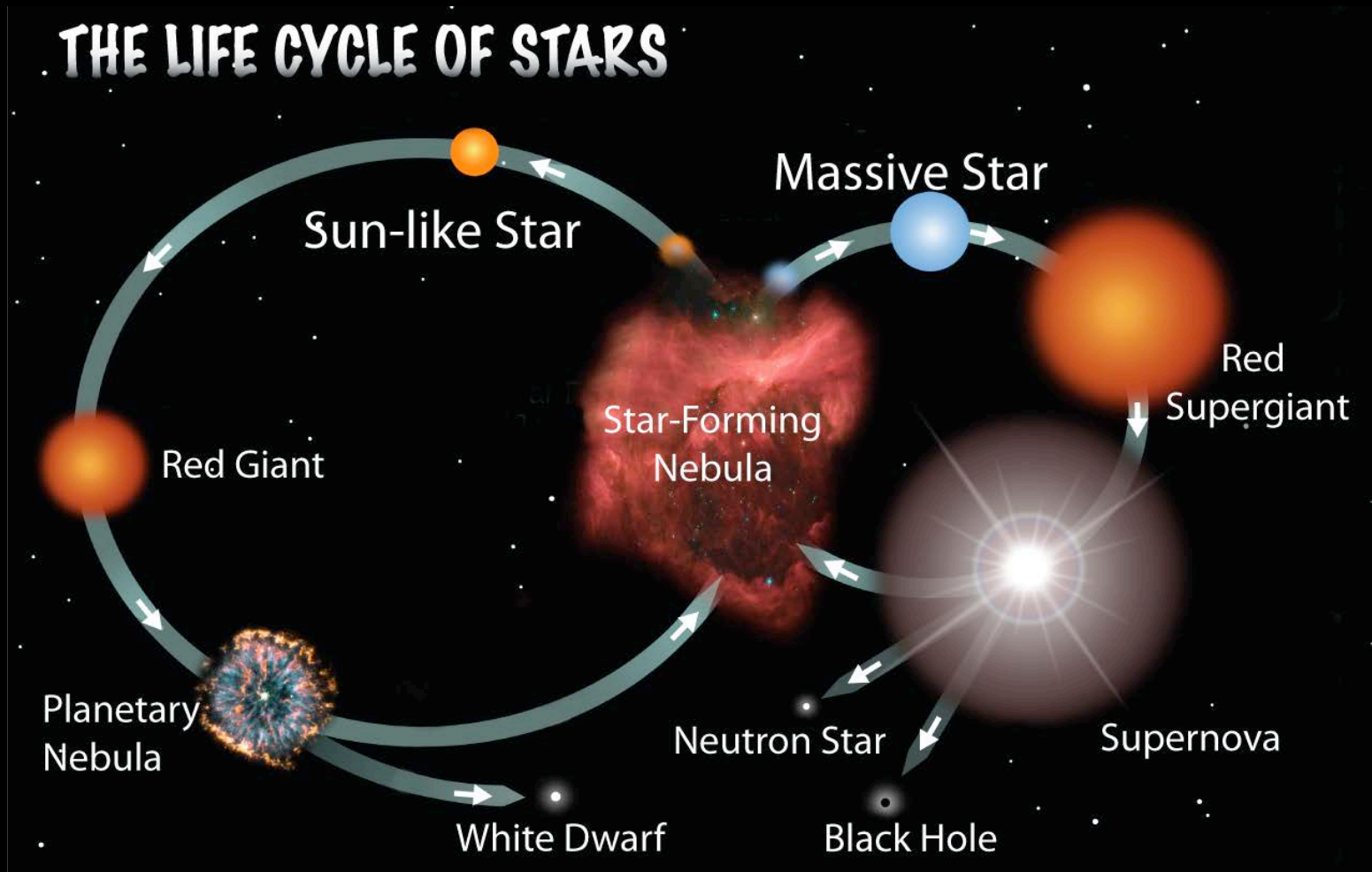


The Birth and Death of Stars



The Birth and Death of Stars

What are Stars?

- Stars are large balls of hot gas.
- They look small because they are a long way away, but in fact many are bigger and brighter than the Sun.
- The heat of the star is made in the centre by *nuclear fusion reactions*.
- There are lots of different colours and sizes of star.

The Birth and Death of Stars

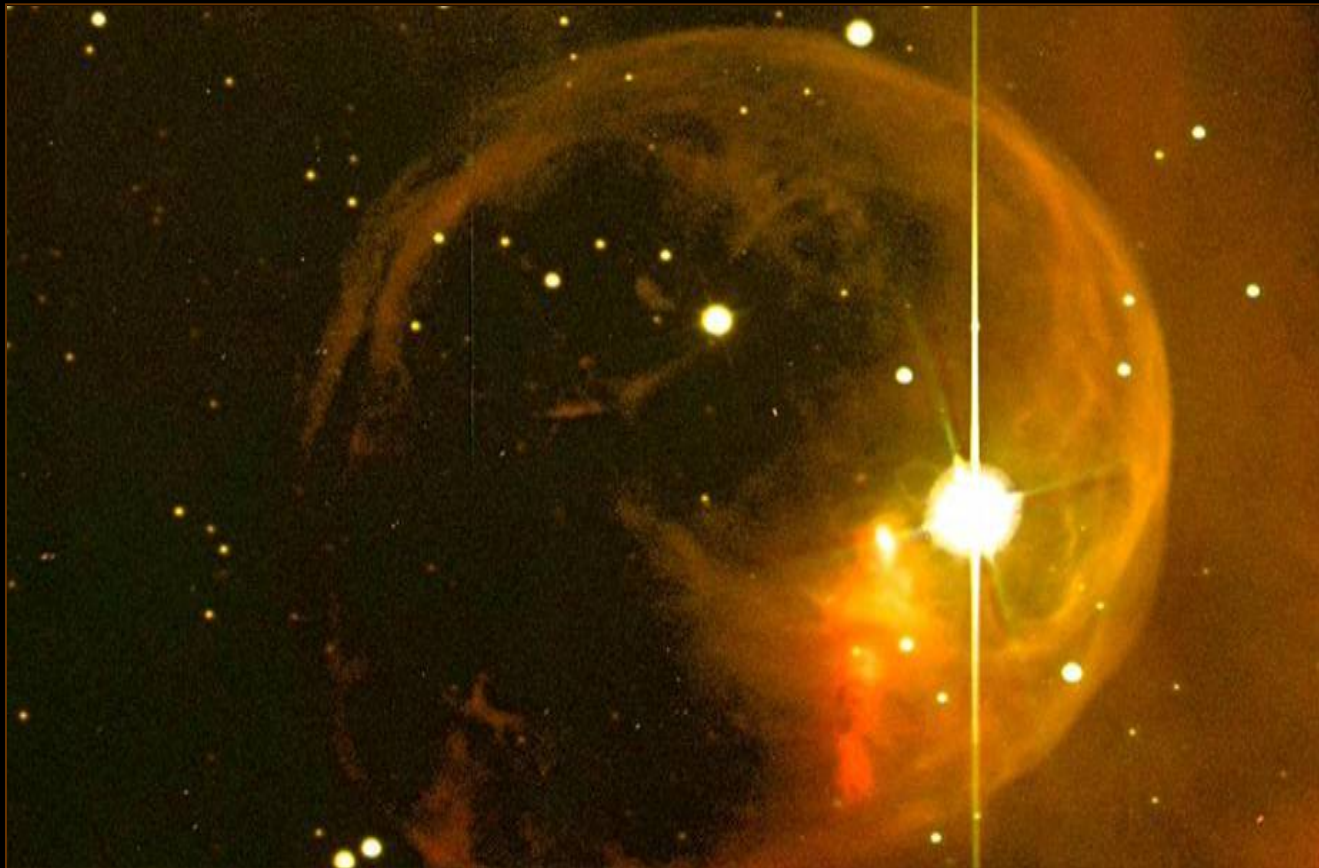
How are stars made?

- Stars are made (or “born”) in giant clouds of dust and gas.
- Sometimes part of the cloud shrinks because of *gravity*.
- As it shrinks it becomes *hotter* and when it is hot enough, *nuclear reactions* can start in the centre... and A Star is Born!



The Birth and Death of Stars

Here you can see the old dust and gas being blown away by the heat of the new star.



“Bubble Nebula” - Image from the Liverpool Telescope

The Birth and Death of Stars

What happens next?

- Once nuclear fusion is producing heat in the centre of the new star, this heat stops the rest of the star collapsing.
- The star then stays almost exactly the same for a long time (about 10 billion years for a star like the Sun).
- The balance between *gravity* trying to make the star shrink and *heat* holding it up is called **Thermodynamic Equilibrium**.

The Birth and Death of Stars

The life of a star

- During its “life” a star will not change very much.
- However, different stars are different colour, size and brightness.
- The bigger a star, the hotter and brighter it is. Hot stars are **Blue**. Smaller stars are less bright, cooler and **Red**.
- Because they are so hot, the bigger stars actually have *shorter* lives than the small, cool ones.

The Birth and Death of Stars

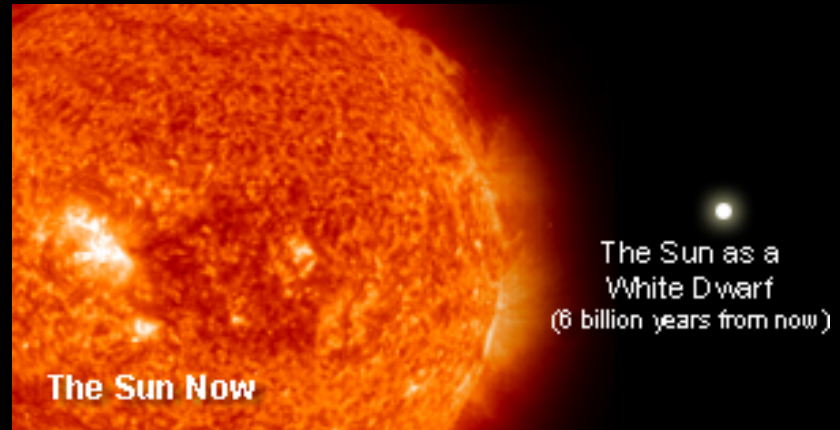
How does a star “die”?

- Eventually, the hydrogen (the “fuel” for the nuclear fusion) in the centre of the star will run out.
- No new heat is made and gravity will take over and the *centre* of the star will shrink.
- This makes the very outside of the star “float up” and cool down, making the star look much *bigger* and *redder* – Called a *Red Giant*



Antares – a Red Giant

The Birth and Death of Stars



The end of a Sun-like star

- For a star like the Sun, no more nuclear fusion can take place, so the centre of the star will then keep collapsing.
- Eventually it can become almost as small as the Earth, but with the same mass as a whole star! This very dense object is called a **White Dwarf**.
- A piece of White Dwarf the size of a mobile phone would weigh as much as an elephant on the Earth!

The Birth and Death of Stars

The end of a Sun-like star

- The outer parts of the star (that formed the Red Giant) then drift off into space and cool down making a **Planetary Nebula**.
- Planetary nebulae have nothing to do with planets, of course, they just look a bit like them in small telescopes!
- Here you can see a planetary nebula called M57 with its White Dwarf in the middle.

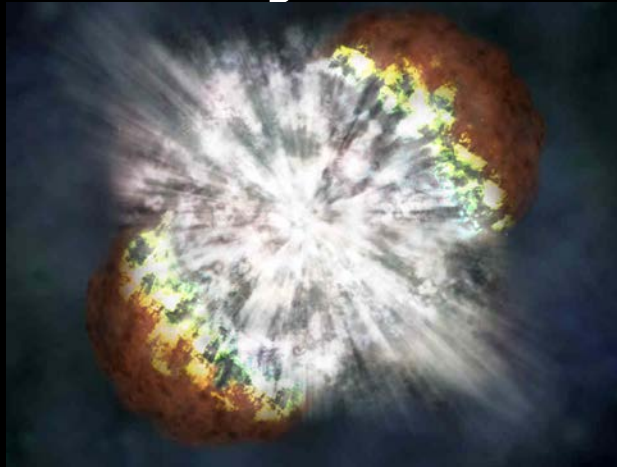


Image from the Liverpool Telescope

The Birth and Death of Stars

The end of a massive star

- For more massive (bigger) stars than the Sun, many more types of nuclear fusion can take place.
- This means several more Red Giant stages.
- However, eventually even the biggest stars run out of fuel and finally collapse.
- For the biggest stars, this collapse causes a huge explosion called a **Supernova**! A Supernova can be brighter than an entire galaxy of 100,000,000,000 stars!



The Birth and Death of Stars

What is left after a Supernova?

- Because the star was so big, the collapse does not stop even with a White Dwarf, but an even more dense object called a **Neutron Star** is made.
- The density of a Neutron star is about 1×10^{18} kg/m³ (that is 1,000,000,000,000,000,000!)
- Sometimes the collapse cannot stop at all and a Black Hole is made, from which not even light can escape!
- The debris of the explosion is blown away and forms a glowing cloud called a **Supernova Remnant**.

The Birth and Death of Stars



The Crab Supernova Remnant

Image from the European Southern Observatory Very Large Telescope

The Birth and Death of Stars

Birth and Death of Stars - Summary

- Stars form in clouds of gas.
- Heat from nuclear fusion, and gravity balance.
- When the hydrogen fuel runs out, a Red Giant is formed.
- For Sun-like stars, a White Dwarf and Planetary Nebula are left.
- For massive stars, a Supernova explosion leaves behind a Supernova Remnant and a Neutron Star or perhaps even a Black Hole.

THE LIFE CYCLE OF STARS

