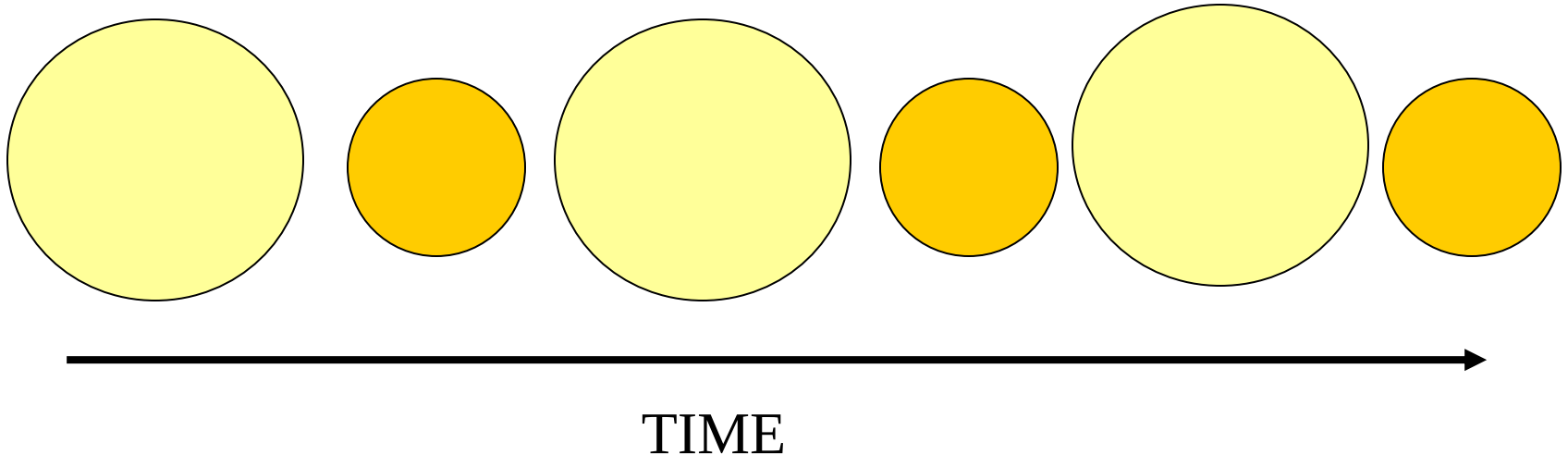
Unit 5
Stars & Celestial Objects

Variable Stars & Nebulae

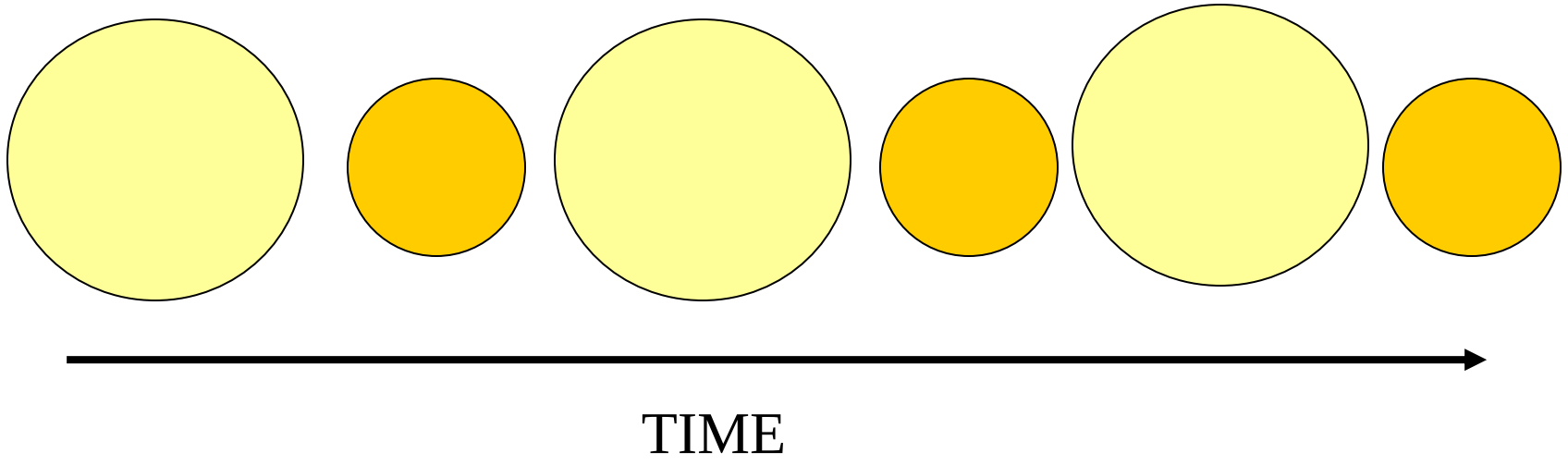
Between 1900-1910, Henrietta Leavitt discovered 1170 “blinking” stars. These stars had variable brightness (luminosity) over a defined period.

- Stars grow brighter then dimmer in repeating cycles
- The time period of the brighter-dimmer cycle was consistent and uniform.

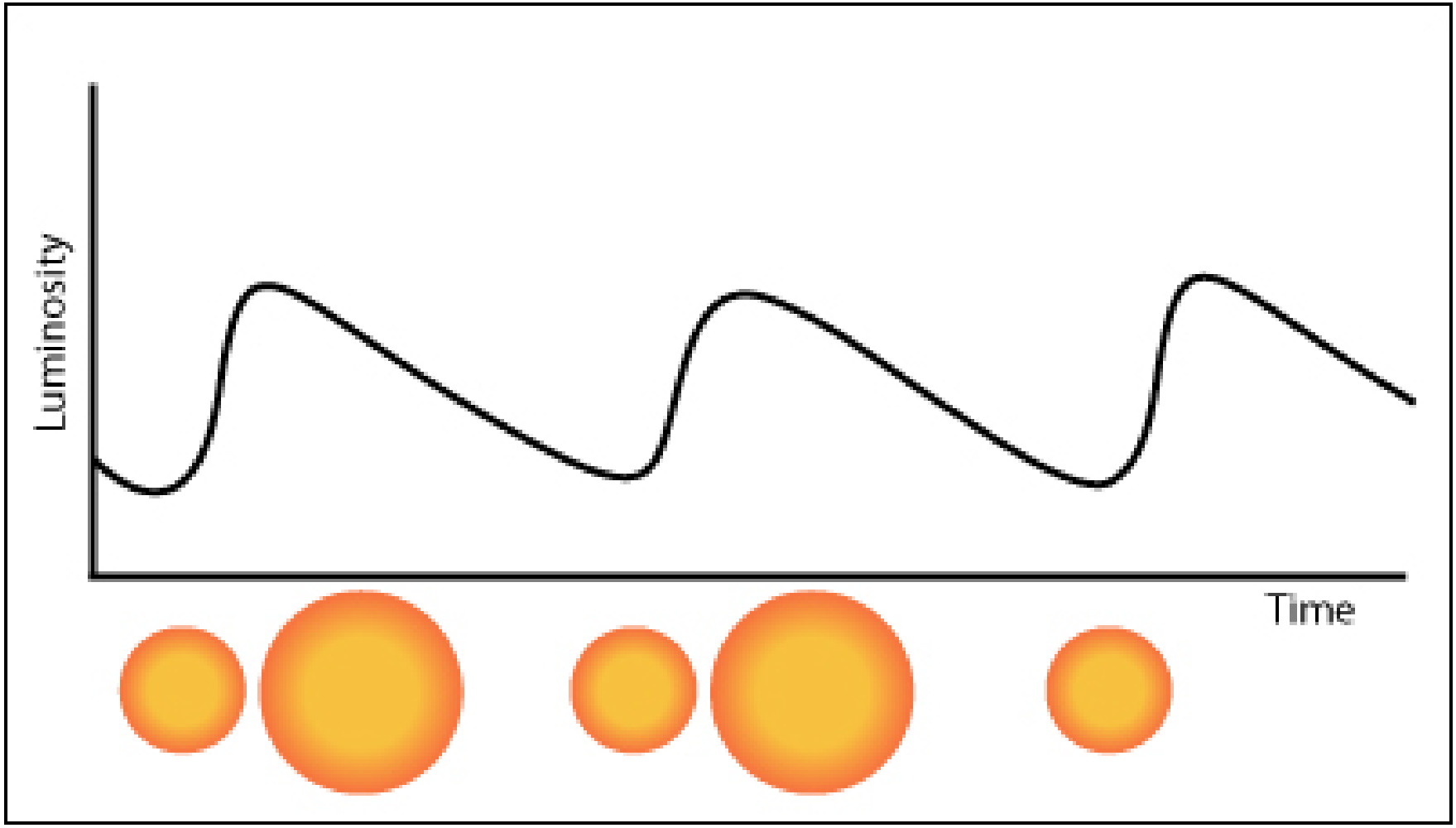


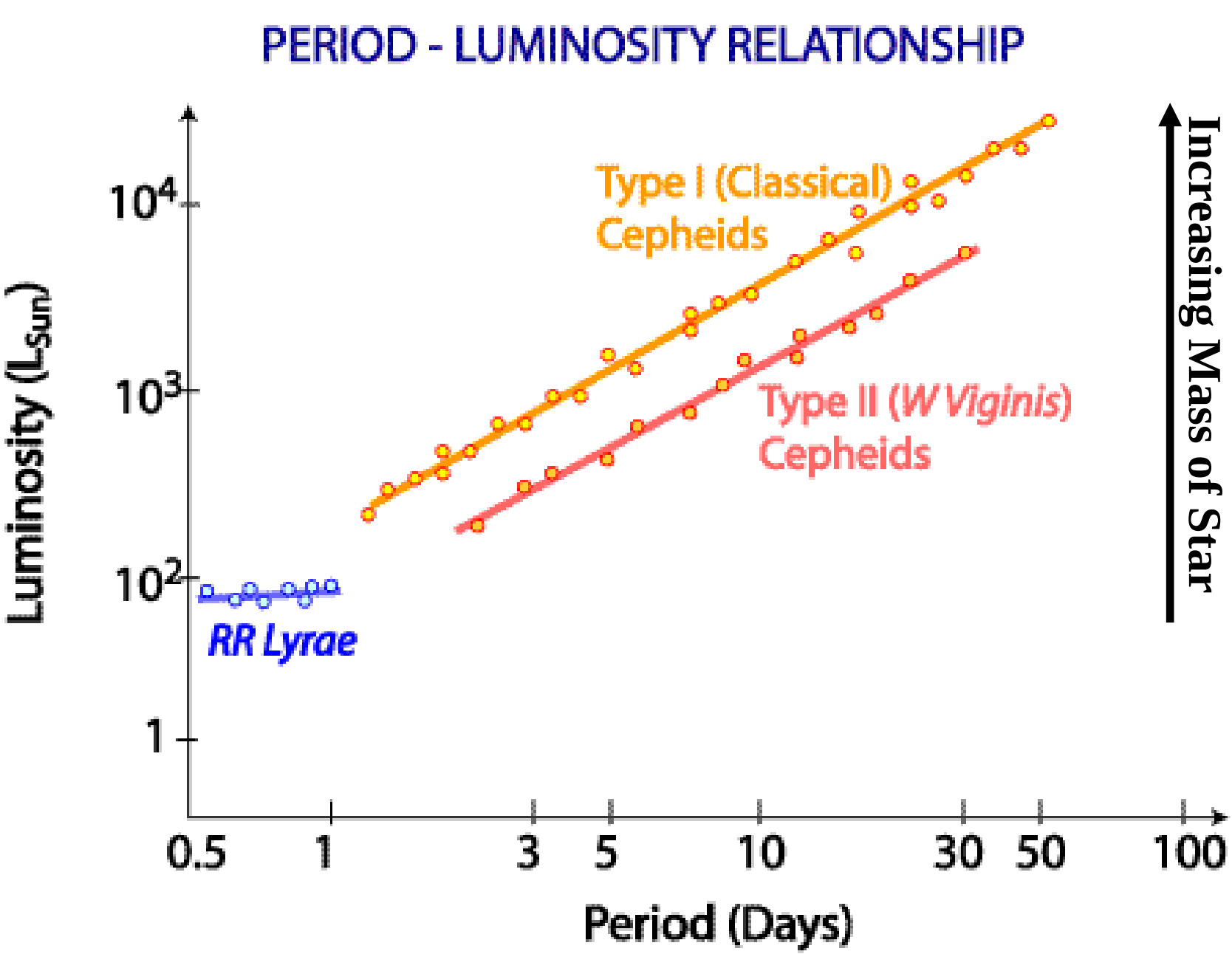
The shorter the time period of the luminosity change (days), the lesser the luminosity/brightness of the star. These were “smaller mass” variable stars.

The longer the time period of the luminosity change (weeks), the greater the luminosity/brightness of the star. These were much “larger mass” variable stars.



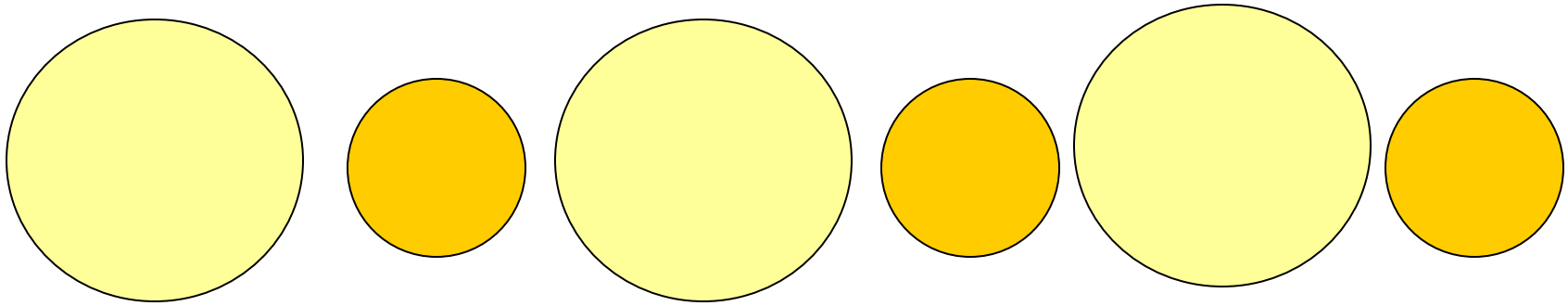
Graph relating the pulsations of **Cepheid variable stars**. Most short-period Cepheid Variable stars pulsate on 5-to-10 day intervals.




PERIOD - LUMINOSITY RELATIONSHIP
Luminosity (L_{sun})
10^4
10^3
10^2
1
Type I (Classical) Cepheids
Type II (*W Viginis*) Cepheids
RR Lyrae
Increasing Mass of Star
0.5
1
3
5
10
30
50
100
Period (Days)

The first was discovered in the constellation Cepheus, and these “blinking” variable stars are Cepheid Variable Stars.

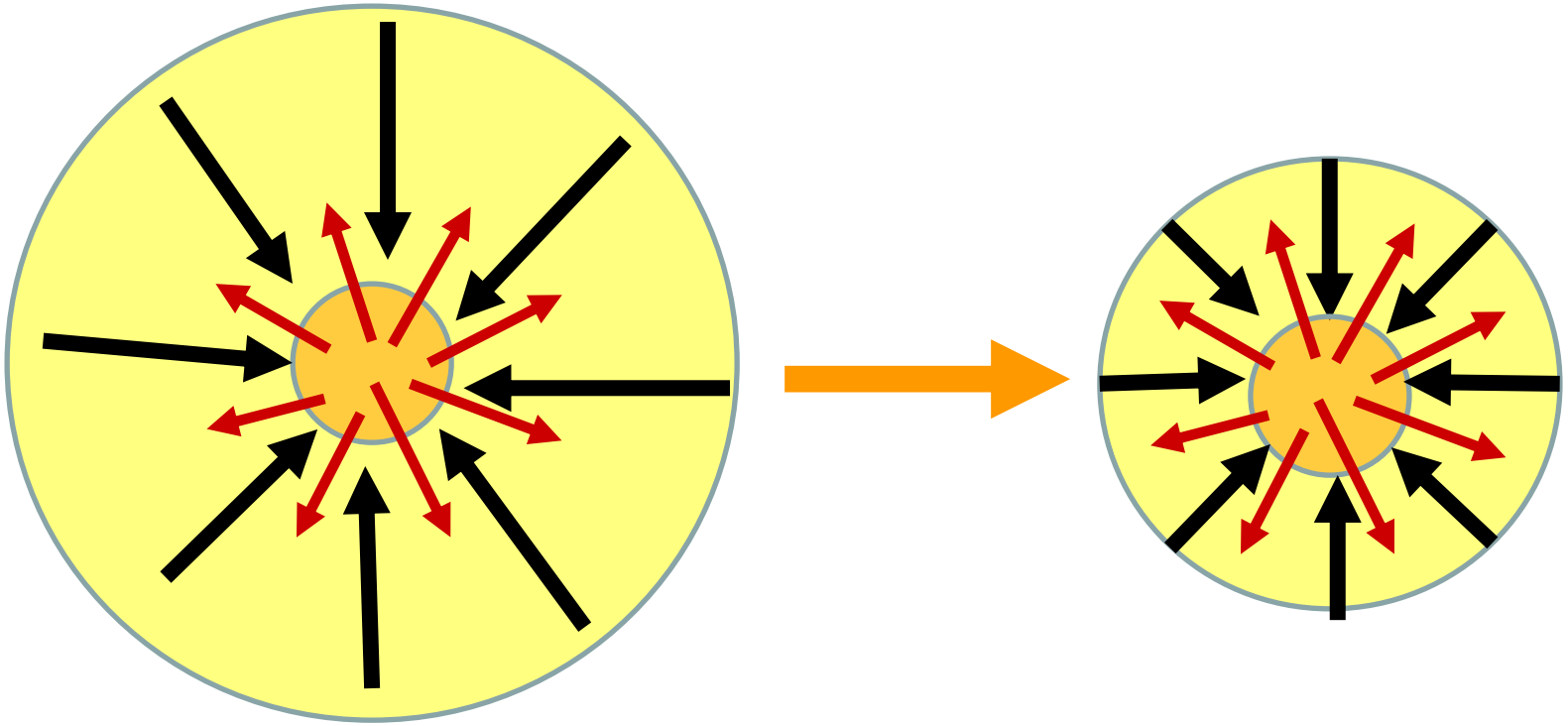
- Most **Cepheid Variable Stars** are **yellow giant** and very rare **yellow supergiant stars**.
- They are in a state of fusion instability and are in progress of changing from **Main Sequence** into giant or supergiant stars.
- Hydrogen fusion slows, then gets faster, then slows, then gets faster as the inward gravity force and the outward fusion-energy push force are not in balance.



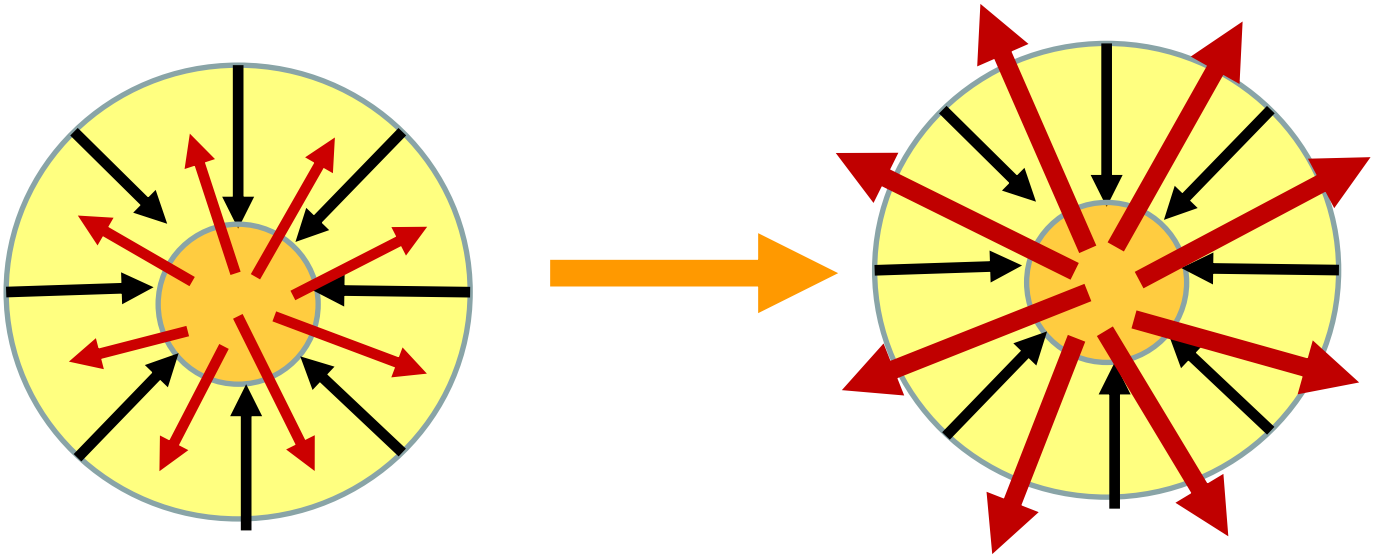
Time 1 → Time 2 → Time 3 → Time 4 → Time 5 → Time 6

Brighter → Dimmer → Brighter → Dimmer → Brighter → Dimmer

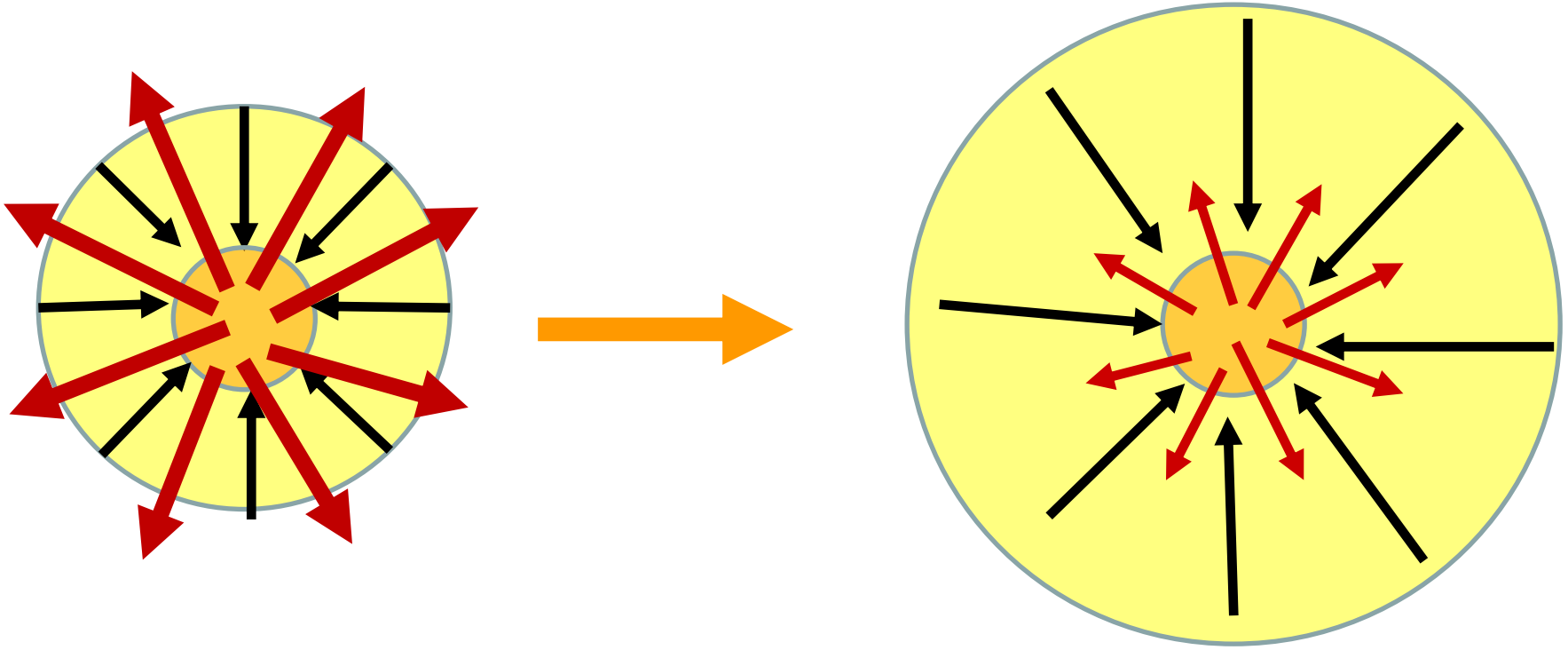
↑ Power → ↓ Power → ↑ Power → ↓ Power → ↑ Power → ↓ Power



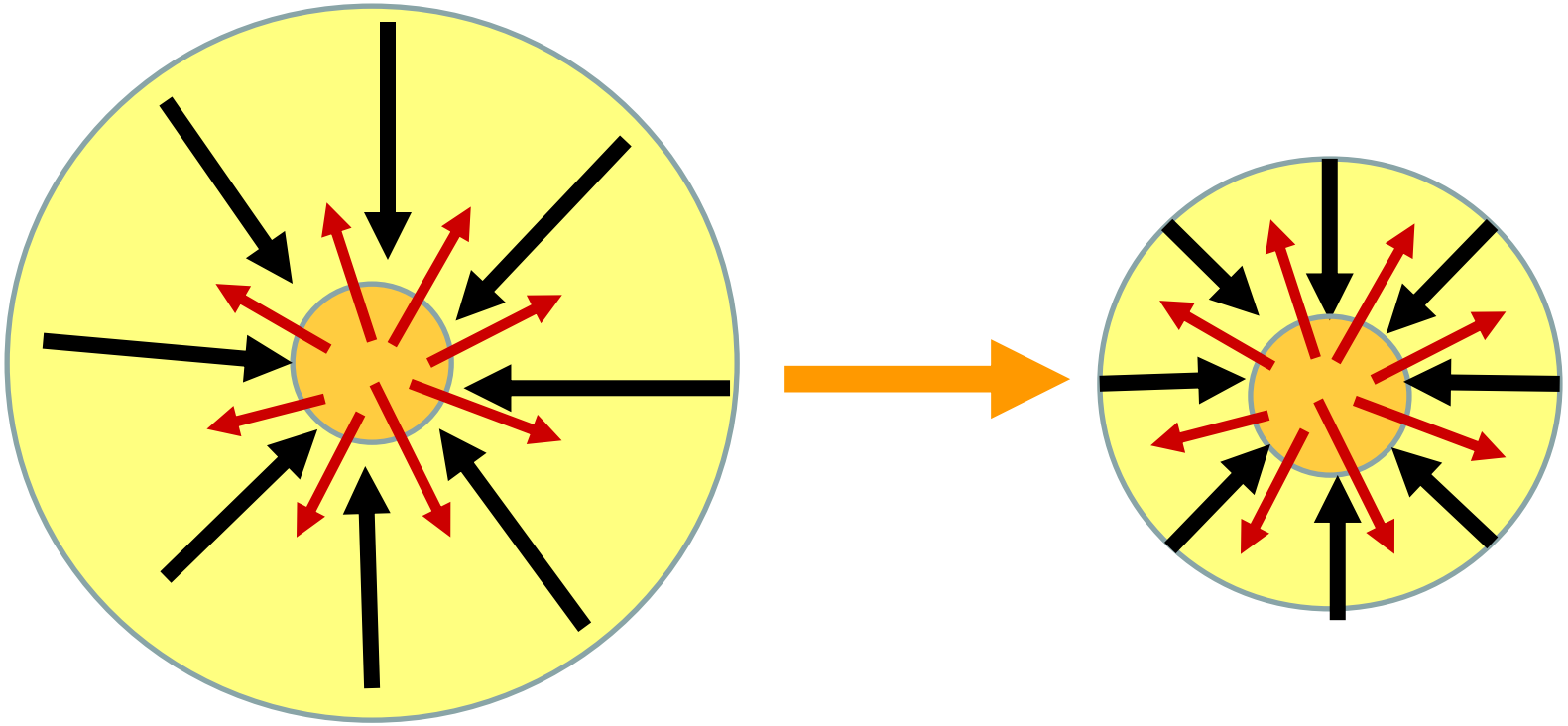
When the rate of hydrogen → helium fusion slows (as the star is running out of hydrogen in the core), the luminosity of the star will decrease (less light). The inward force of gravity is much stronger than the outward push force of the energy/heat from the core. The star will collapse and get smaller in size and get dimmer.



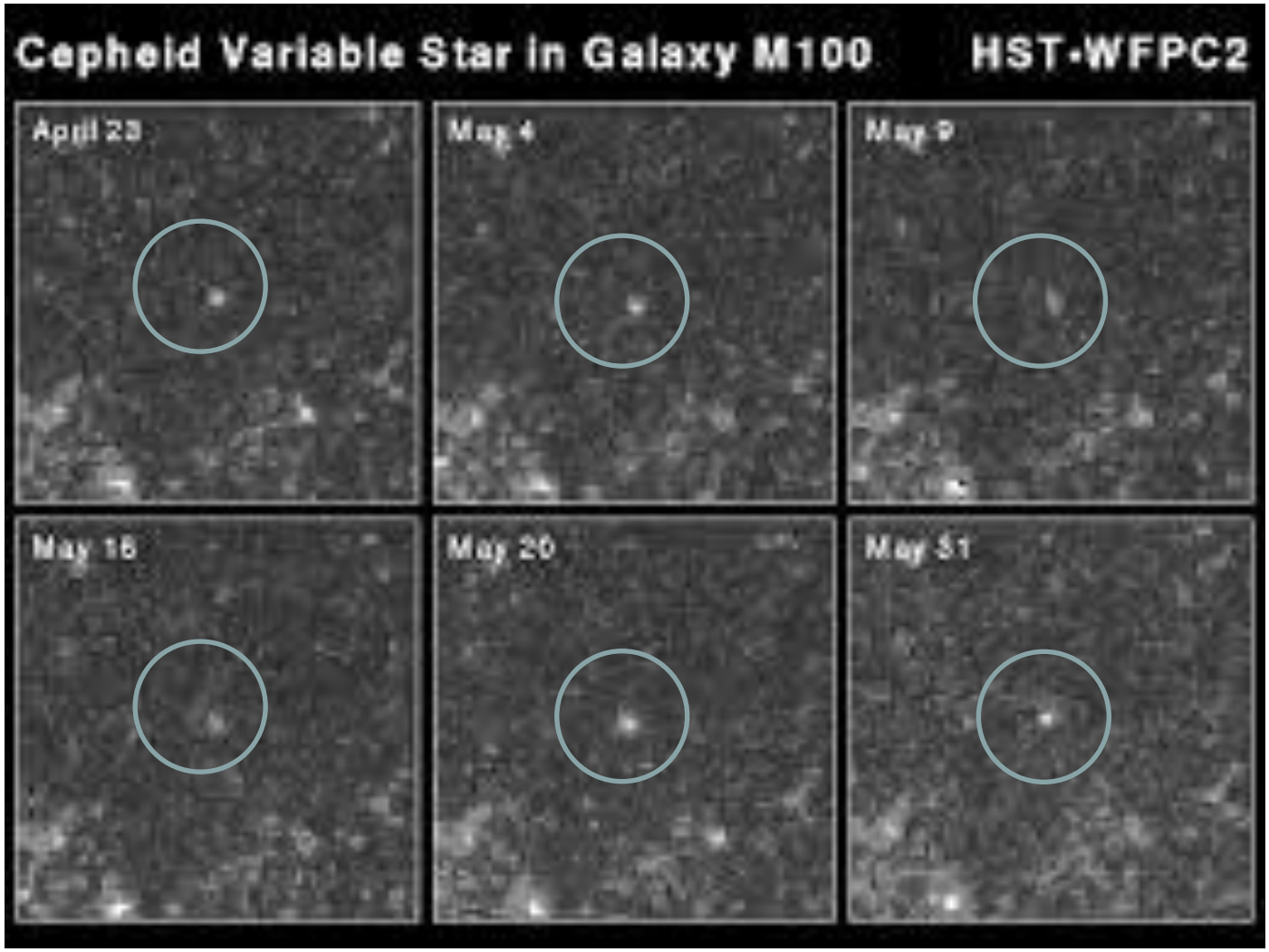
As gravity squeezes the mass of the star onto the core, the pressure and heat inside the core increases astronomically. This forces hydrogen and helium to fuse at a very high rate, or “flash”. A lot of heat and light is created. The huge increase in fusion creates astronomical outward push force that overwhelms the inward gravity,



The stronger outward push force from the core pushes the mass of the star outward. The star expands in size very rapidly. As it expands outward, the rate of fusion in the core slows because there is less pressure pushing inward on the core. Fusion slows and the star cools.



The inward gravity becomes stronger than the outward push force of the heat/energy from the core because fusion had slowed so much. The star will collapse inward and get smaller in size and get dimmer again. The cycle repeats.


Cepheid Variable Star in Galaxy M100
HST-WFPC2
April 23
May 4
May 9
May 16
May 20
May 31

All Cepheid Variable stars that have **the same cycle period** (for example, 5 days) are **all the same mass** and **the same luminosity**.

This important because *if any two variable stars are the same mass and same luminosity, but have different brightness, they are different distances away from Earth.*

This is called **Standard Candle Method** of determining distances to galaxies.

The distances to galaxies can be determined mathematically by calculating the brightness differences between the Cepheid Variables in the Milky Way Galaxy and distance galaxies.

The Standard Candle Method example:

The headlights on the car have luminosities of 200 Watts. That is how much light power is released. This does not change regardless of distance.

The headlights of the same car have different brightness depending on the distance away from the camera. Closer to the camera, much brighter (bottom photo). Farther from the camera, much dimmer (top photo).

Nebula: A large cloud of gas and dust in interstellar space. Nebulae can also contain asteroids, comets, ice crystals, and other materials.

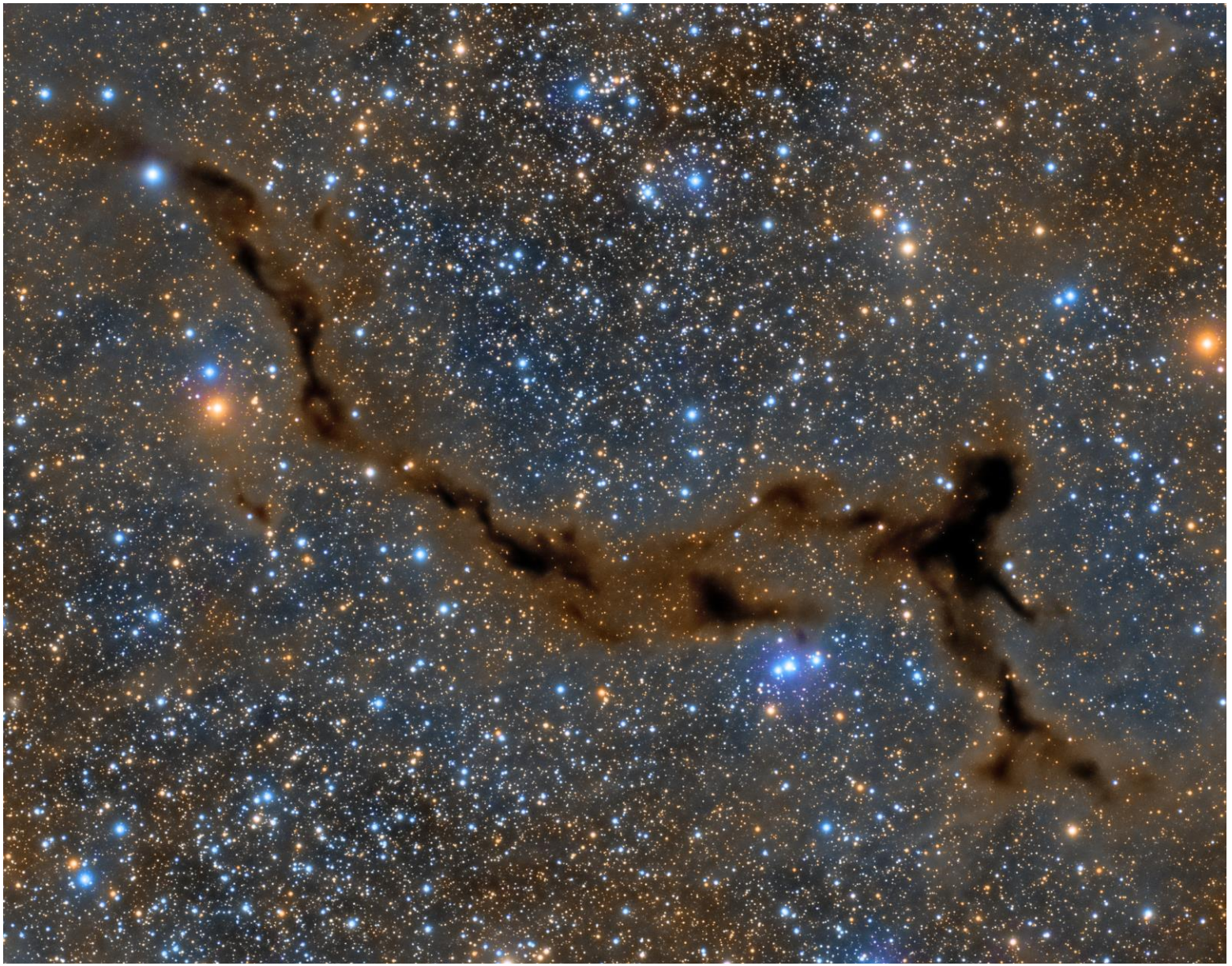
- Dark nebula (absorption nebula)
- Reflection nebula
- Emission nebula
- Planetary nebula
- Supernova remnant nebula

Diffuse nebulae are the dark, reflection, and emission nebulae. They typically do not have defined shapes or structures.

Dark nebula is a cloud of gas and dust that is very cold, so it does not produce visible light. Dark nebula blocks the light from stars and other luminous objects behind them. They appear as black or dark gray zones in the night sky.

Horsehead Nebula.

Barnard 150 (the Seahorse Nebula)



Barnard 72 (the Snake Nebula)

Witch Head Nebula.

Reflection nebula is a cloud of gas and dust that is close to luminous stars. The nebula does not produce visible light. It will reflect the starlight from the nearby luminous stars.

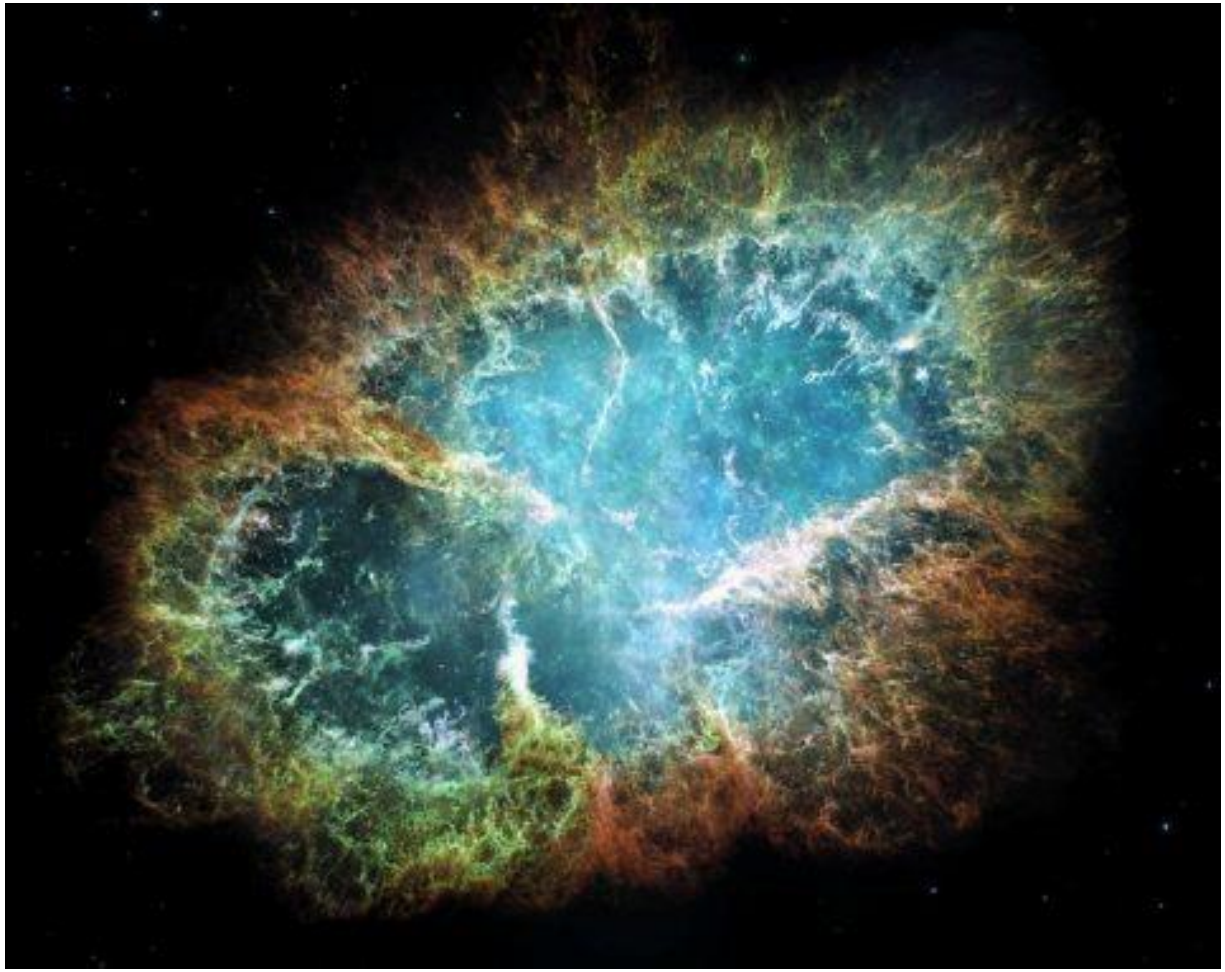
Ghost Nebula

Emission nebula is a cloud of gas, plasma, and dust that is very hot. The nebular material is being heated and ionized by the solar winds of nearby blue and white supergiant stars. This heat causes the gases in the nebula to glow and emit visible light.

Iris Nebula

Orion Nebula

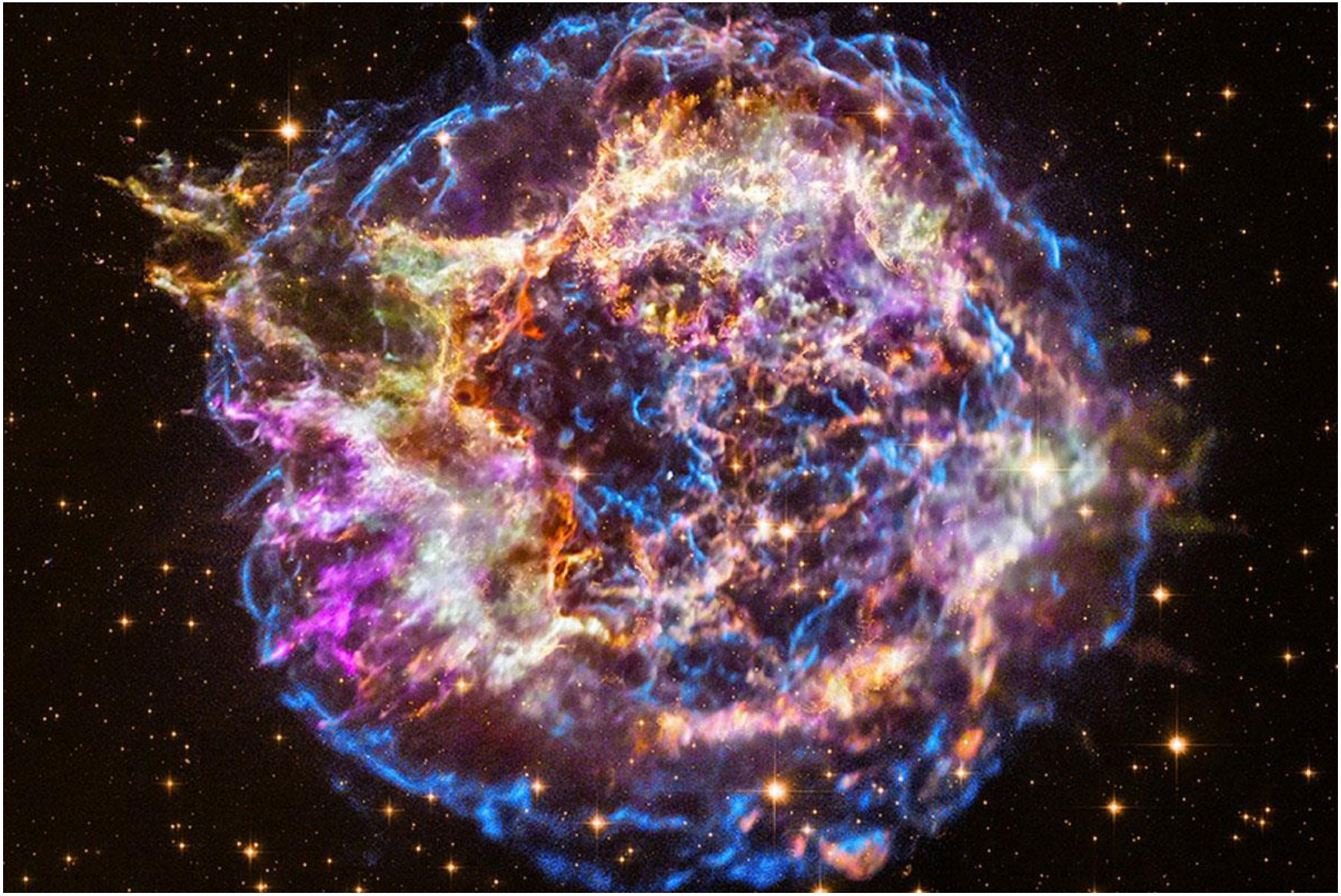
Supernova Remnant nebula is a cloud of gas, dust, and rock that is formed after a red supergiant star went supernova. The nebular materials are very hot and glow different colors of visible light, ultraviolet, and xrays.



Crab Nebula

Veil Nebula

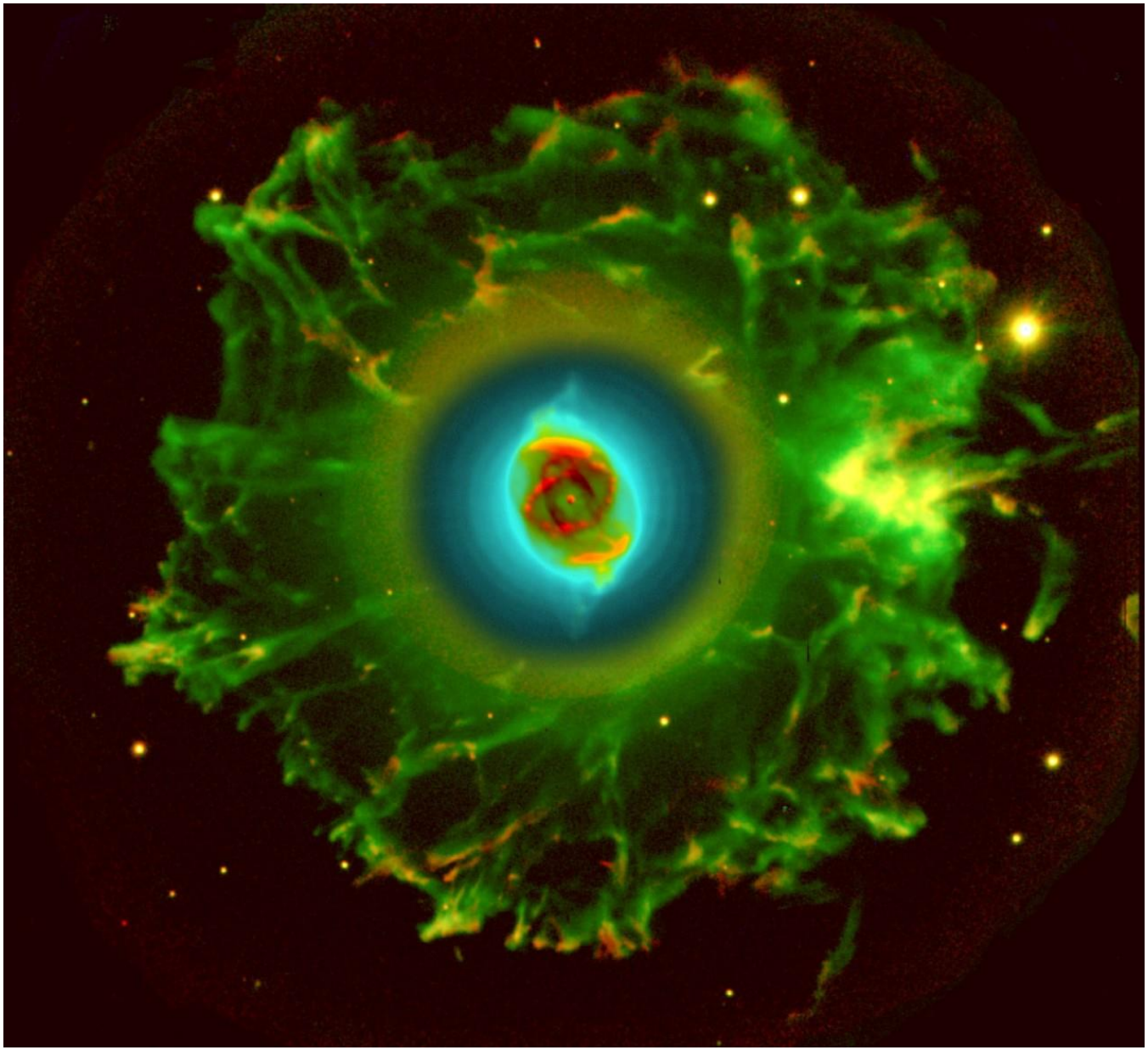
Cassiopeia A Nebula



Hourglass nebula

Planetary nebula is a cloud of gas, dust, and rock that is formed after a red giant star degenerates into a white dwarf and ejects its outer layers of gases into space. The nebular materials are very hot and glow different colors of visible light, ultraviolet, and xrays. A white dwarf star lies in the center.

Cats Eye Nebula



NGC 2077 Jewel Bug Nebula