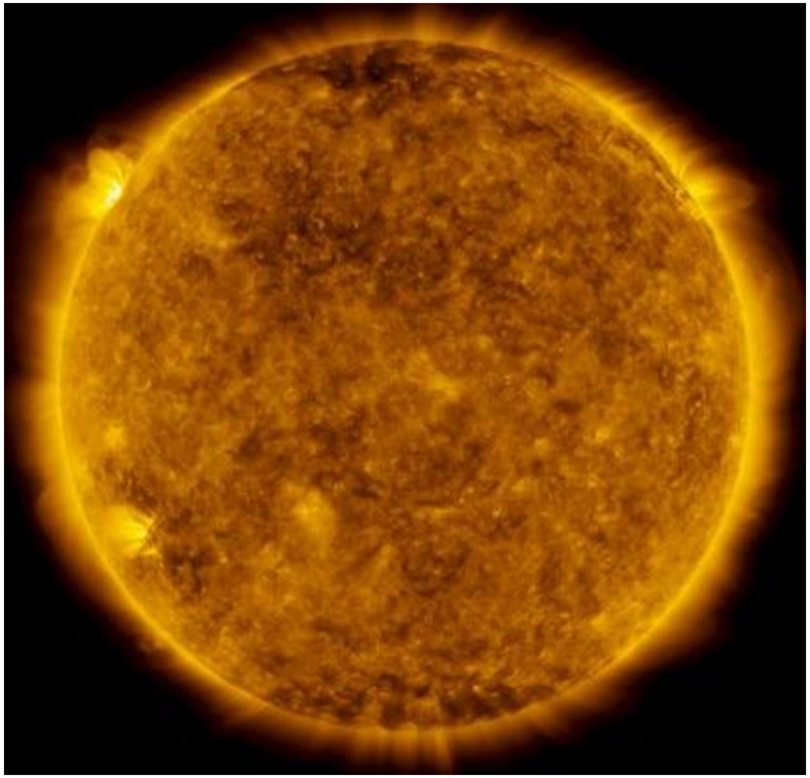
Unit 5
Stars & Celestial Objects

Stars
Part 1

Stars are large balls of very hot plasma that are held together in a spherical shape by the inward force of gravity.

- Stars must be sufficiently large enough in mass to cause **fusion** in their cores.
- The fusion creates the heat and light that gives the star its energy.

The Sun is a star. It is made of hot plasma. It fuses elements in its core to make heavier elements. It produces its own heat and light.



A star is a **luminous** object. Luminous objects make and release their own light.

Luminosity is the power of a star or a light generating object.   Luminosity describes how much light energy is released by a luminous object per second. Luminosity is measured in units of Watts.

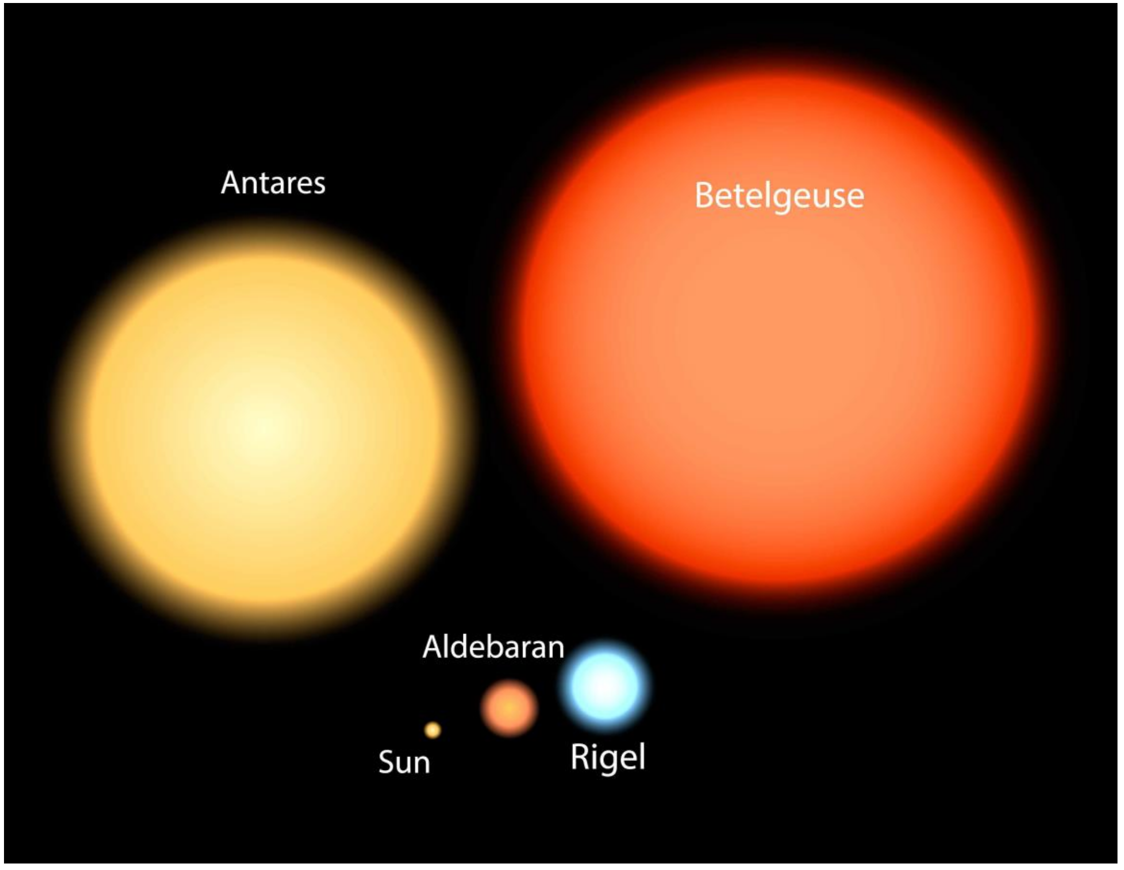
Luminosity of stars is equivalent to the ***Wattage rating*** of a light bulb. The greater the Wattage of the light bulb, the more light it produces per second, the brighter it will appear.

Stars with very large luminosities release more light energy per second than stars with lower luminosities.

As a general rule…

Stars with *larger masses and larger diameters have greater luminosities*.

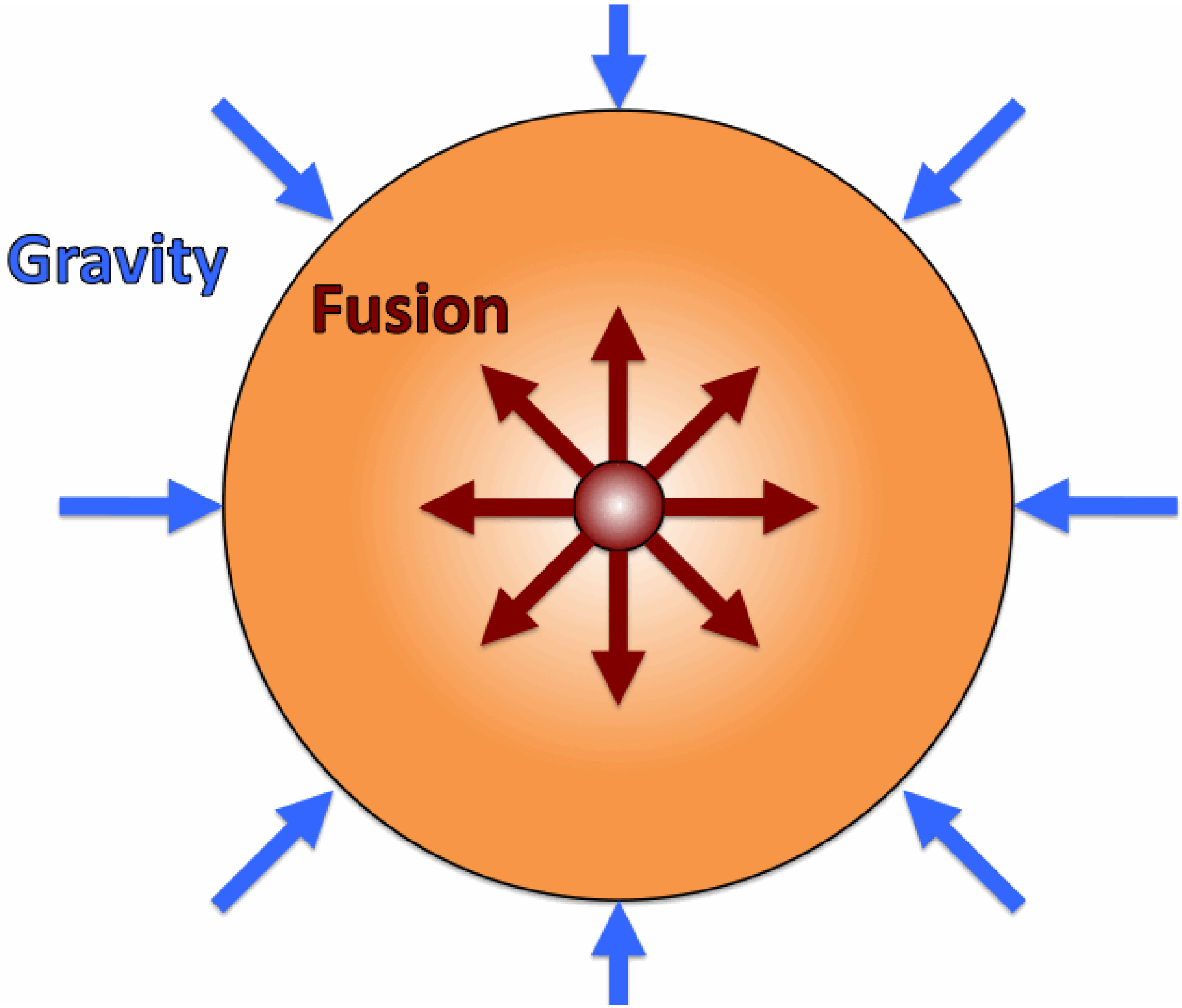
Stars with *lower masses and smaller diameters have lesser luminosities*.



The photograph shows a size comparison between stars.

Compared to the other stars in the picture, the Sun has the lowest luminosity—it is small in mass and small in diameter compared ot the others.

Giant stars and Supergiant stars are always more luminous than dwarf stars because of their much larger masses and stronger inward gravity upon their cores.



More "Fuel"

More mass in the star → More hydrogen or other elements that are available for fusion in the star's core.

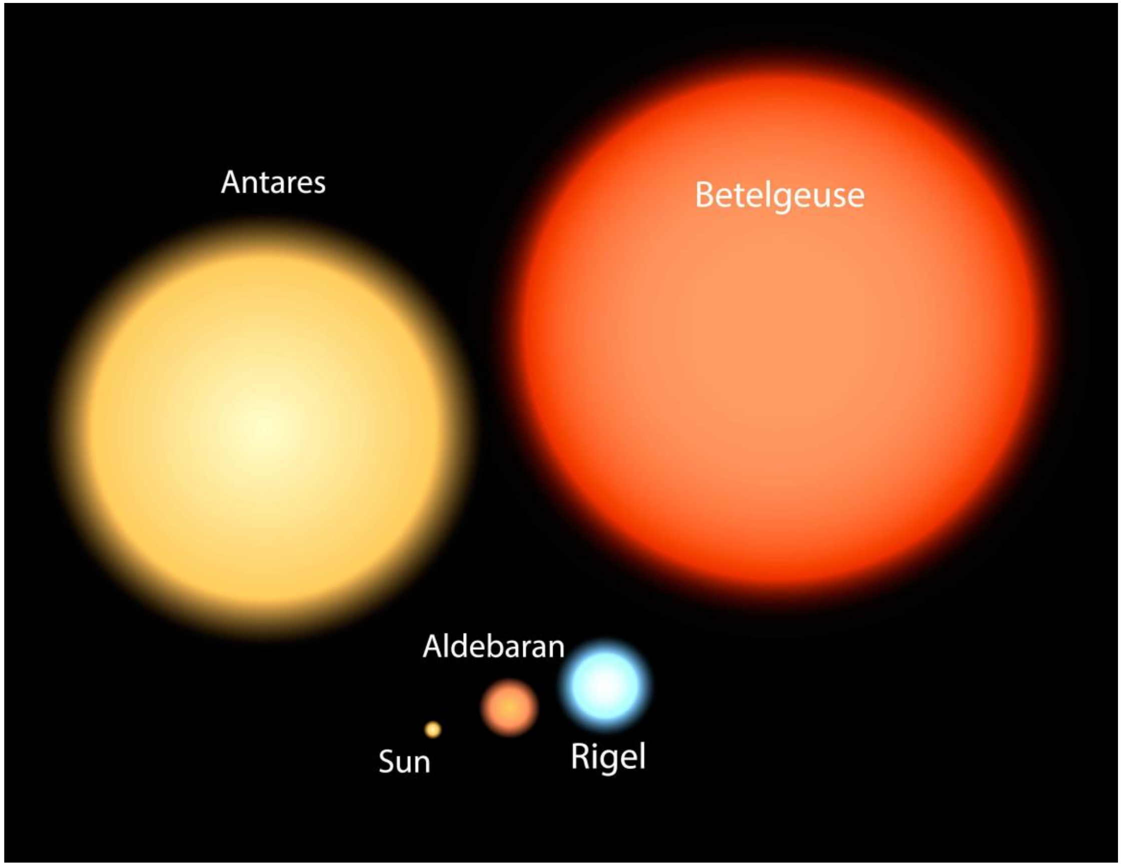
More "Force"

More mass in the star → Stronger gravity force pulling inward onto the core, and stronger force to fuse the atoms together into new elements.

More "Heat in the Core"

More mass in the star → Hotter the core becomes due to the higher rate of fusion, the fusion rate is accelerated more.

Star	Mass	Luminosity
Sun	$2.00x10^{30}$ kg	$3.82x10^{26}$ Watts
Canopus	$1.95x10^{31}$ kg	$4.09x10^{30}$ Watts
Rigel	$3.58x10^{31}$ kg	$2.52x10^{31}$ Watts
Proxima Centauri	$2.45x10^{29}$ kg	$6.50x10^{23}$ Watts

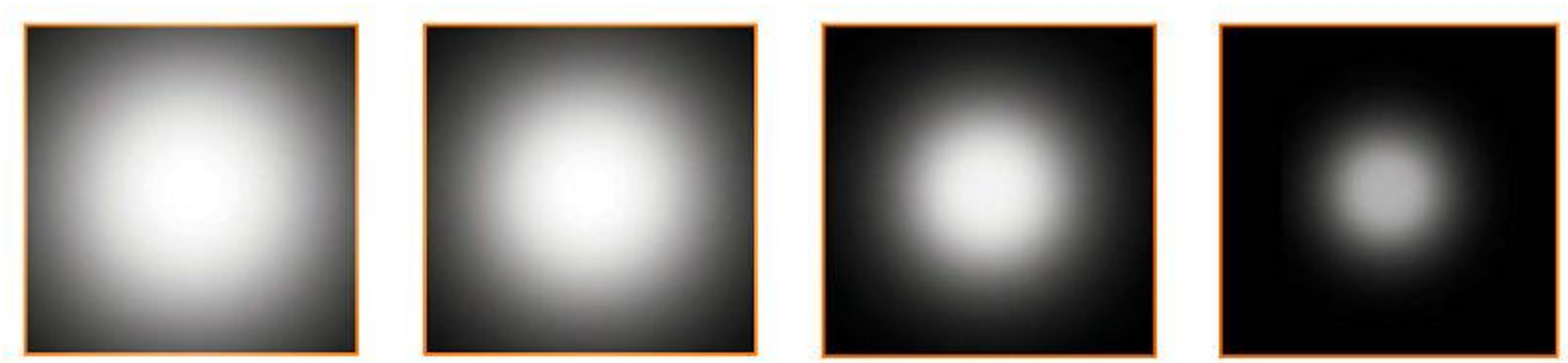


Brightness is the intensity of light observed at a known distance away from the object. Sometimes it is referred to as the *radiant flux*.

The brightness of a star or galaxy in the night sky depends on three factors:

1. **Luminosity**: Power of the star
2. **Distance**: How far away the star is from Earth.
3. **Scattering or interference**: Any nebulae, gas, or dust in between the star and Earth.

Comparison of the **brightness** of four different flashlight bulbs with different **luminosities** at the *same distance away*: 1.0 meter distance



17 Watts | 8.0 Watts | 3.3 Watts | 0.3 Watts

More light energy released per unit time. Brighter.

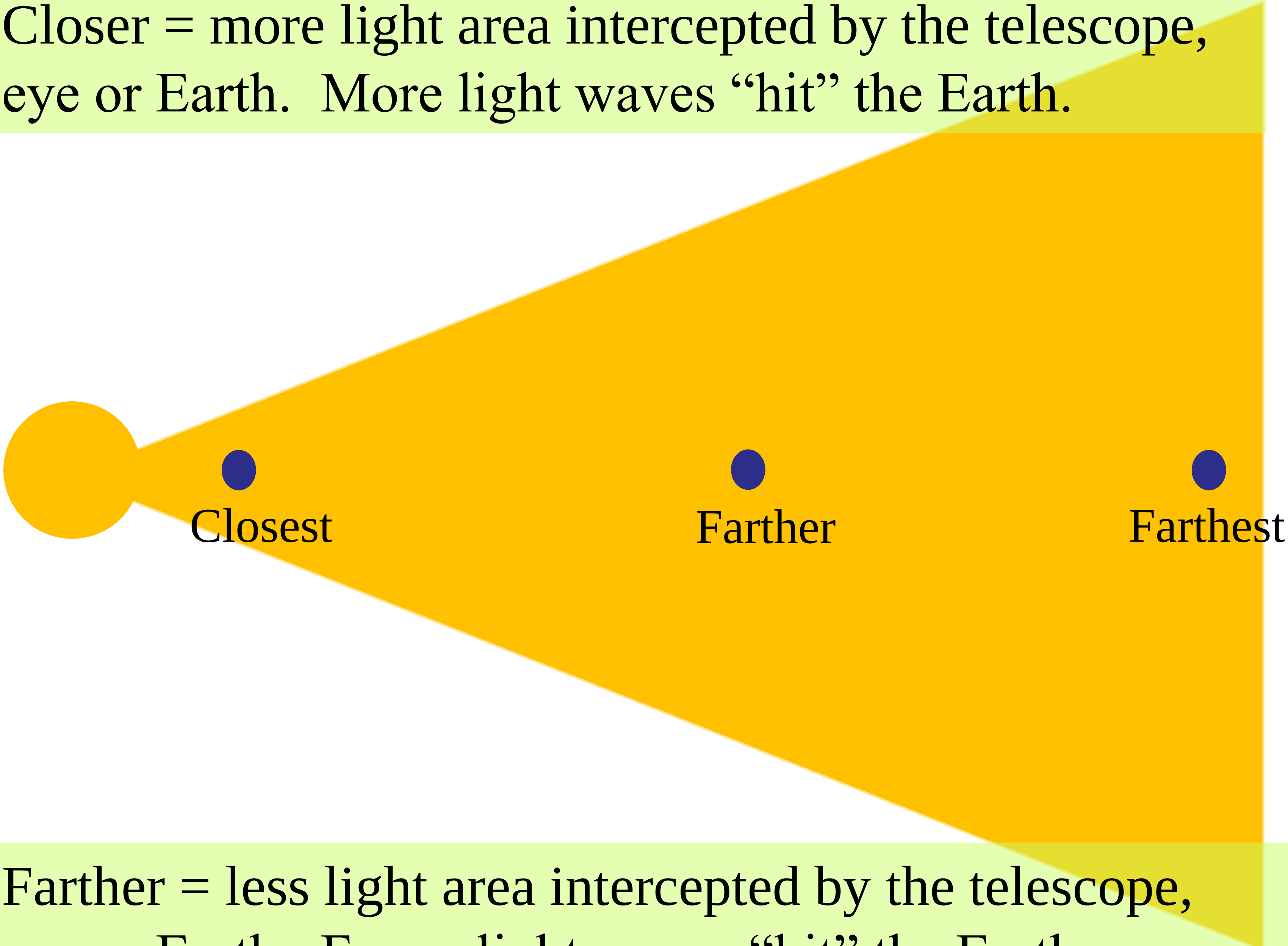
Lesser light energy released per unit time. Dimmer.

Brightness also depends on how far away the star or galaxy is from Earth.

- Closer to Earth = brighter
- Farther from Earth = dimmer

The headlights of the car remain the same—luminosity does not change. The brightness of the headlights is different based on the distance between the approaching car and the camera.

Closer = more light area intercepted by the telescope, eye or Earth. More light waves "hit" the Earth.

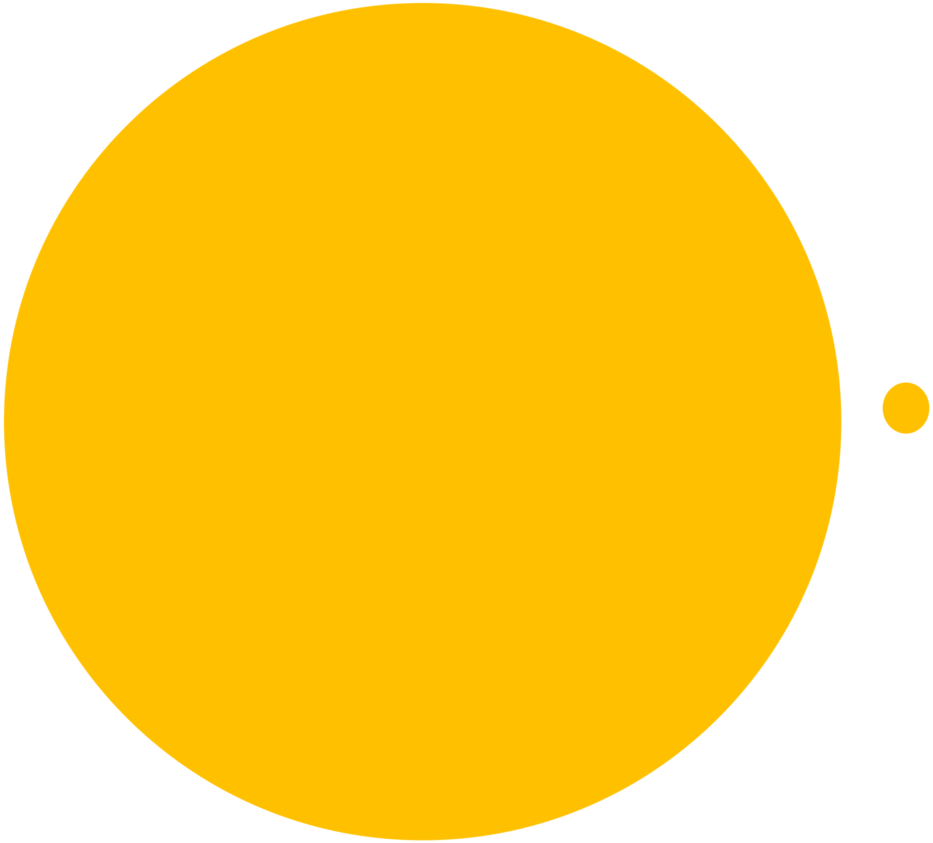


Farther = less light area intercepted by the telescope, eye or Earth. Fewer light waves "hit" the Earth.

Most of the blue and white stars in the constellation Orion appear to be very similar in brightness.

They appear with similar brightness because more luminous stars are farther from Earth and less luminous stars are close to Earth.

If two stars have the **same color** (determined by surface temperature), but *different luminosities*, the star with the greater luminosity has the greater surface area, greater diameter, and greater mass (a larger star)



An orange dwarf star and an orange giant star have the same surface temperatures (~4000 ºK).

The orange giant star will appear brighter because of size.

- Bigger surface area
- More release of light by surface.

The majority of **starlight** is visible light (all colors ROYGBIV) with infrared and ultraviolet light.

- Cooler stars tend to have more infrared and lesser ultraviolet light.
- Hotter stars tend to have more ultraviolet and lesser infrared light.

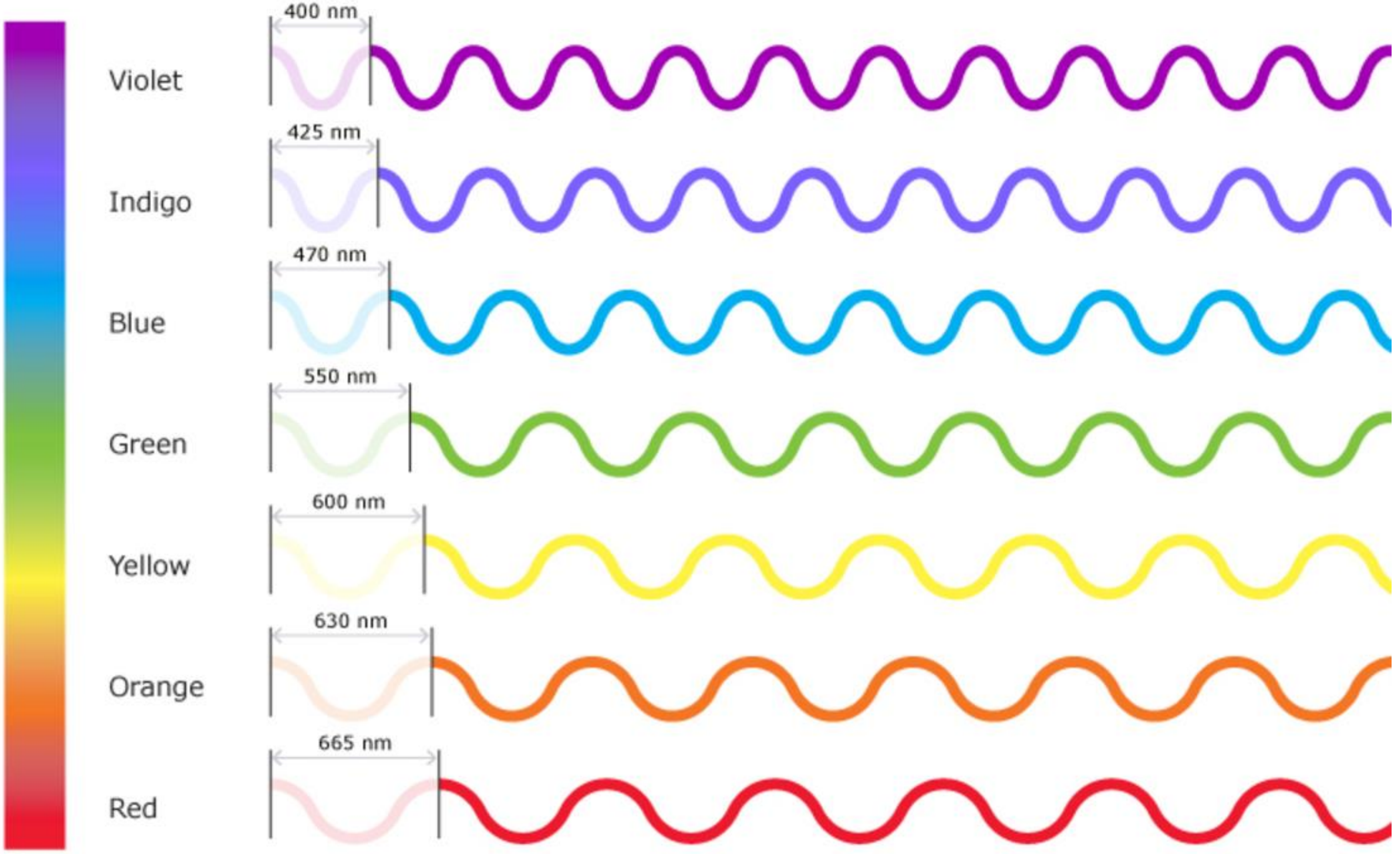
Remember the classes of electromagnetic radiation

- Gamma
- X-ray
- Ultraviolet
- Visible
- Infrared
- Microwave
- Radiowave

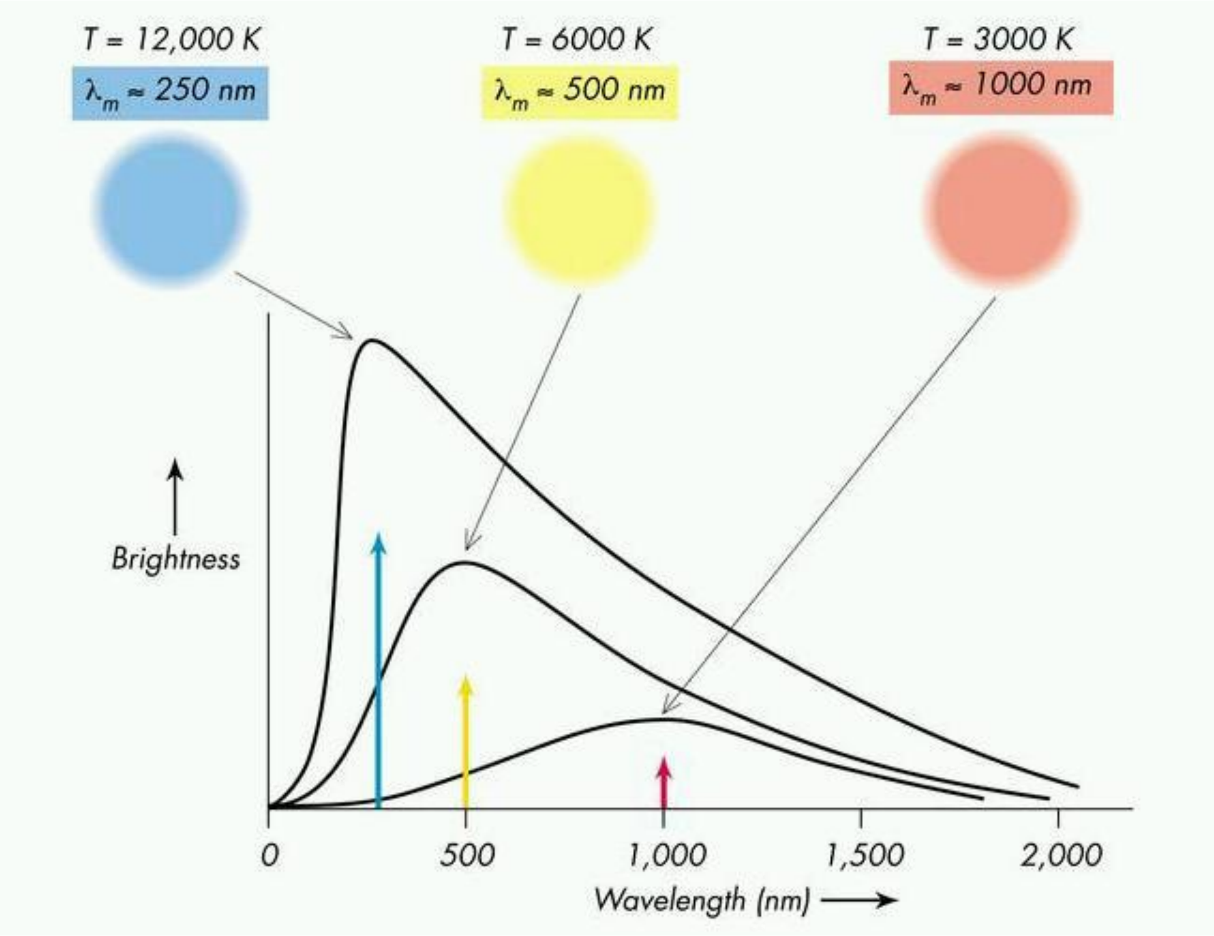
Stars come in **five colors**: Red, orange, yellow, white, and blue. The color of a star's **photosphere** is determined by the temperature of the plasma in the photosphere.

Shortwave

Longwave



- **Hotter stars** radiate light with **shorter wavelengths** and **higher frequencies** (more energy) i.e. "bluish"
- **Cooler objects** radiate light with **longer wavelengths** and **lower frequencies** (less energy) i.e. "reddish"



Red is the coolest color of stars. Red has the longer wavelength and lower frequency of visible light.

Blue is the hottest color of stars. Blue has the shortest wavelength and highest frequency.

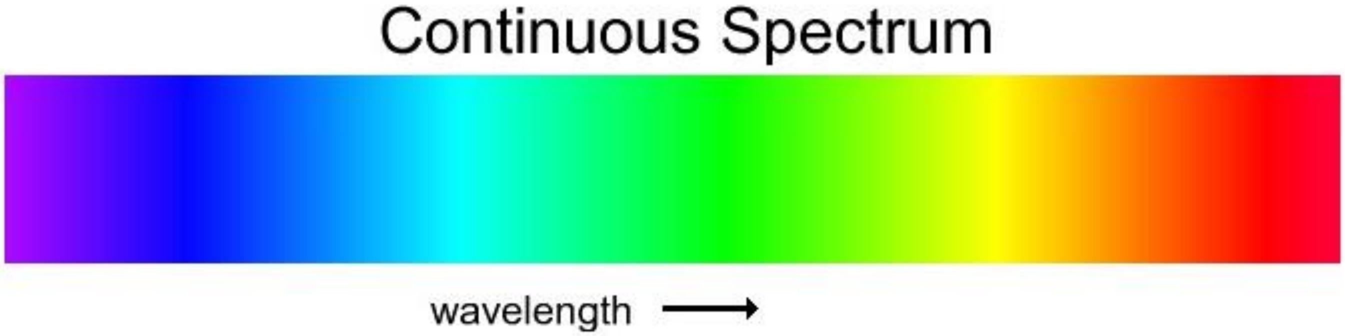
How do scientists know what elements are in stars?

Emission Lines and Emission Spectra

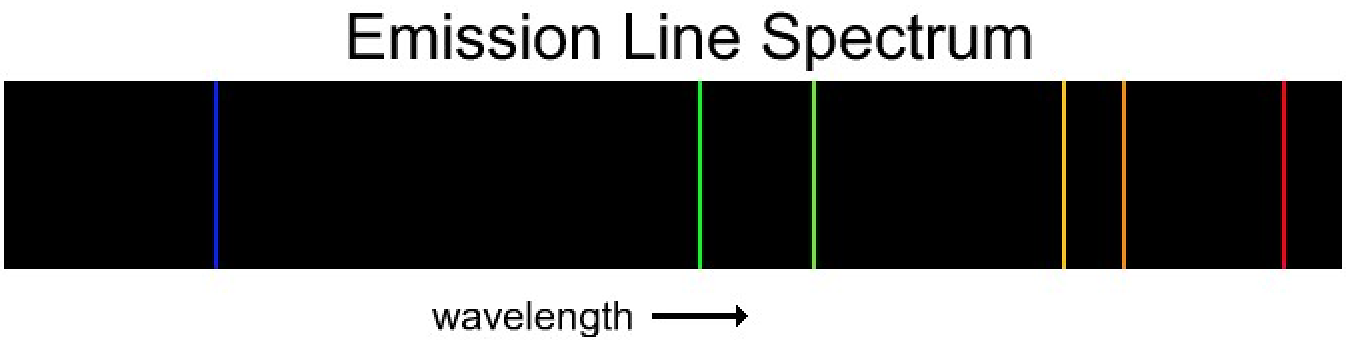
- Emission means to "give off, release".
- The excited atoms of certain elements only **emit** certain wavelengths of light.
- Light is formed and released by atoms when their energized electrons want to return to their normal energy by releasing light wave.

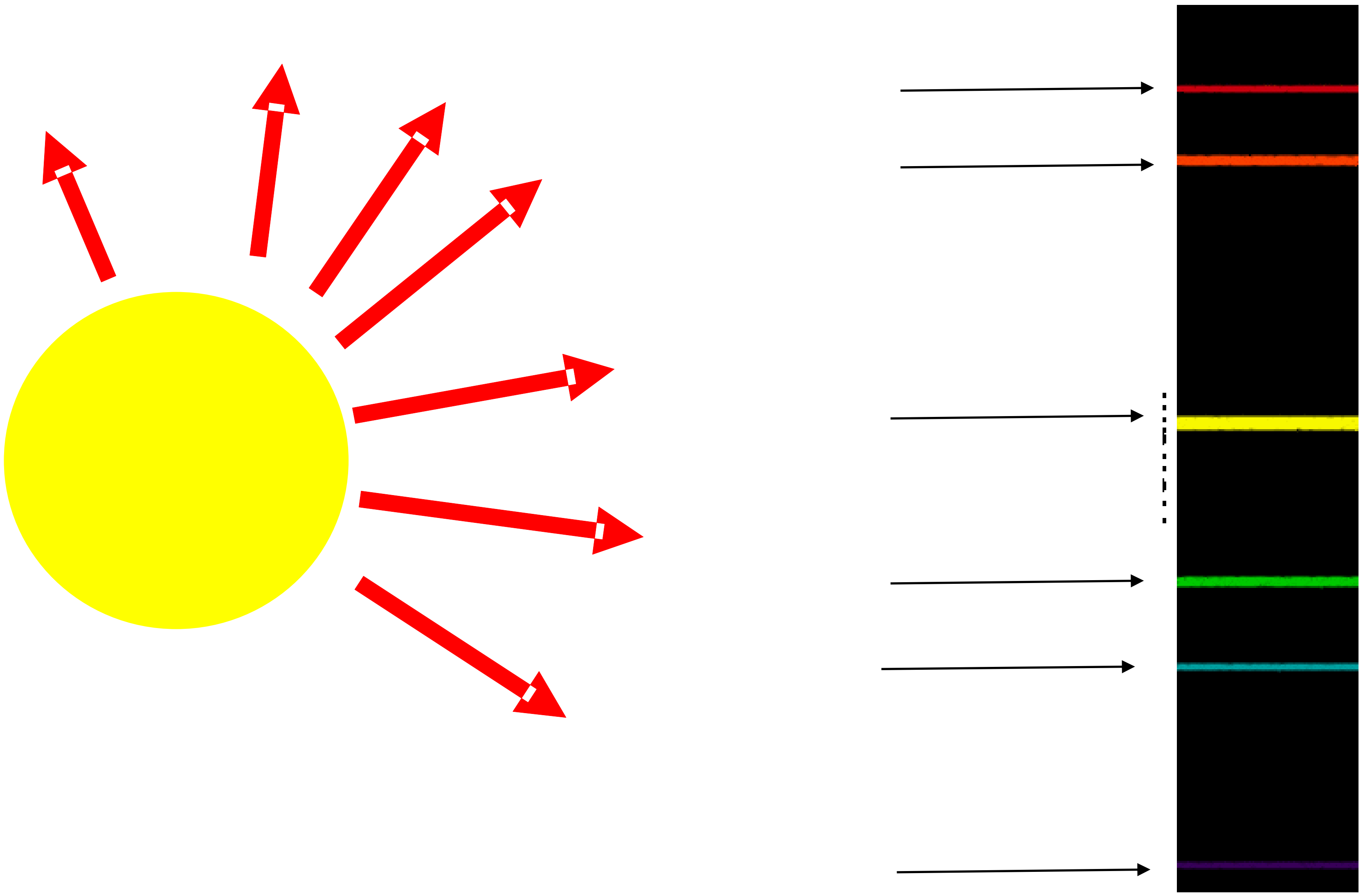
The emitted wavelengths are like the atoms' fingerprints.

Stars emit a an almost **continuous spectrum** of light—they release most or all color wavelengths of light at the same time into space because most stars have many, many different elements in their photospheres.



Using special filters, the emissions line spectrum is revealed for individual elements that are present in the star.



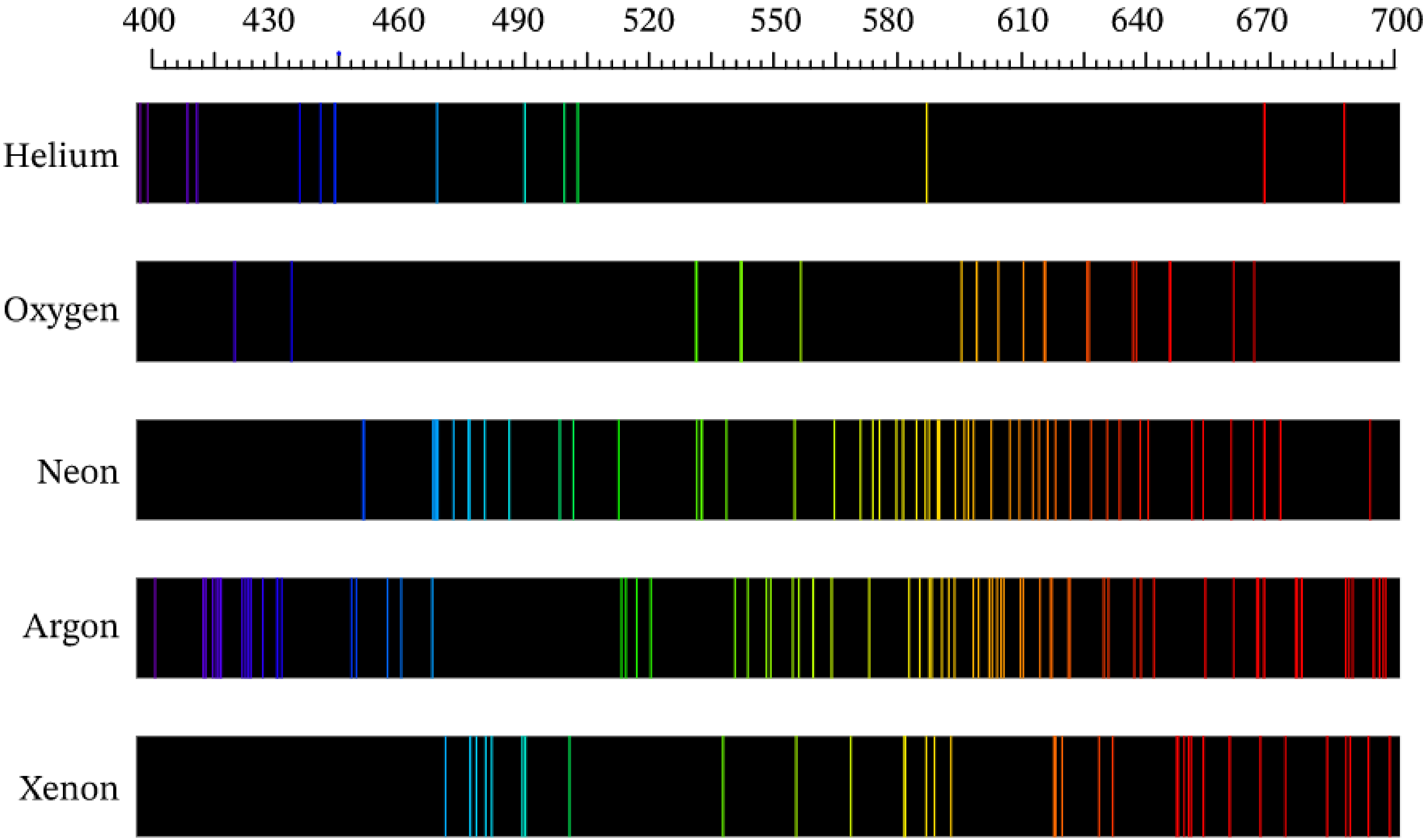


The elements in the star are determined by the patterns of emission spectral lines that are measured by special cameras and telescopes.

Pure elements glow specific colors when they are heated to very hot temperatures (incandescence) and burned. The color we see is a mixture of many different wavelengths of light given off by that element at the same time.

Hydrogen emission spectrum: When hydrogen atoms are excited by heat and energy, they release very specific wavelengths of visible light.

Helium emission spectrum: When hydrogen atoms are excited by heat and energy, they release very specific wavelengths of visible light.


400
430
460
490
520
550
580
610
640
670
700
Helium
Oxygen
Neon
Argon
Xenon