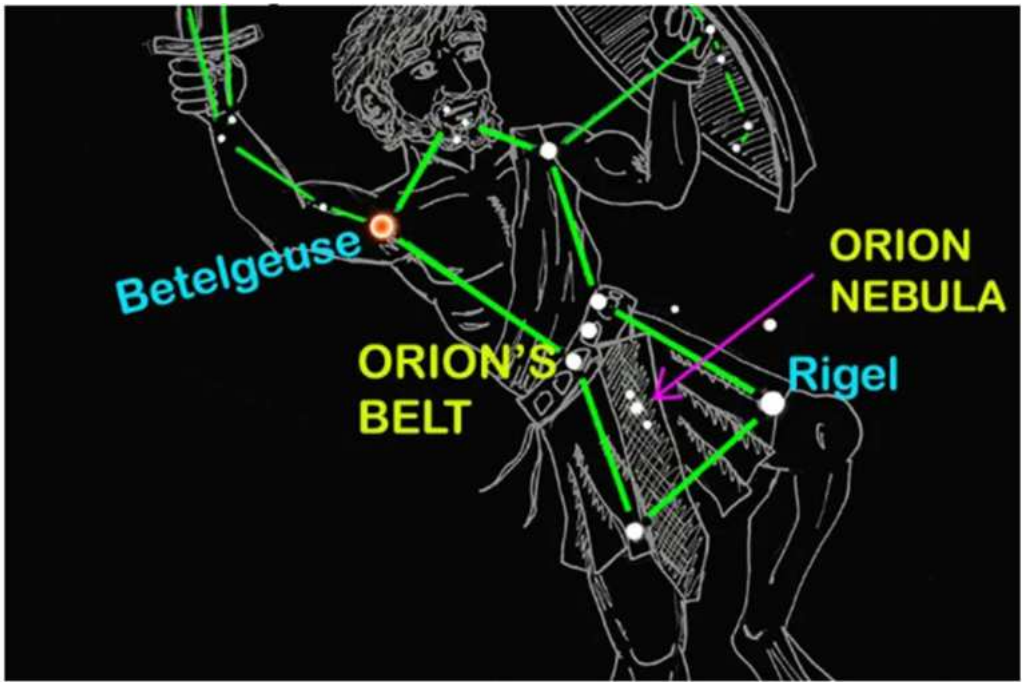
The Orion Constellation

Babies and Big, Bright Stars

The Orion Constellation: A Sky View

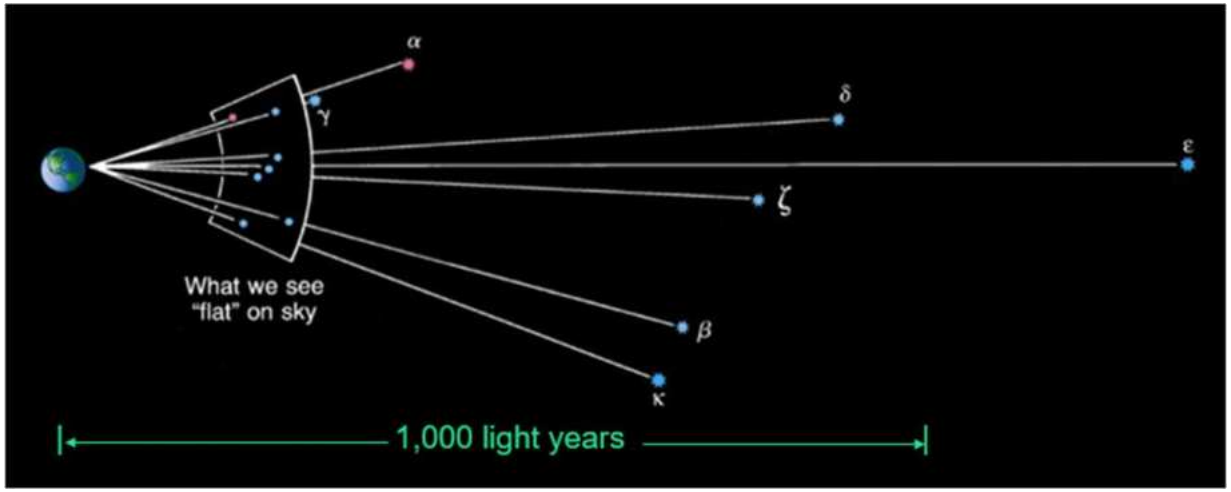
A winter constellation

Orion Constellation Diagram



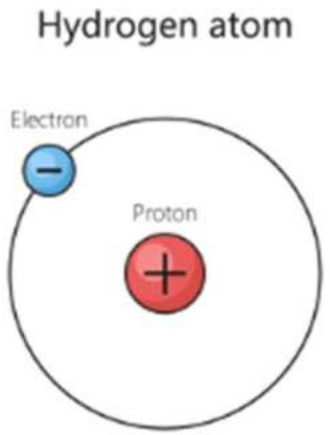
Orion Constellation: Not in One Plane

- Orion constellation viewed from the side



Let's Review What Powers Stars

- Let's talk about atoms for a moment. Normally an atom has a nucleus which contains protons (+ve charge), neutrons (neutral charge). Outside the nucleus are negatively charged electrons.
- In a star's core, there are no intact atoms due to high temperatures/pressures. So we have a "plasma" soup of free electrons and free nuclei.
- Hydrogen is the smallest atom. One proton in the nucleus (no neutron) and one electron.



Number of Protons in Various Atoms

Let's focus on the number of protons in an atom

Atom	# of Protons in Nucleus
Hydrogen	1
Helium	2
Carbon	6
Oxygen	8

How do stars make energy/heat

Fuse atoms together. This is called a fusion reaction and it releases a lot of energy. This is what powers stars!!

Two types of forces involved.

a) Strong Nuclear force – this is the strong force that holds protons and neutrons together in a nucleus. This helps the fusion reaction happen once smaller atoms are compressed together, at high speed

b) Coulomb "repulsive" force which makes it hard for protons to come close together since they have the same positive charge. A lot of heat and pressure are required to overcome this force to fuse atoms. This makes it difficult for fusion to happen. Magnet/balls

Nuclear Fusion in a Star

- In the core of a young star, hydrogen atoms (1 proton each) under very high temperatures and pressures, **fuse** together to make the heavier atom called **helium** (2 protons). Complicated steps.

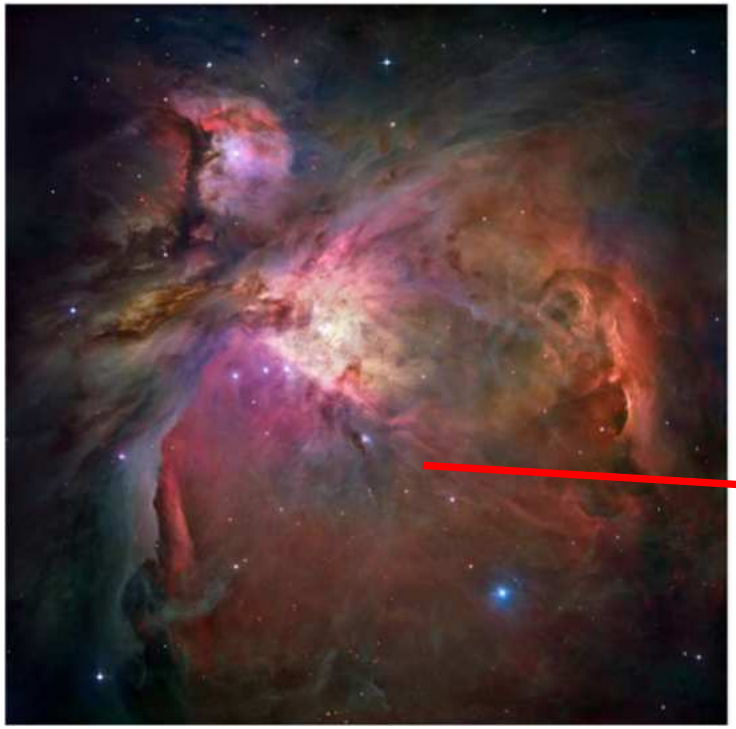
The high core temperature makes the hydrogen atoms smash together fast and the high core pressure pushes the hydrogen together with a lot of force

- **In the process, a small amount of mass is left over** and this excess mass is converted into **energy.**
- Einstein said that Mass and Energy are related by his equation $E = MC^2$

If you want to fuse larger atoms, it takes a lot more heat/pressure since **more protons** (**much bigger bar magnets !!!!)**

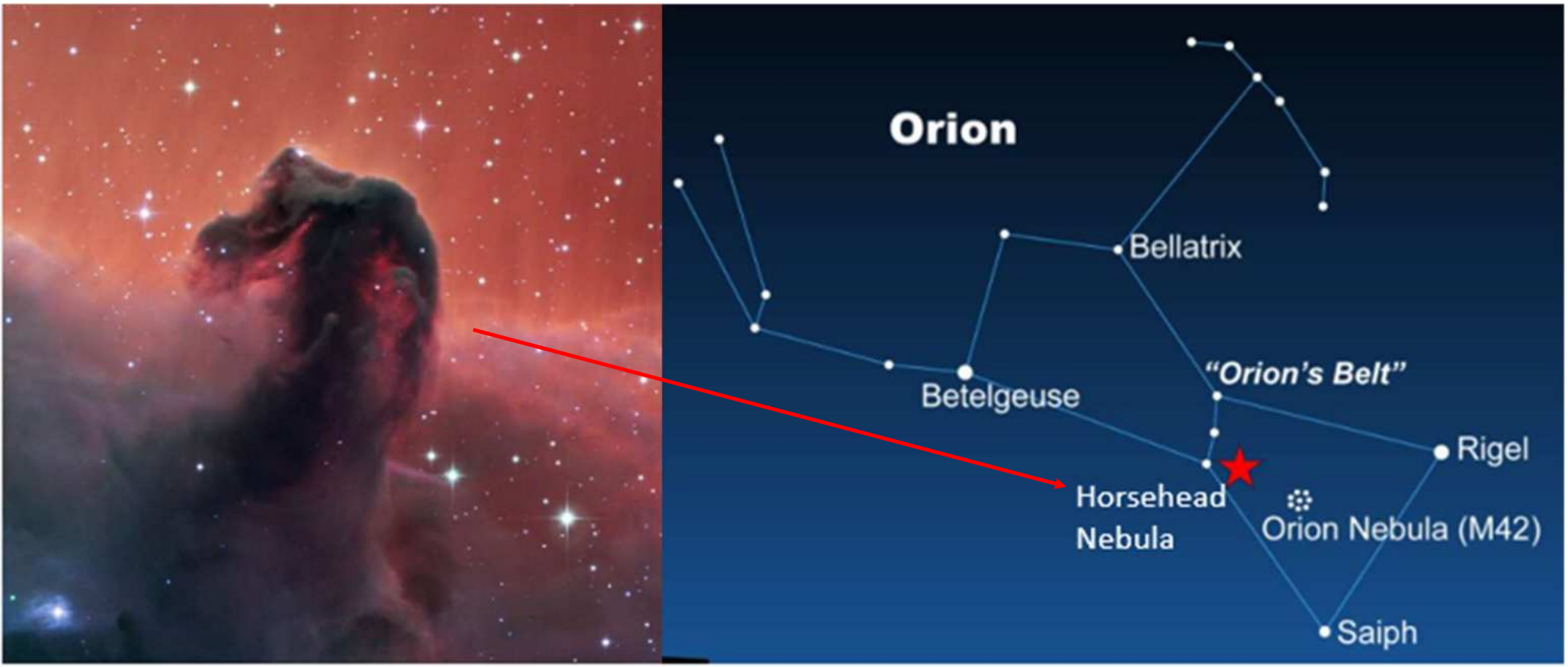
The Orion Nebula

The Orion Nebula: a birthplace of stars in Orion



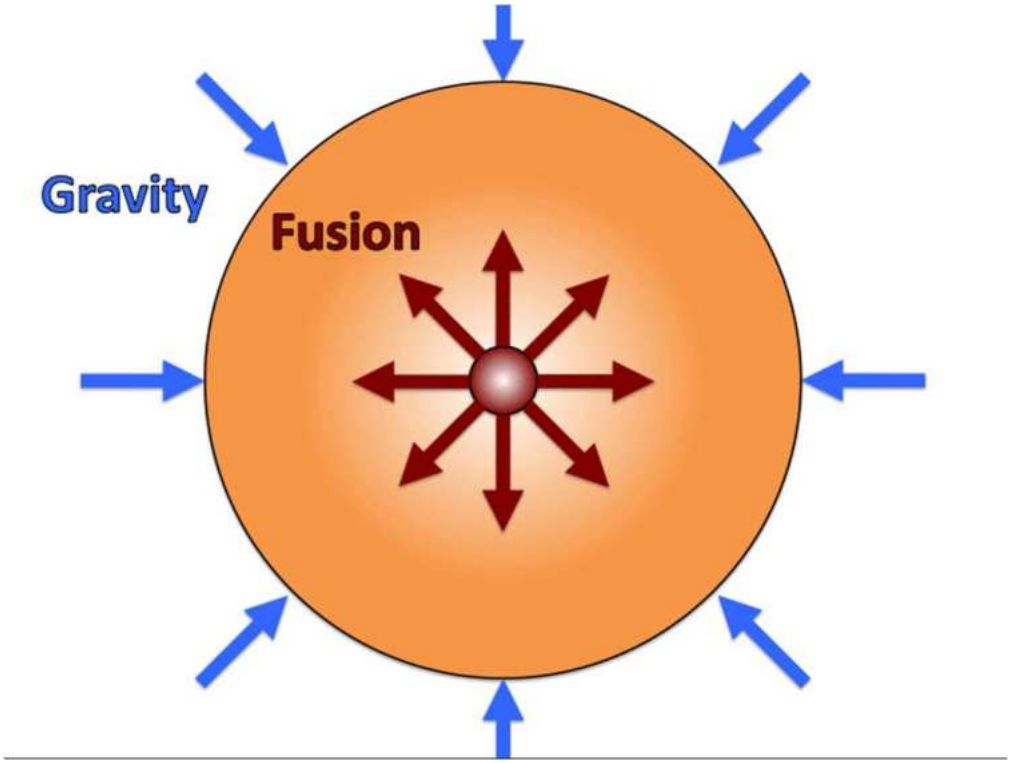
Primarily Hydrogen gas gathers and, due to gravity, it coalesces/compresses until temperatures and pressures are high enough for hydrogen fusion

Horsehead Nebula



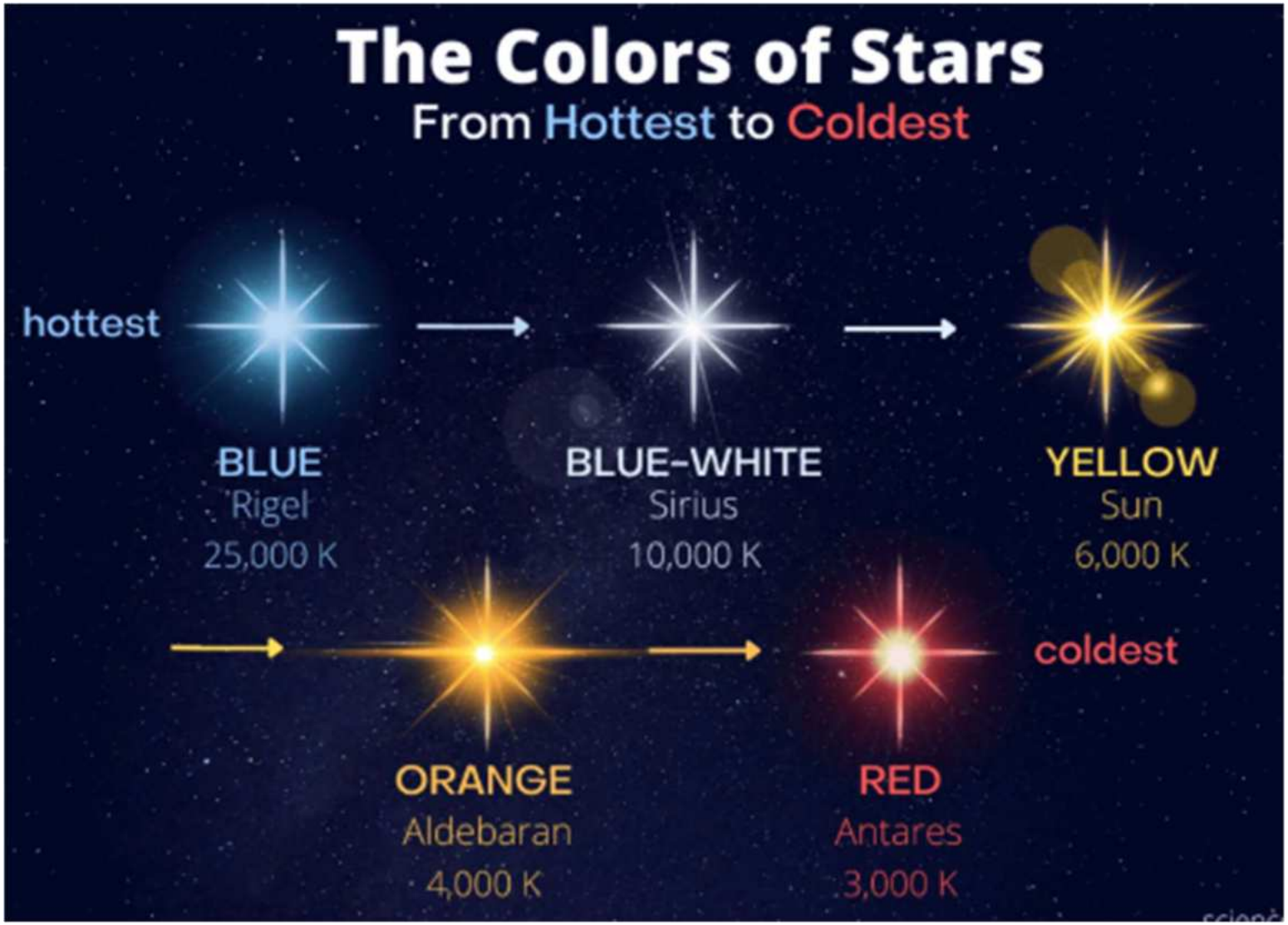
Forces that control a star – a balancing act

"Hydrostatic Equilibrium"



Star Evolution

- A star will eventually fuse all of its hydrogen to helium. The core shrinks due to gravity and it heats up. This causes outer layers to expand and as they are now farther away from the core, they cool. This is the red giant stage (red because overall the star is cooler).
- If the core gets hot enough/high enough pressure then helium can fuse to yield carbon (6 protons) and oxygen (8 protons).
- This process continues until the star is not massive enough to fuse elements or it makes iron and iron is too stable to create fusion energy. Our sun will just collapse to a white dwarf. Supergiant stars like **Betelgeuse** and **Rigel** will undergo a massive supernova explosion

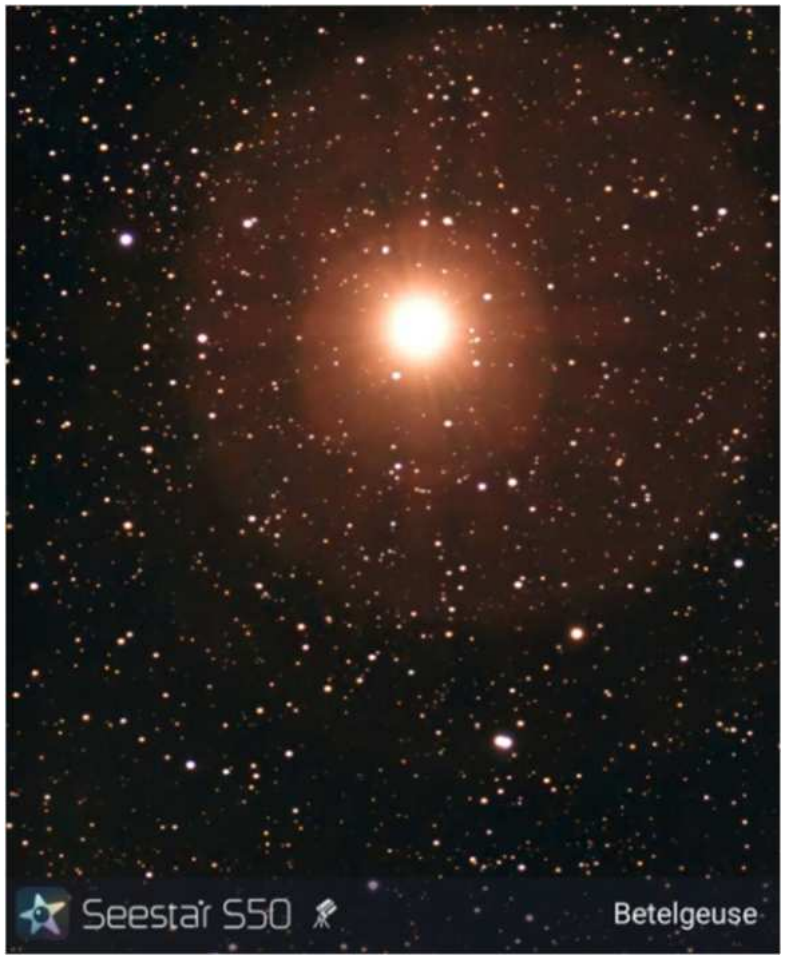

The Colors of Stars
From Hottest to Coldest
hottest
BLUE
Rigel
25,000 K
BLUE-WHITE
Sirius
10,000 K
YELLOW
Sun
6,000 K
coldest
ORANGE
Aldebaran
4,000 K
RED
Antares
3,000 K

Orion Constellation Diagram

Let's initially focus on **Betelgeuse** which is red coloured and **Rigel** which is Blue coloured

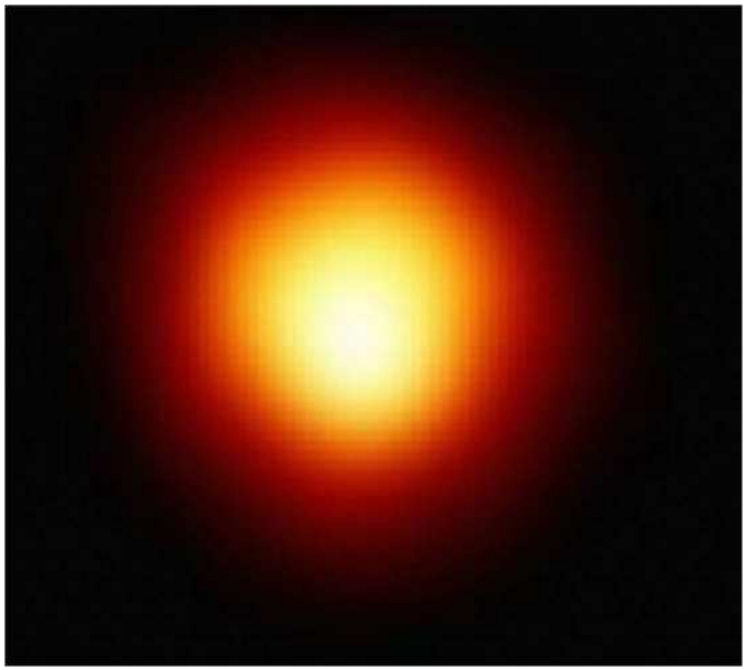
Both are very large (supergiant) bright stars

Betelgeuse Seestar S50 and Hubble photos

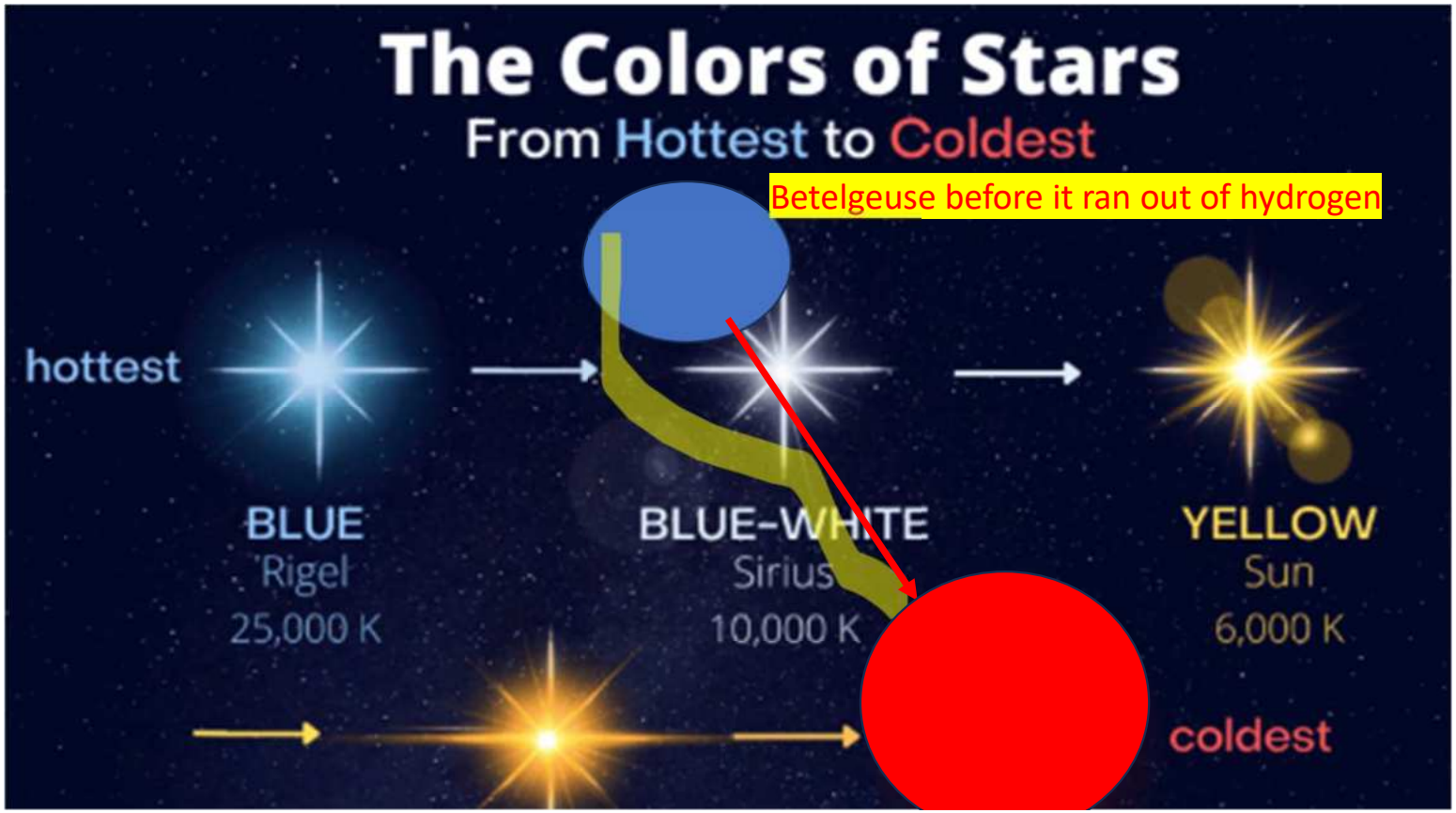


A red supergiant. Outer layers have cooled (so red).

Star is “variable” because of its instability (re brightness and size) as it reaches the later stages of its life



Betelgeuse transition from giant blue star to Red Supergiant



Betelgeuse (the “armpit”) vs Rigel (the “foot”)

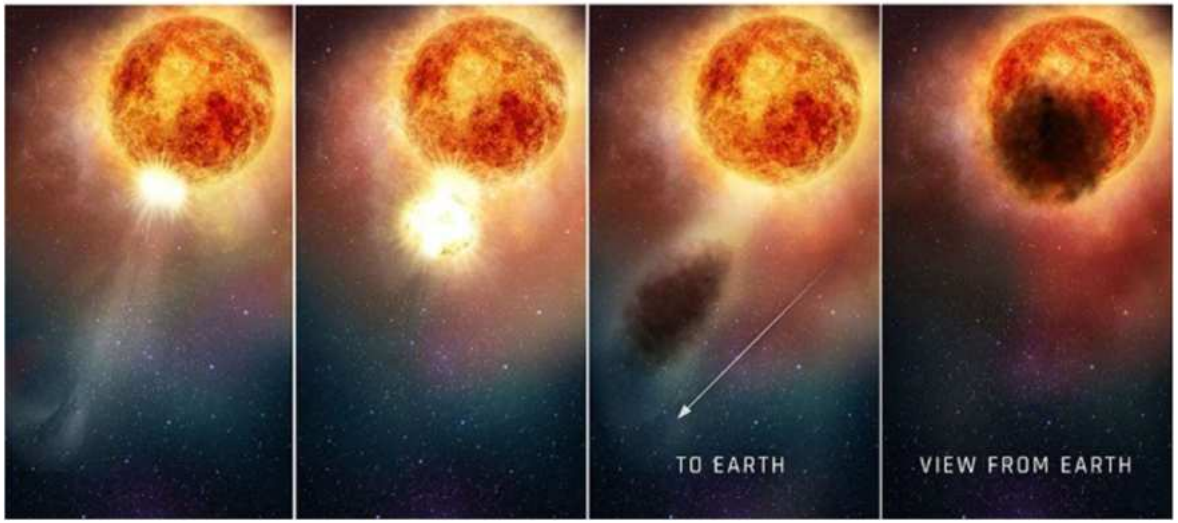
	Betelguese	Rigel
Mass versus our sun	11 – 19 suns	21 – 23 suns
Age (our sun is about 6 billion years old)	10 million years	8 million years
Luminosity (versus our sun)	7,500 – 14,000 times our sun	120,000 times our sun
Rank of brightness in sky	10^{th} brightest in the night sky	7^{th} brightest in the night sky
Size versus our sun	700 times the size of the sun	70 times the size of the sun
Surface Temperature (our sun is 5,500^{o}C)	3,300^{o}C	12,100^{o}C (used to be 30,000^{o}C)
Distance from Earth	640 light years (varies)	864 light years

Betelgeuse has run out of hydrogen and has swelled to become cooler, red supergiant

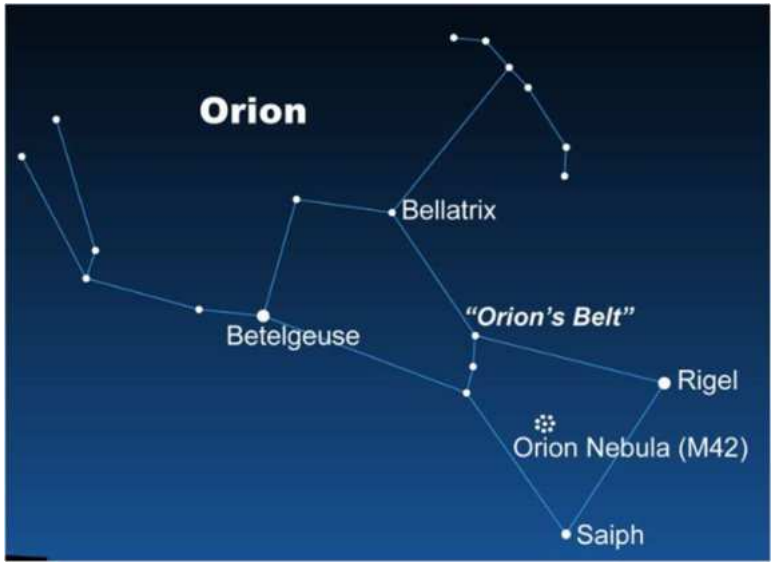
Rigel was a much larger/hotter star than Betelgeuse before becoming a hot blue supergiant (most of its hydrogen has been used up)

Temporary Dimming of Betelgeuse

Large mass of plasma ejected from the southern hemisphere
This cooled to form a massive dust cloud which partially obscured the southern hemisphere



Other Notable Stars in Orion



- Bellatrix ("female warrior") – third brightest star in Orion
- Blue white star which will eventually become a white dwarf
- Very hot (22,000 ^{o}C), which is hotter than Rigel or Betelgeuse but is smaller than them.
- Saiph is another blue super giant which will eventually supernova

Why is Orion Constellation so special

- Even without binoculars, or a telescope:
  - You can spot Orion's belt, so easy to recognize the constellation
  - Rigel is blue coloured and very bright (we know it is a blue supergiant).
  - Betelgeuse has a red tinge and is very bright (we know that it is a red supergiant).

We know that both stars will explode in a Supernova explosion once they make iron in their core. Betelgeuse will likely blow up first. Estimates are between today and 100,000 years from now (we're not absolutely certain exactly at what stage of their nuclear fusion life they are at).

Perhaps it has already happened, as the light we see from these stars is hundreds of light years away (640 for Betelgeuse and 864 for Rigel).

The explosion will release more energy than our sun will generate in its 12 billion year lifetime!!

The Chinese witnessed a Supernova in 1054 AD. Wouldn't that be exciting to see!!!