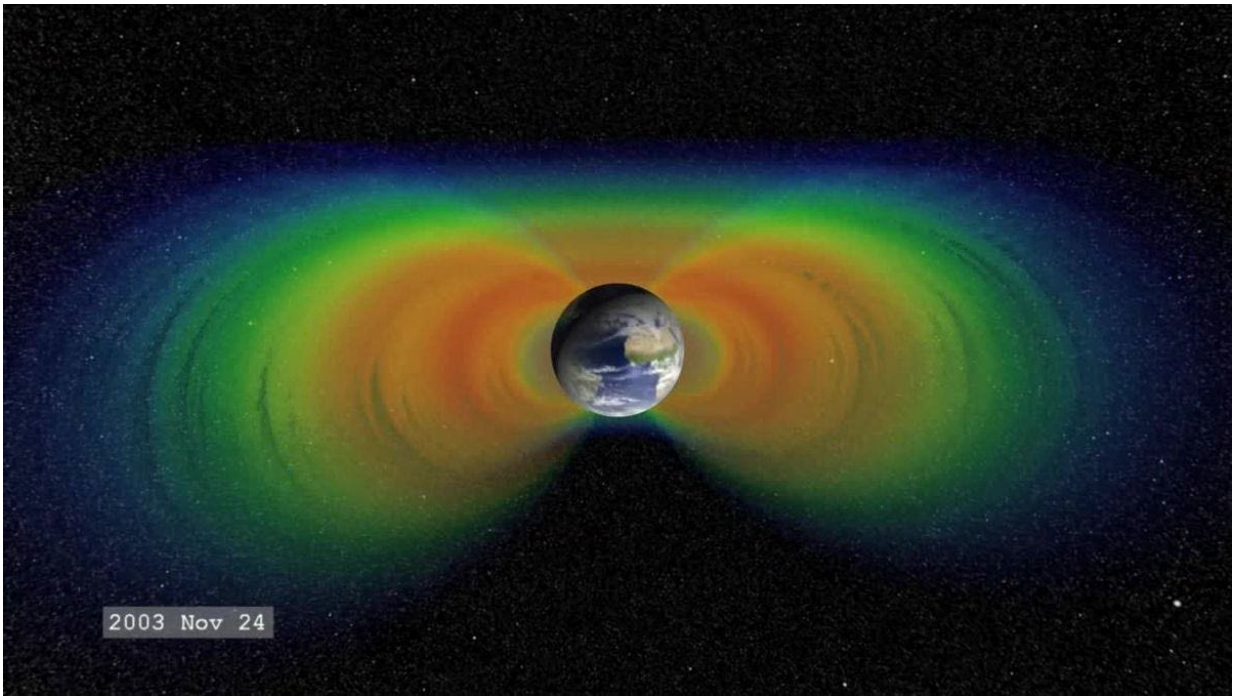
Van Allen Radiation Belts



5 https://science.nasa.gov/mission/van-allen-probes/

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Earth's Moon: One Small Step

6 https://science.nasa.gov/moon/

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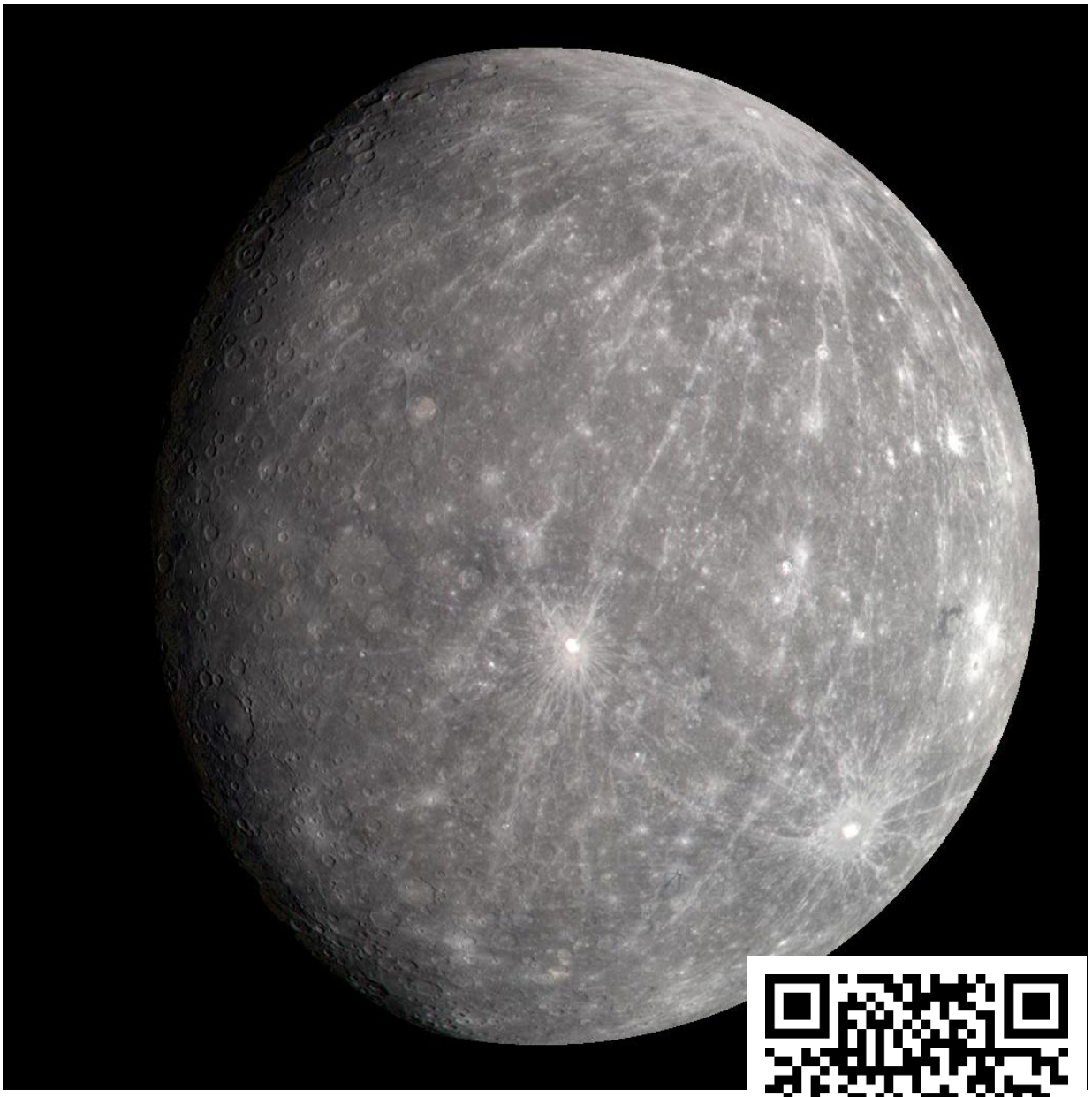
Mercury: Closest to the Sun



7 https://science.nasa.gov/mercury/exploration/

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Venus: Our Nearest Neighbor

8 https://science.nasa.gov/venus/

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Earth: Here We Are!

9 https://science.nasa.gov/earth/

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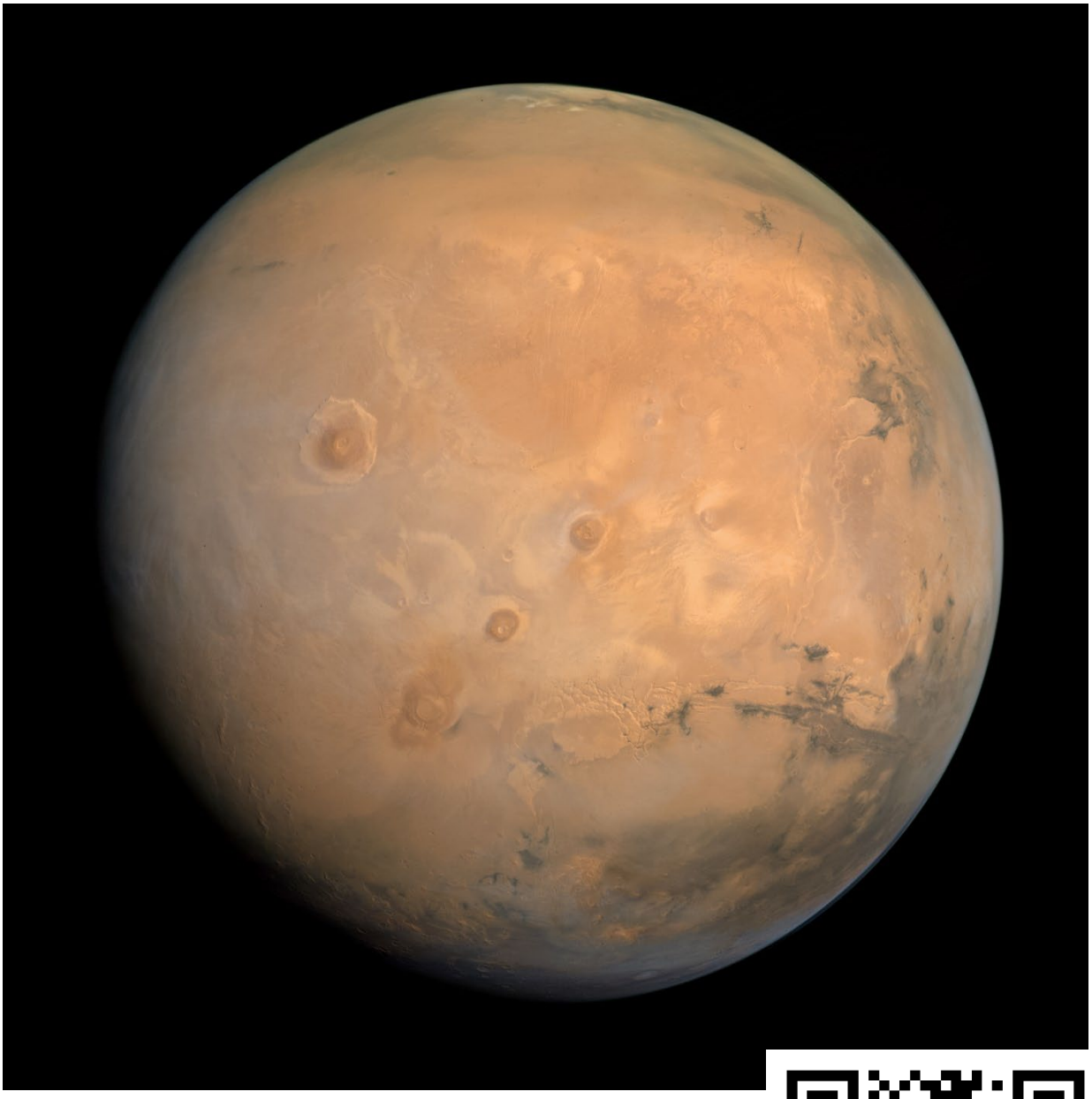
What's Up There?

Mars: The Red Planet



10 https://science.nasa.gov/mars/

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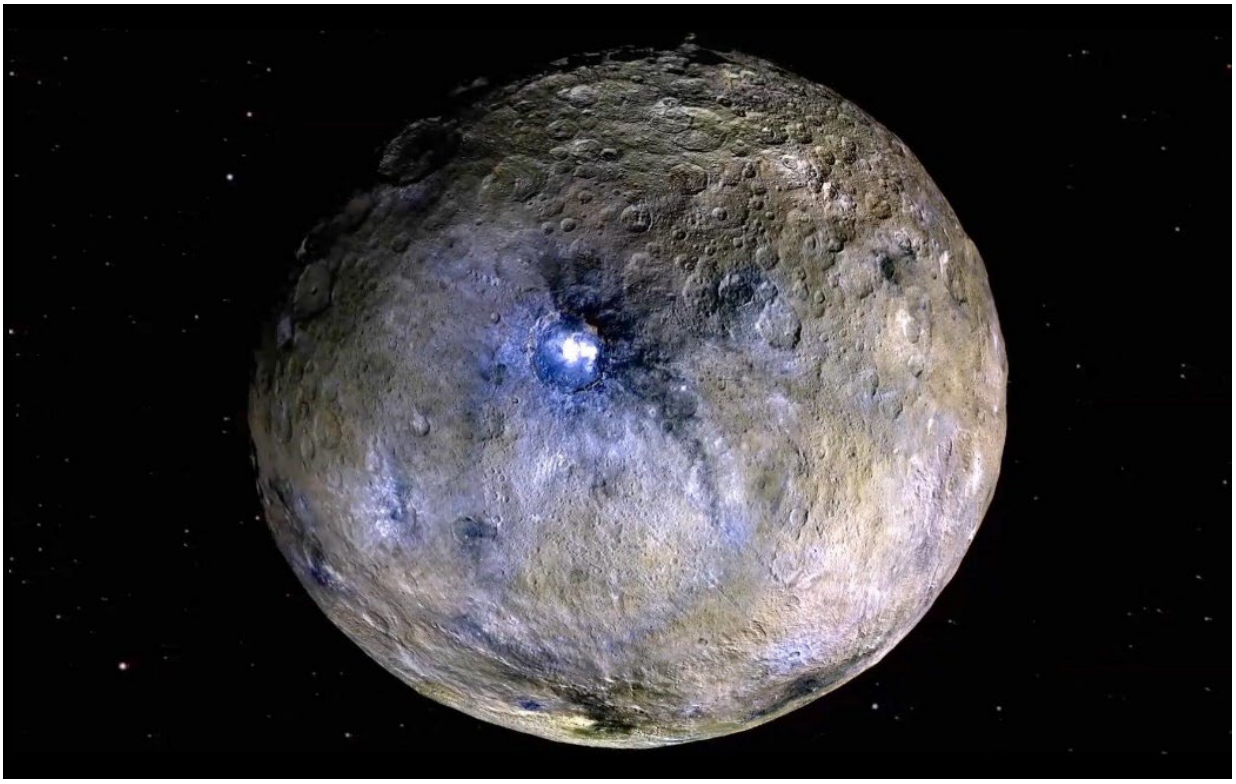
Ceres and Vesta: The Largest Asteroids



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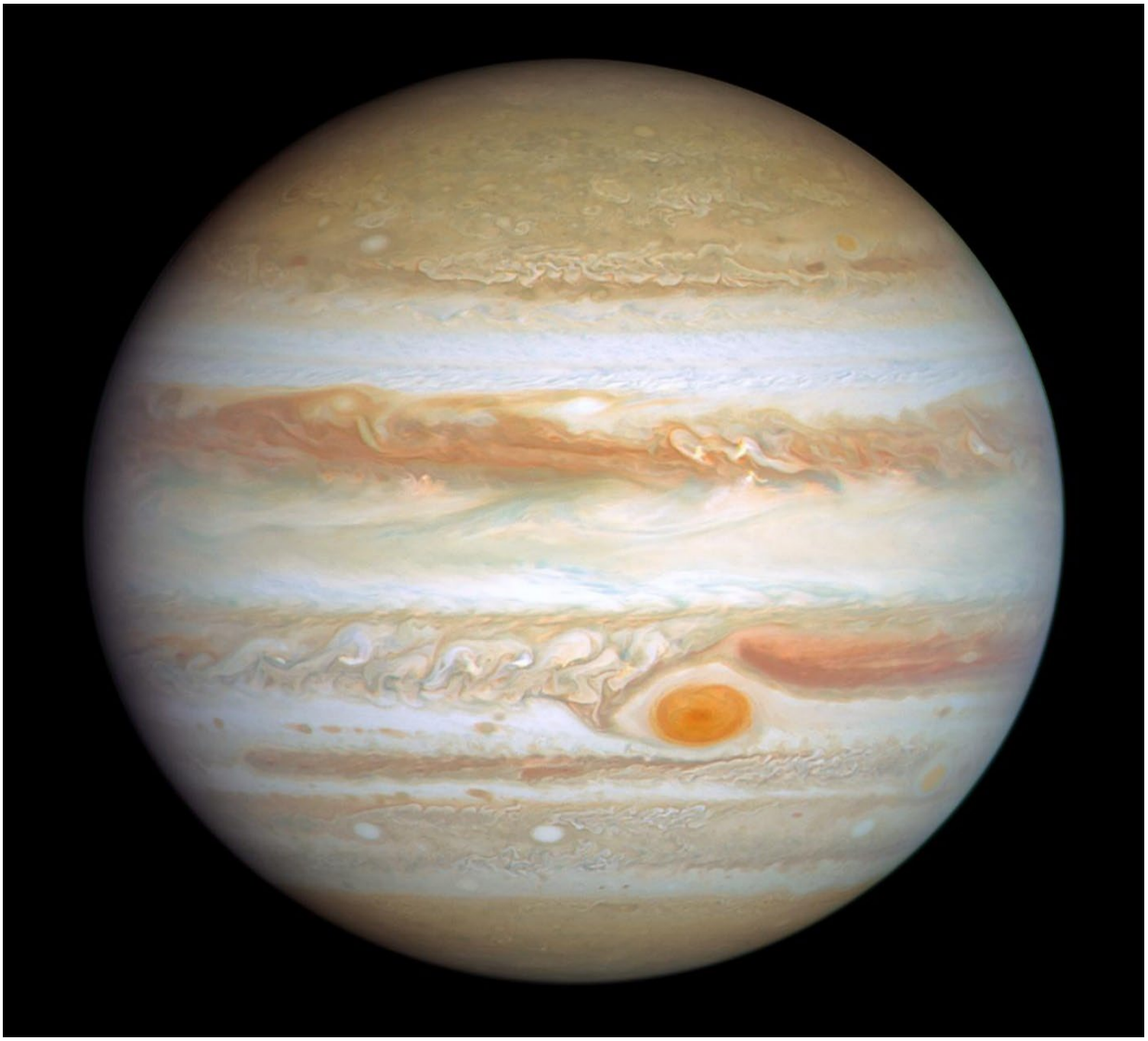
11 https://science.nasa.gov/solar-system/asteroids/

What's Up There?

Jupiter: The Giant



12 https://science.nasa.gov/jupiter/

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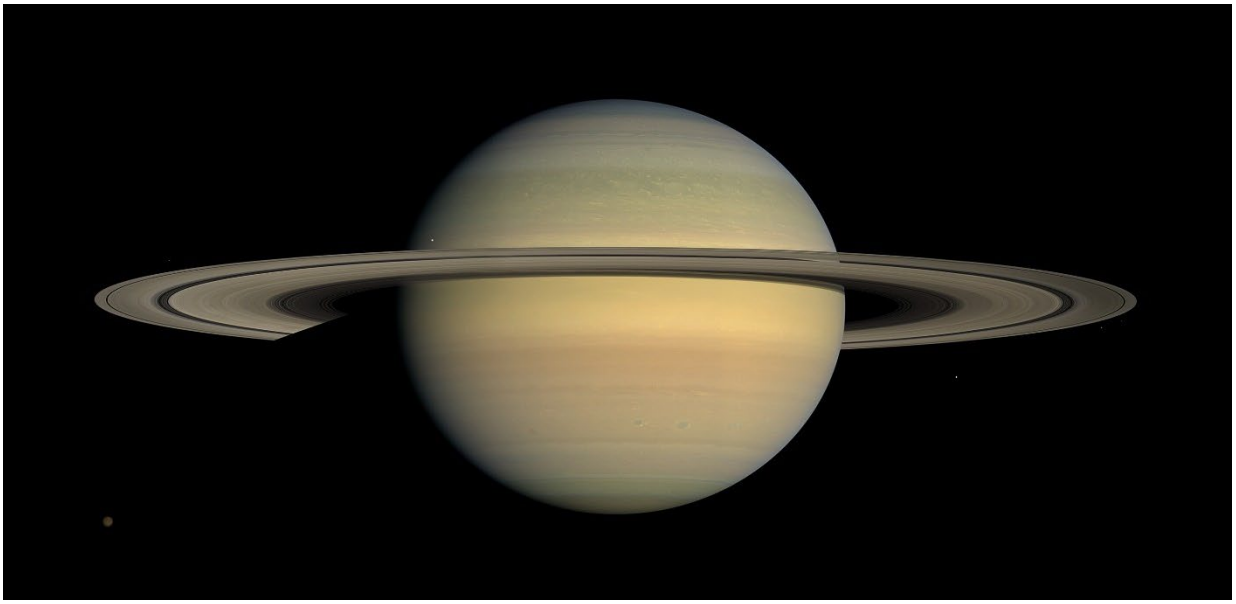
Saturn: Lord of the Rings



13 https://science.nasa.gov/saturn/

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Uranus: The Ice Giant

14 https://science.nasa.gov/uranus/

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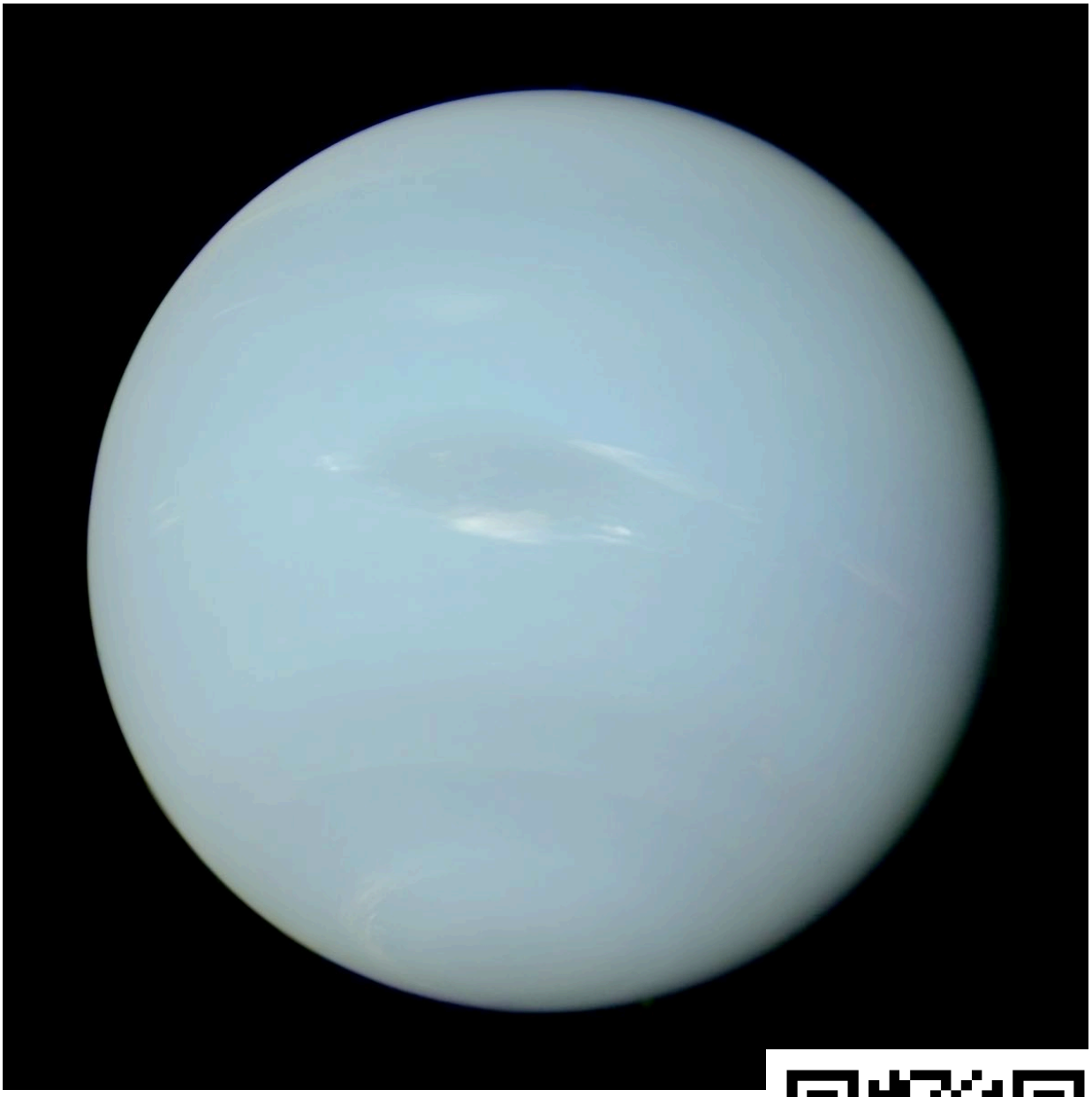
Neptune: The Planet of Math



https://science.nasa.gov/neptune/

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What's Up There?

Pluto: Looks Like a Planet to Me!

16 https://science.nasa.gov/dwarf-planets/pluto/

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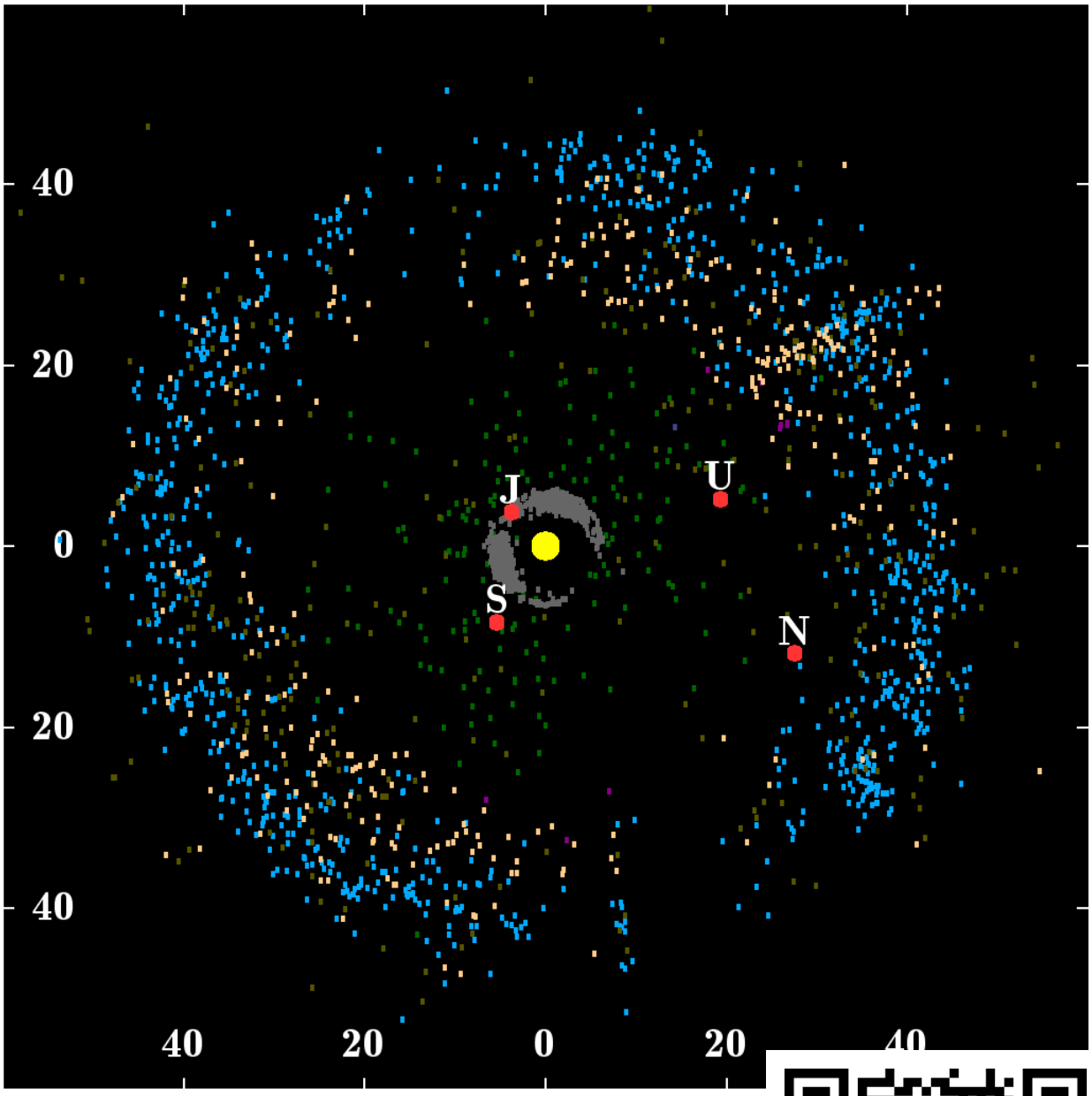
What's Up There?

The Kuiper Belt: 100,000 Planets?



17 https://science.nasa.gov/solar-system/kuiper-belt/

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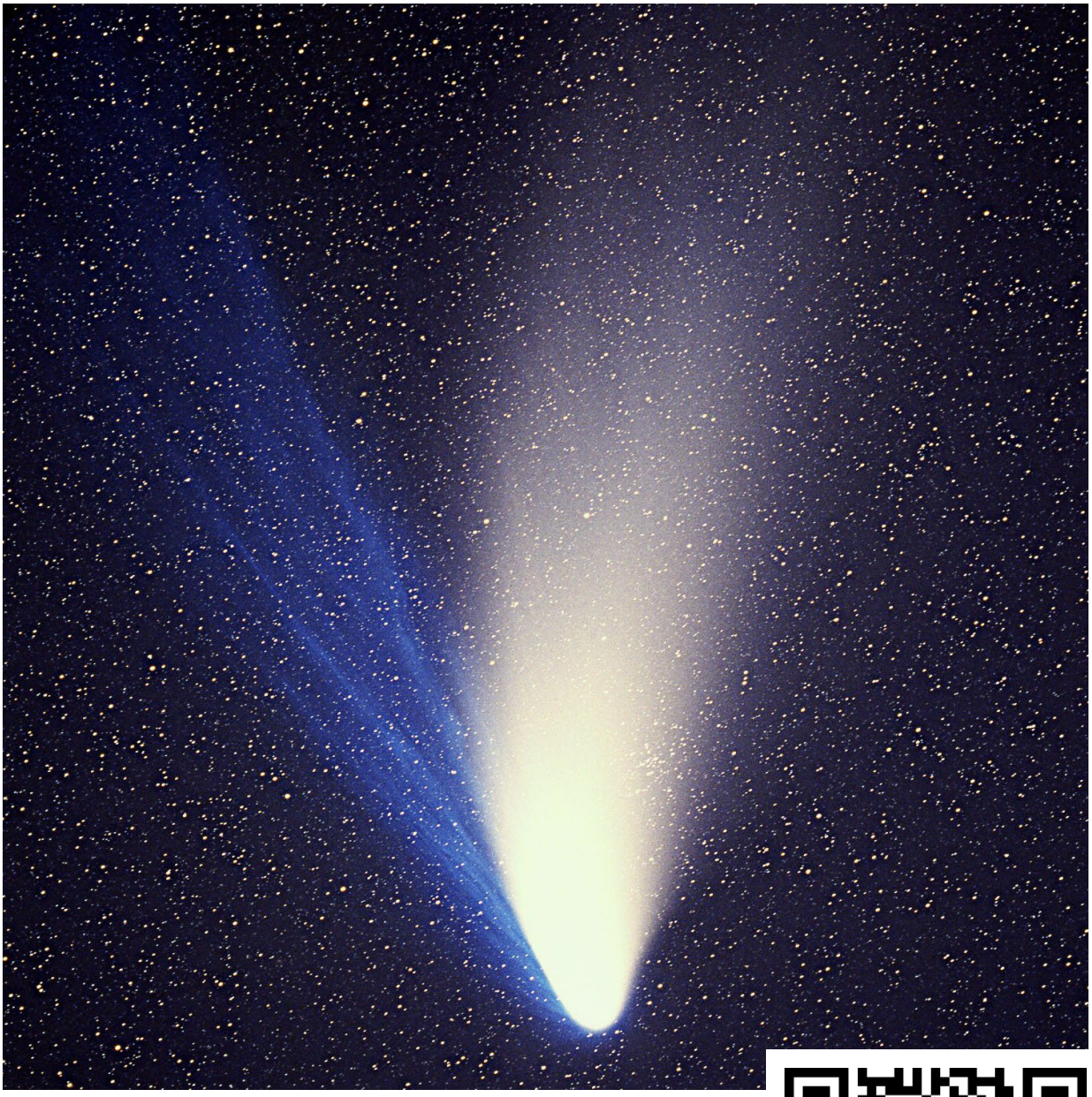
Comets: Taking the Long Way



18 https://science.nasa.gov/solar-system/comets/

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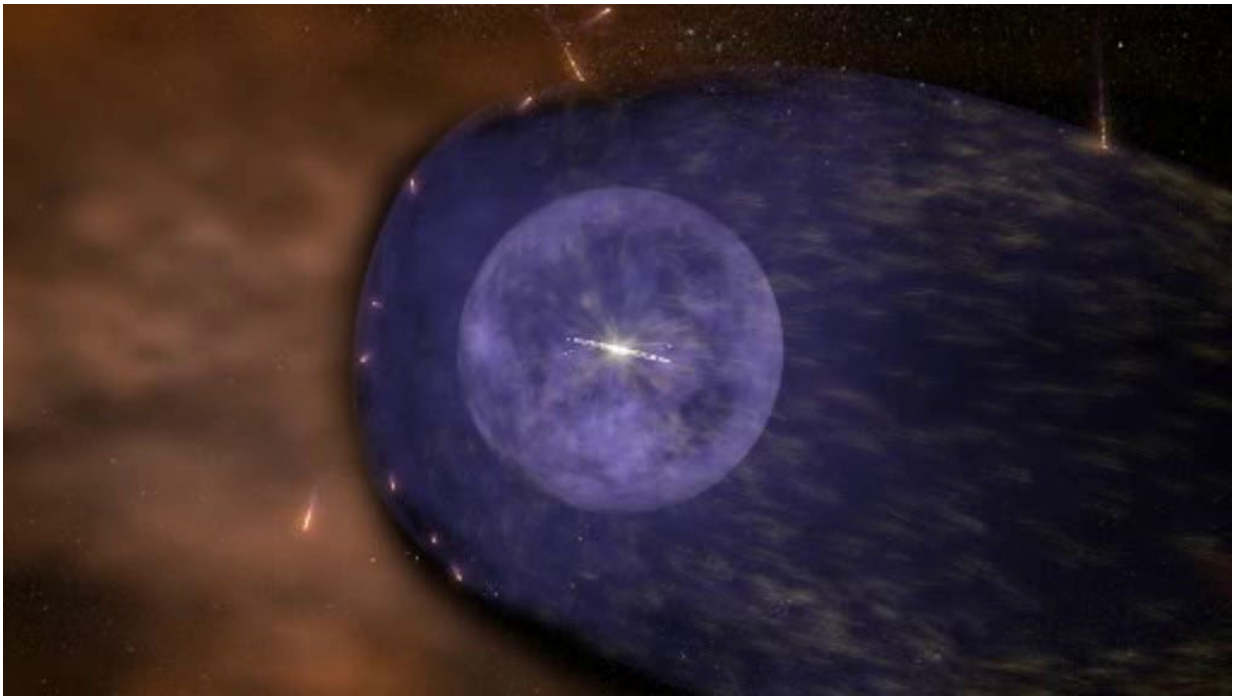
The Heliopause: The Edge of Space



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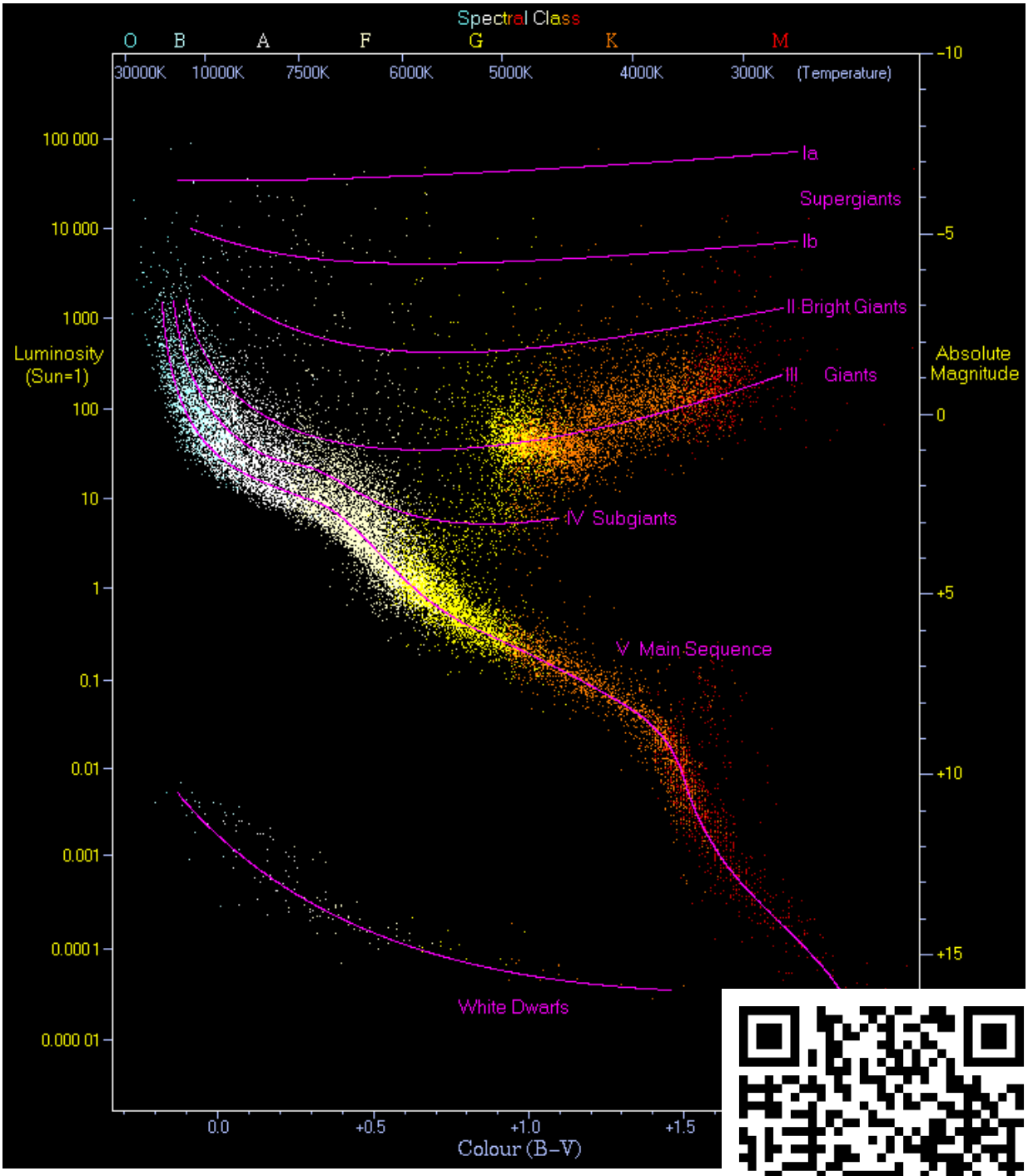
https://science.nasa.gov/missions/voyager-program/voyagersdiscovers-evidence-of-the-heliopause/

What's Up There?

Stars and the Main Sequence



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https://en.wikipedia.org/wiki/Main_sequence

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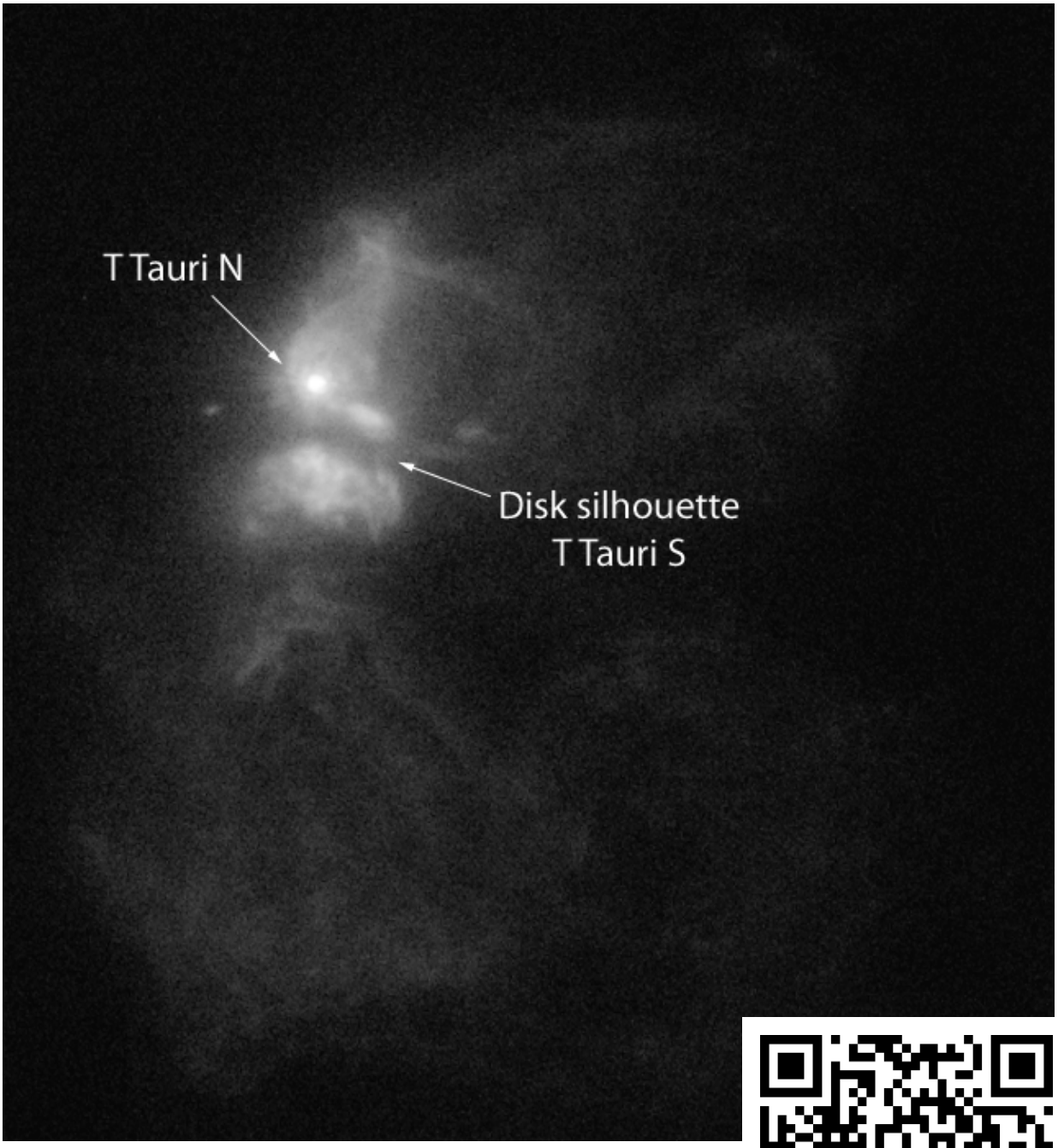
Protostars: Ready to Ignite



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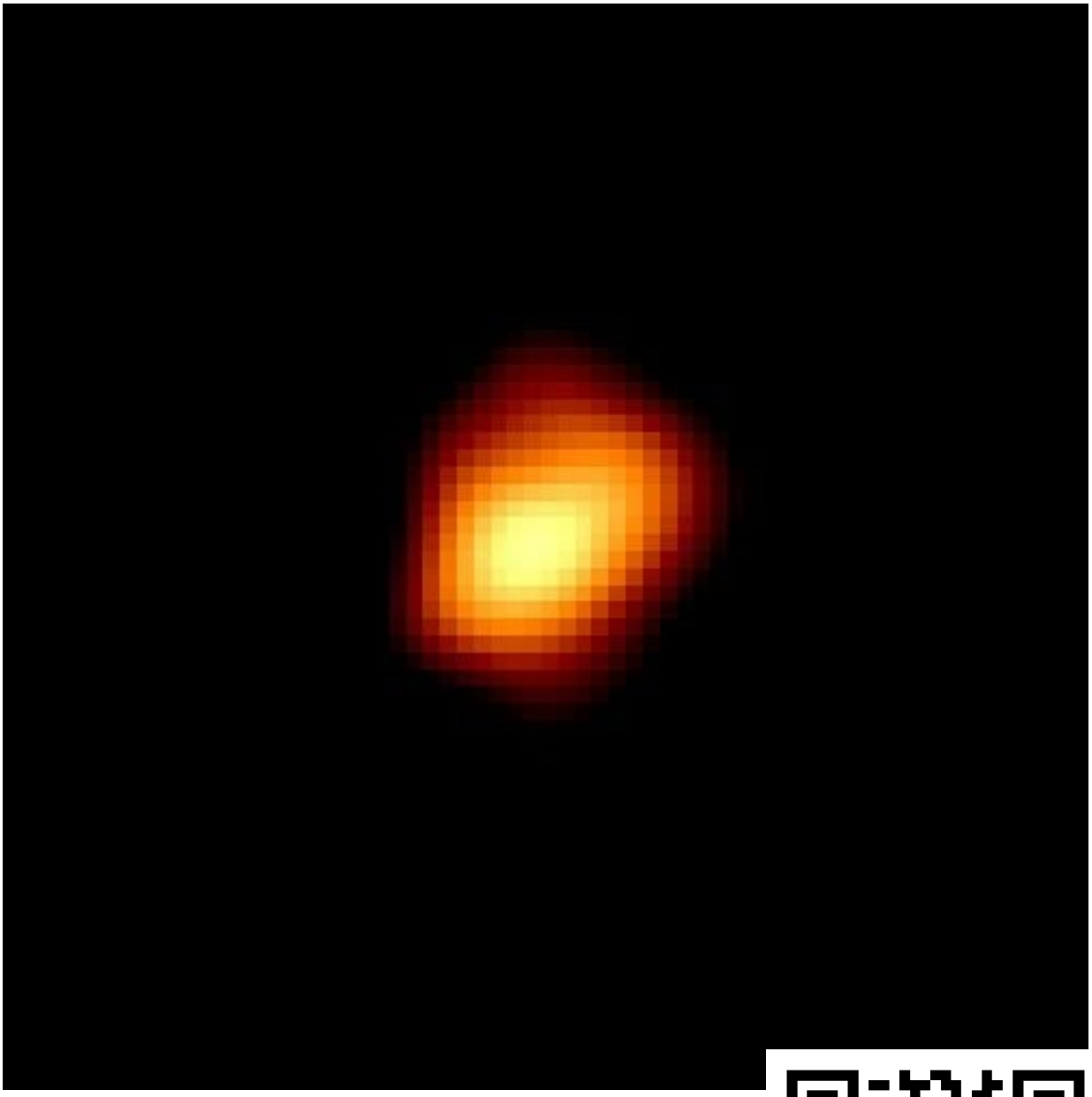
https://www.nasa.gov/universe/stars/protostars/

What's Up There?

Red Giants: Aging Stars



22 https://en.wikipedia.org/wiki/Red_giant

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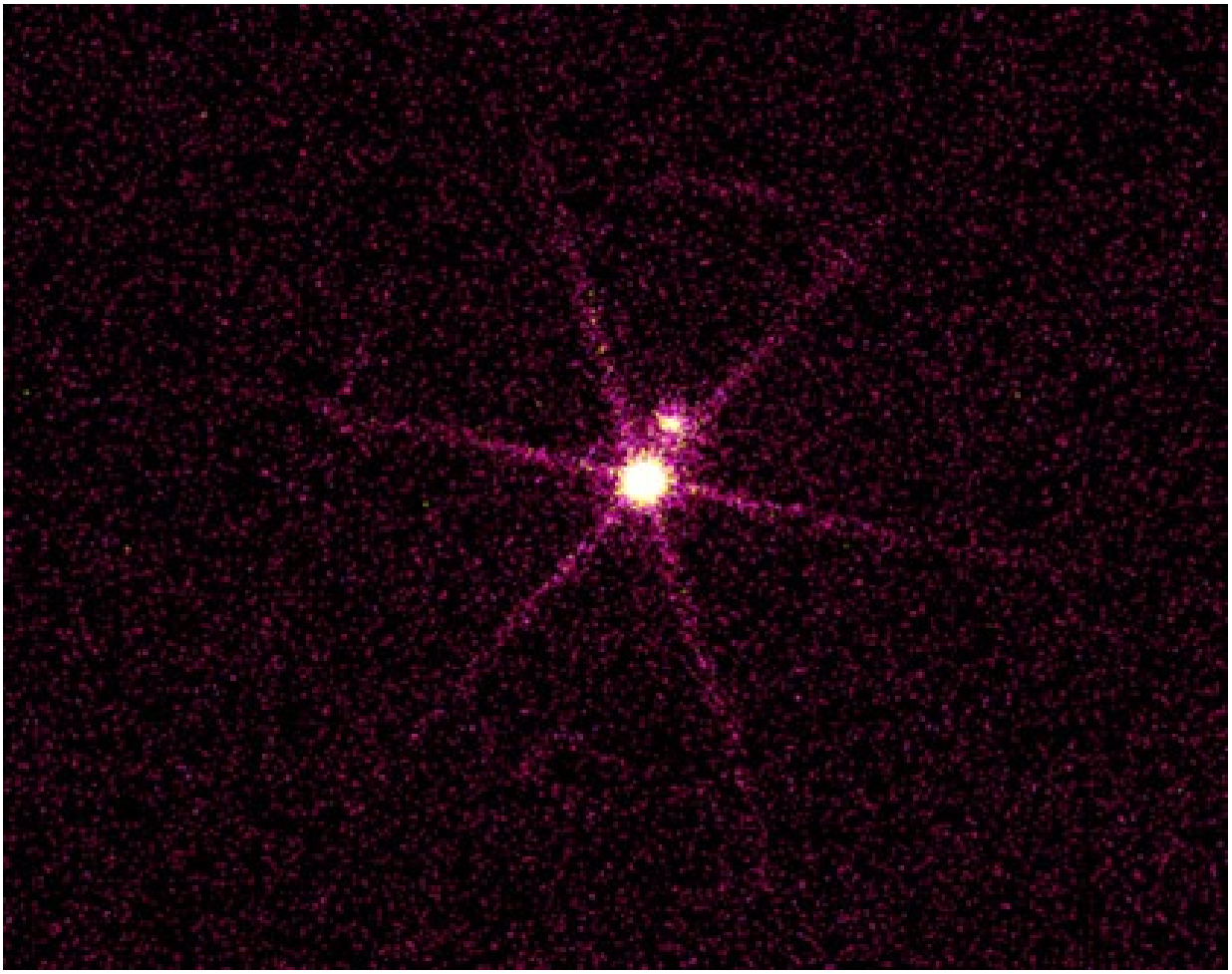
What's Up There?

White Dwarfs: Cooling Stars



23 https://en.wikipedia.org/wiki/White_dwarf

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What's Up There?

Red Dwarf Stars: Not Big Enough

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https://en.wikipedia.org/wiki/Red_dwarf

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Blue Main Sequence Stars: Burning Bright

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25 https://en.wikipedia.org/wiki/B-type_main-sequence_star

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Blue Super-Giant Stars: Bigger and Brighter

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https://en.wikipedia.org/wiki/Blue_supergiant

What's Up There?

Red Supergiant Stars: Warning Signs

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https://en.wikipedia.org/wiki/Red_supergiant

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Supernova: There Goes the Neighborhood

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What's Up There?

Neutron Stars: What's Left Behind

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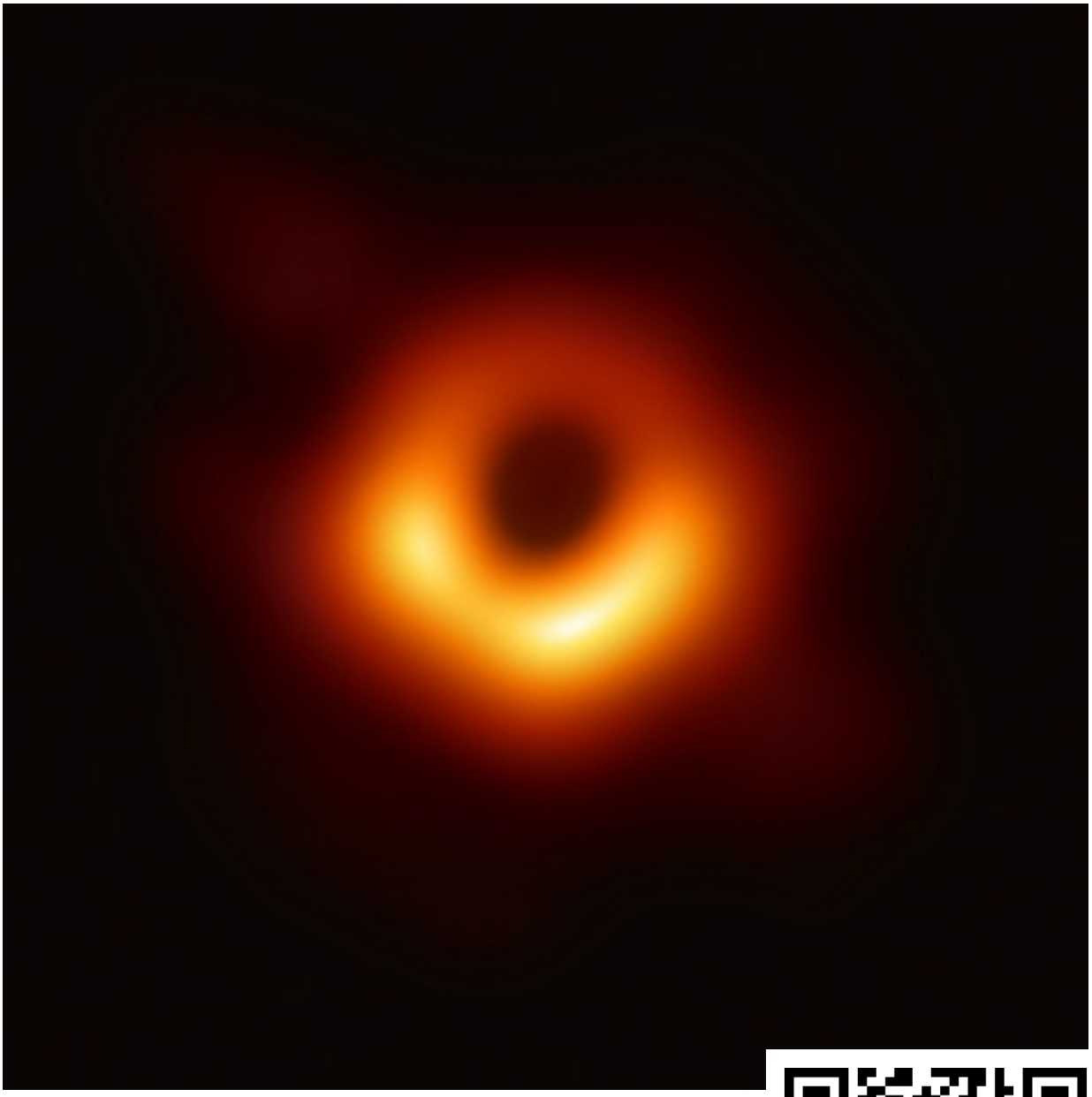
29 https://en.wikipedia.org/wiki/Neutron_star

What's Up There?

Black Holes: The End of the Line



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https://science.nasa.gov/universe/black-holes/

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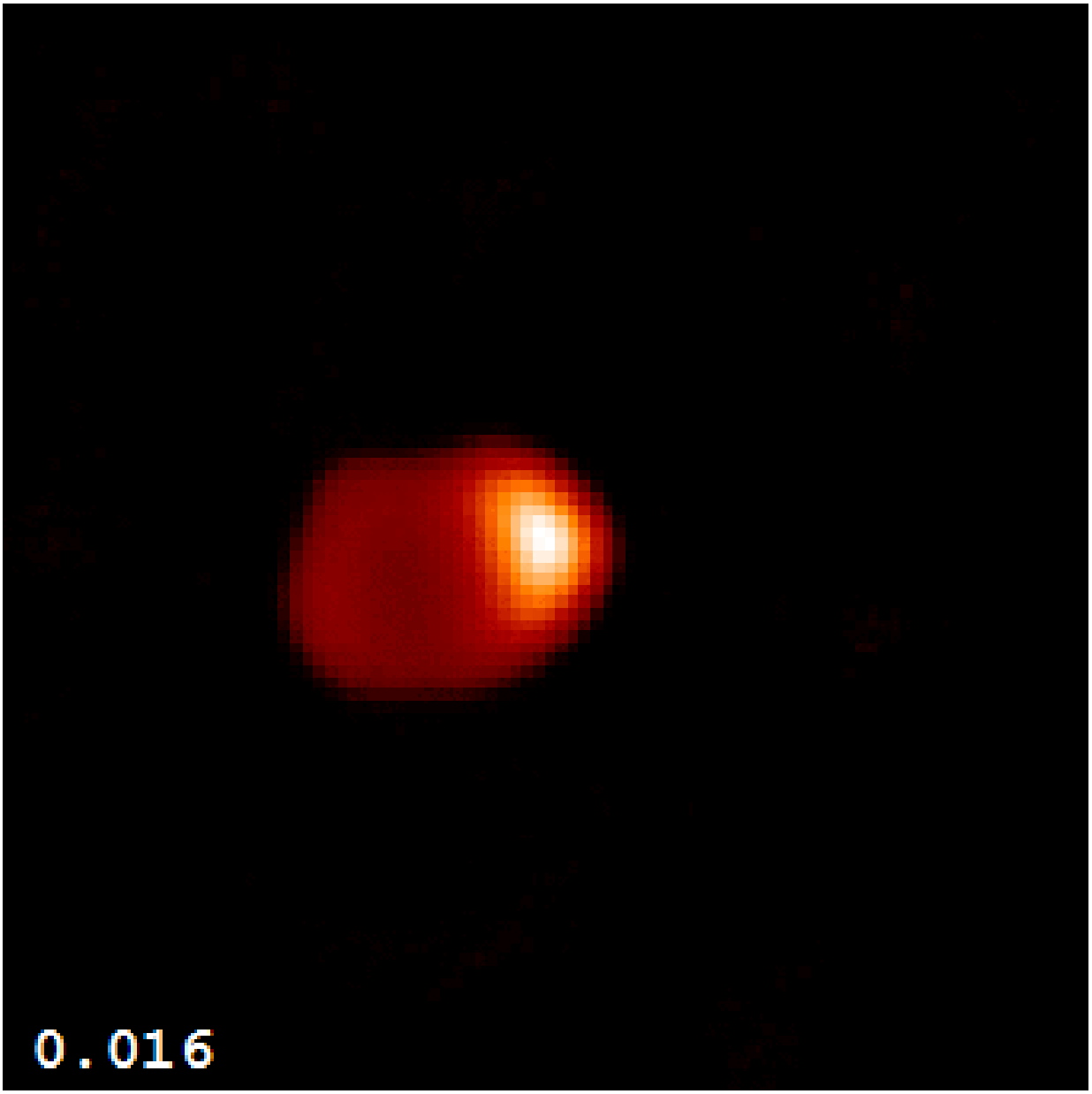
Binary Stars



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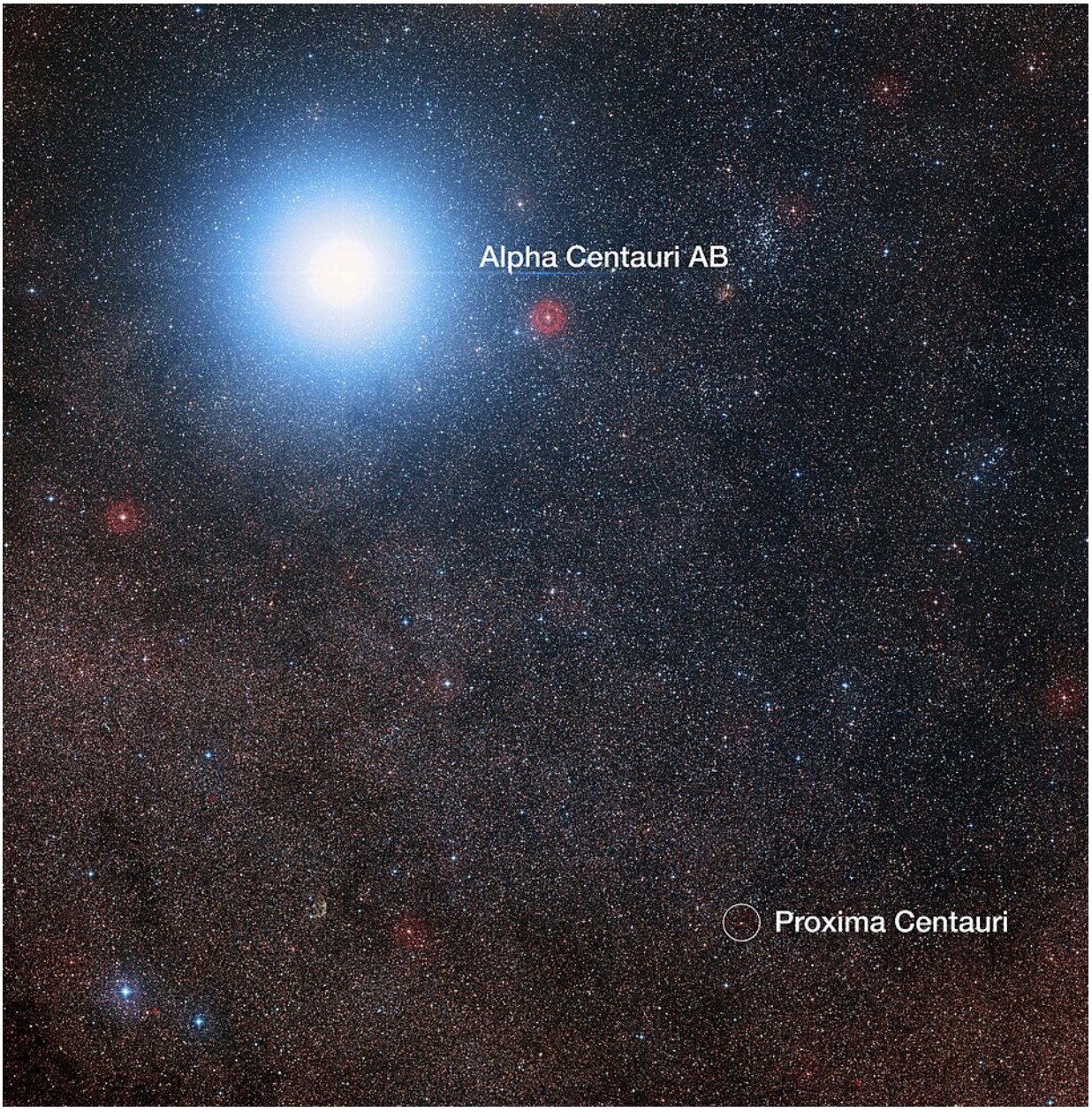
Trinary Stars



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Star Clusters

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https://en.wikipedia.org/wiki/Star_cluster

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What's Up There?

Emission Nebulae

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https://en.wikipedia.org/wiki/Emission_nebula

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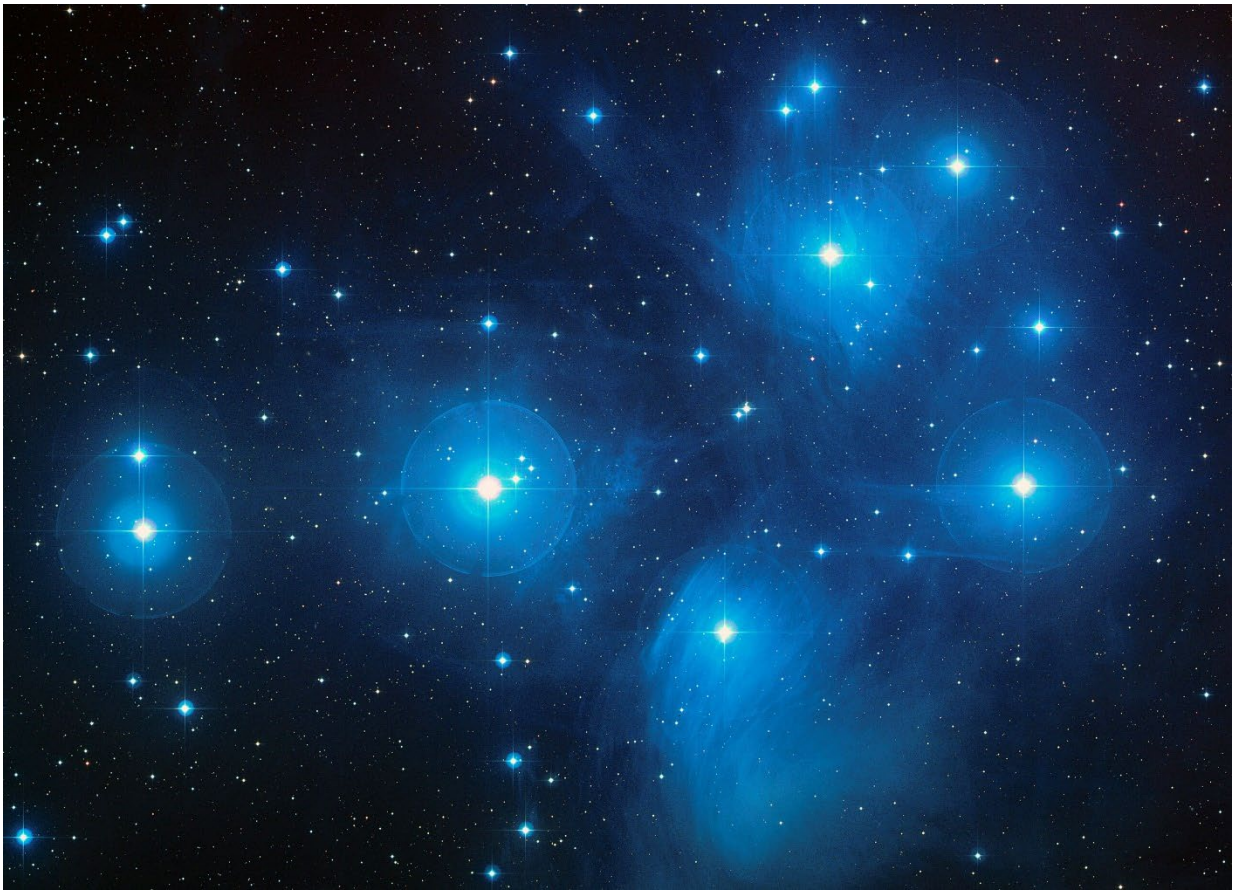
Reflection Nebulae



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https://en.wikipedia.org/wiki/Reflection_nebula

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Dark Nebulae

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https://en.wikipedia.org/wiki/Dark_nebula

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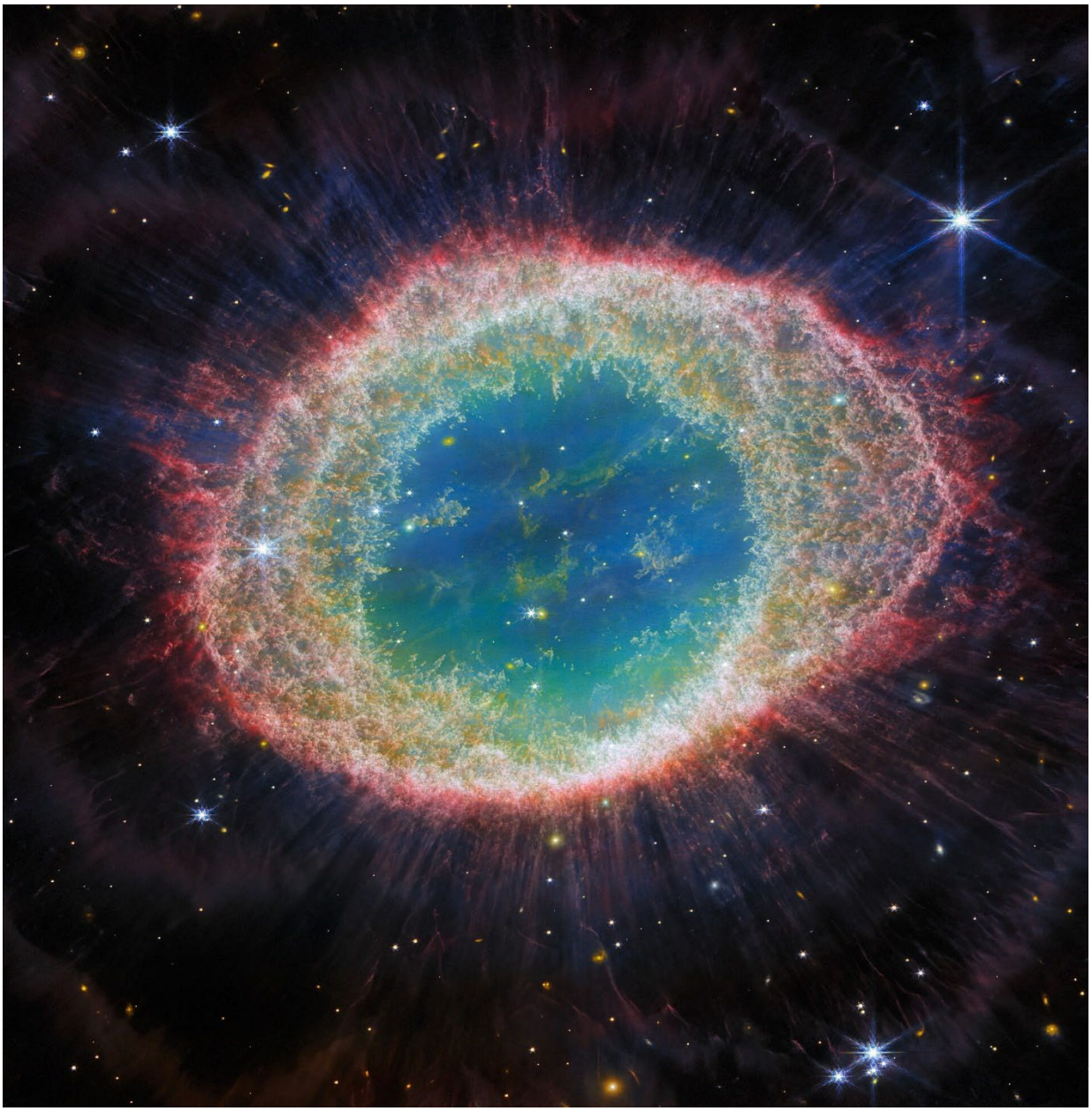

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https://en.wikipedia.org/wiki/Planetary_nebula

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Spiral Galaxies

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https://en.wikipedia.org/wiki/Spiral_galaxy

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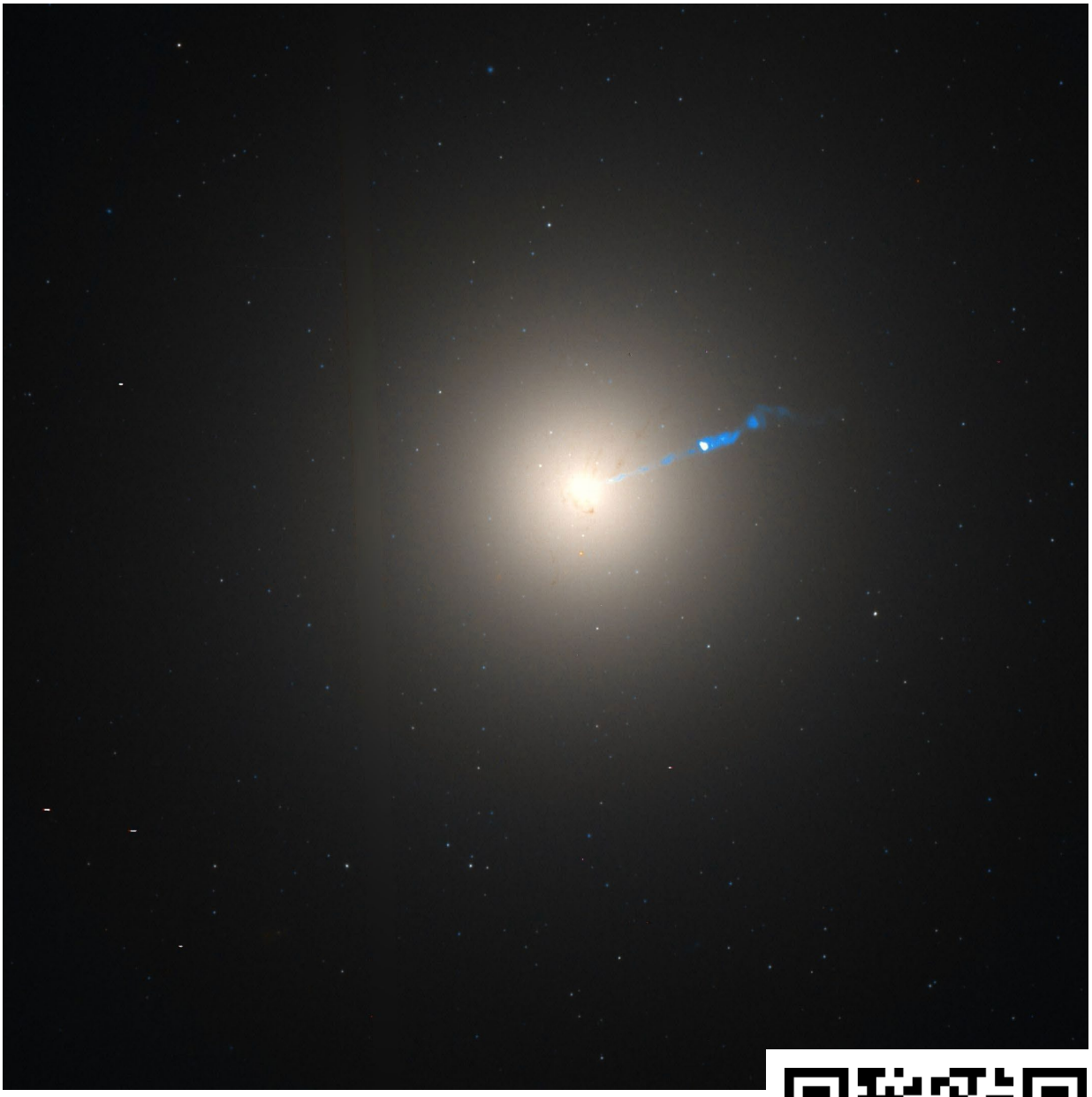
Elliptical Galaxies



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https://en.wikipedia.org/wiki/Elliptical_galaxy

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Irregular Galaxies

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