THE LOUD DEATHS OF MASSIVE STARS

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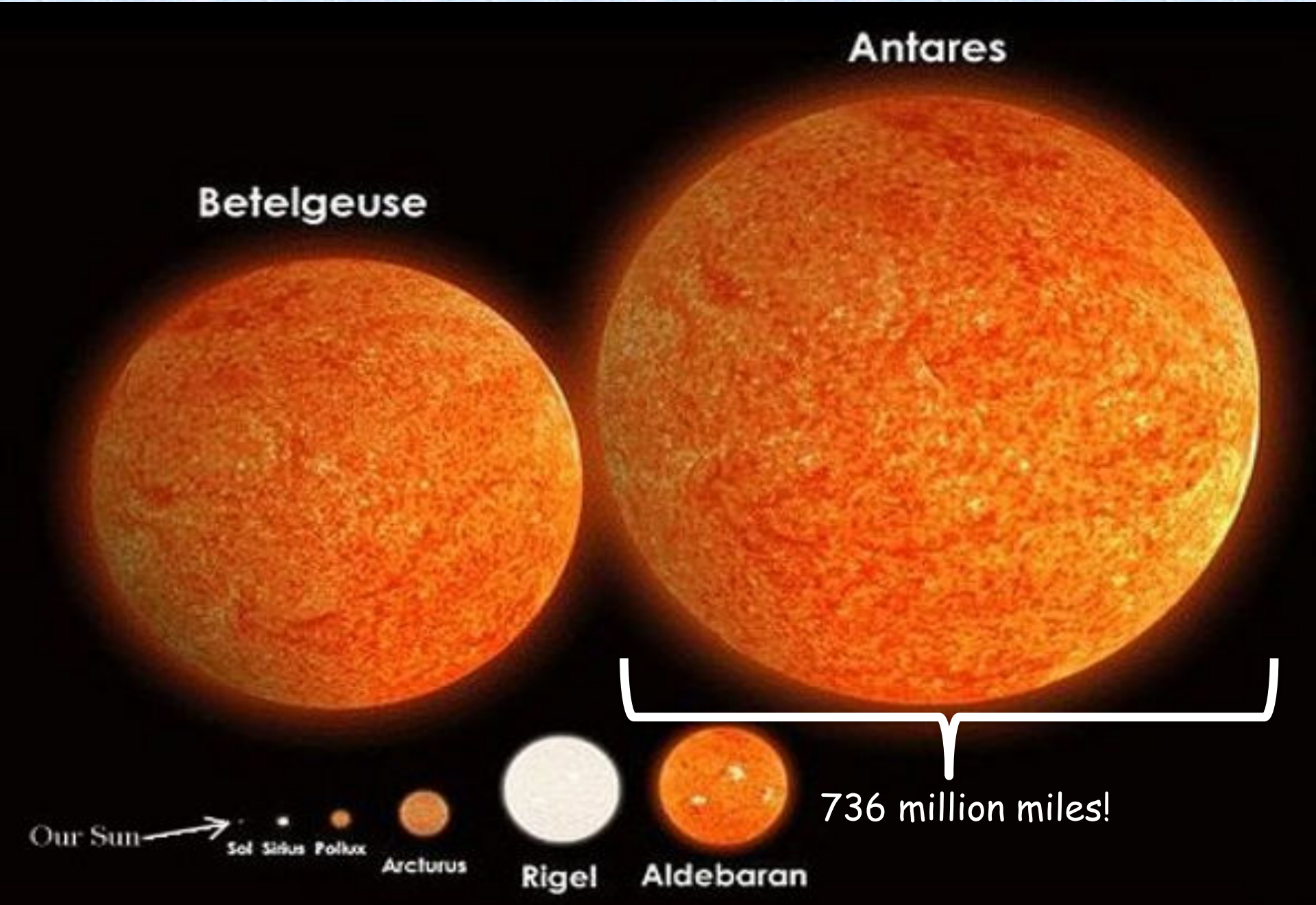
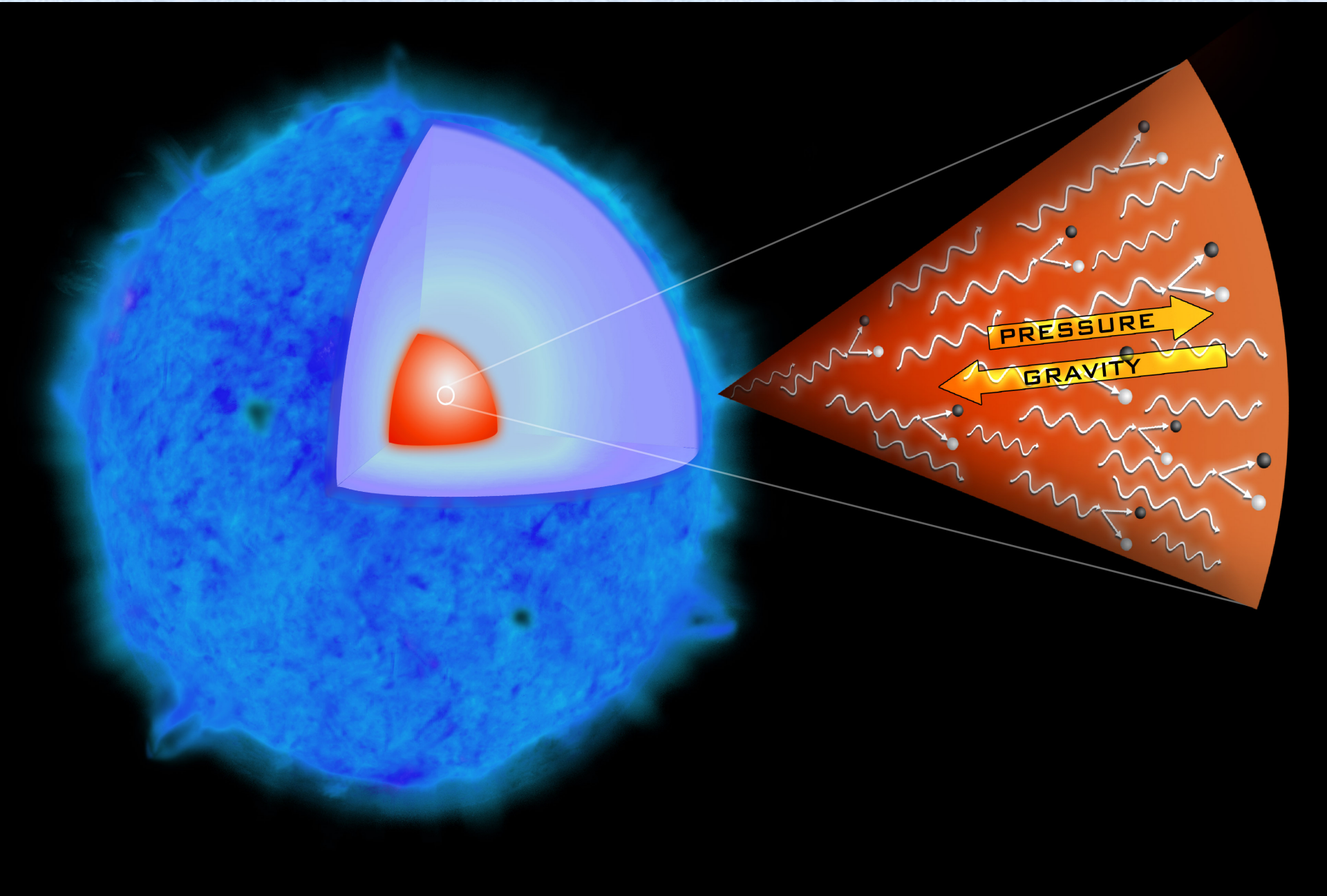
It takes a stare at the sky in a clear night away from the city to see…

- Thousands of stars of different colors, luminosities
- Stars of different mass, different age (some young, some old)

Our sun is quite small compared to some other stars

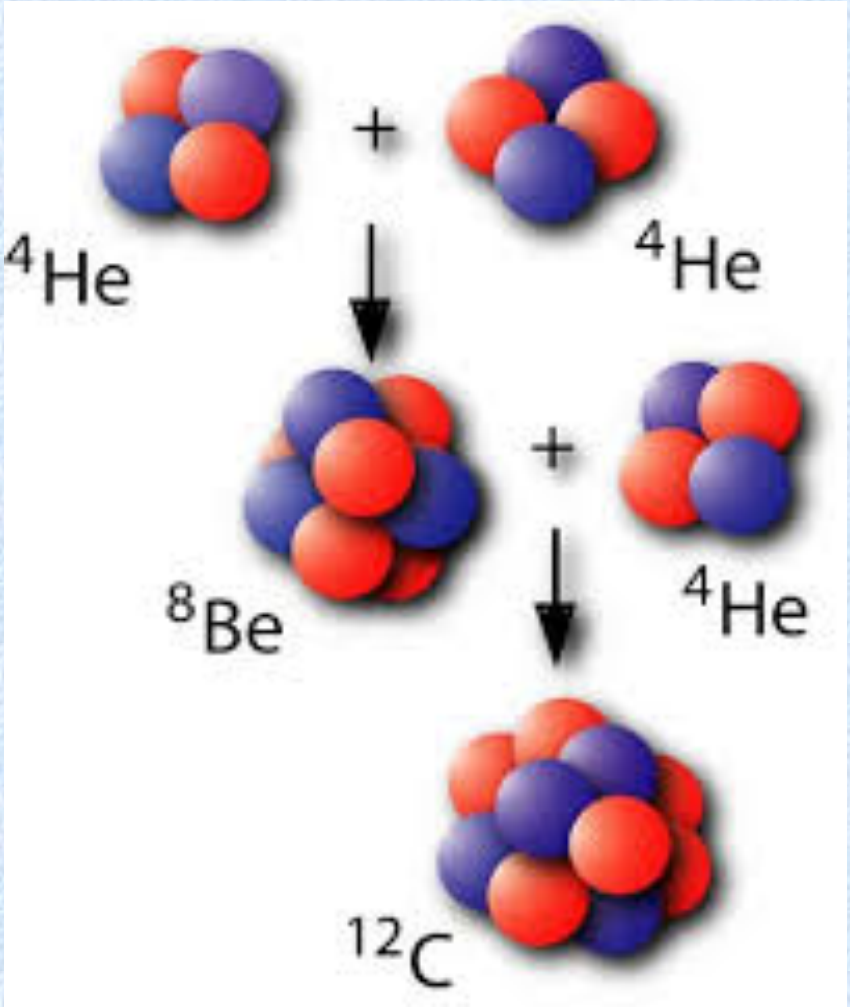


But what exactly is a star and what keeps it shining?



The life cycles of massive stars ($M > 8\ M_{sun}$) are quite different from that of sun-like stars

Stellar nuclear fusion



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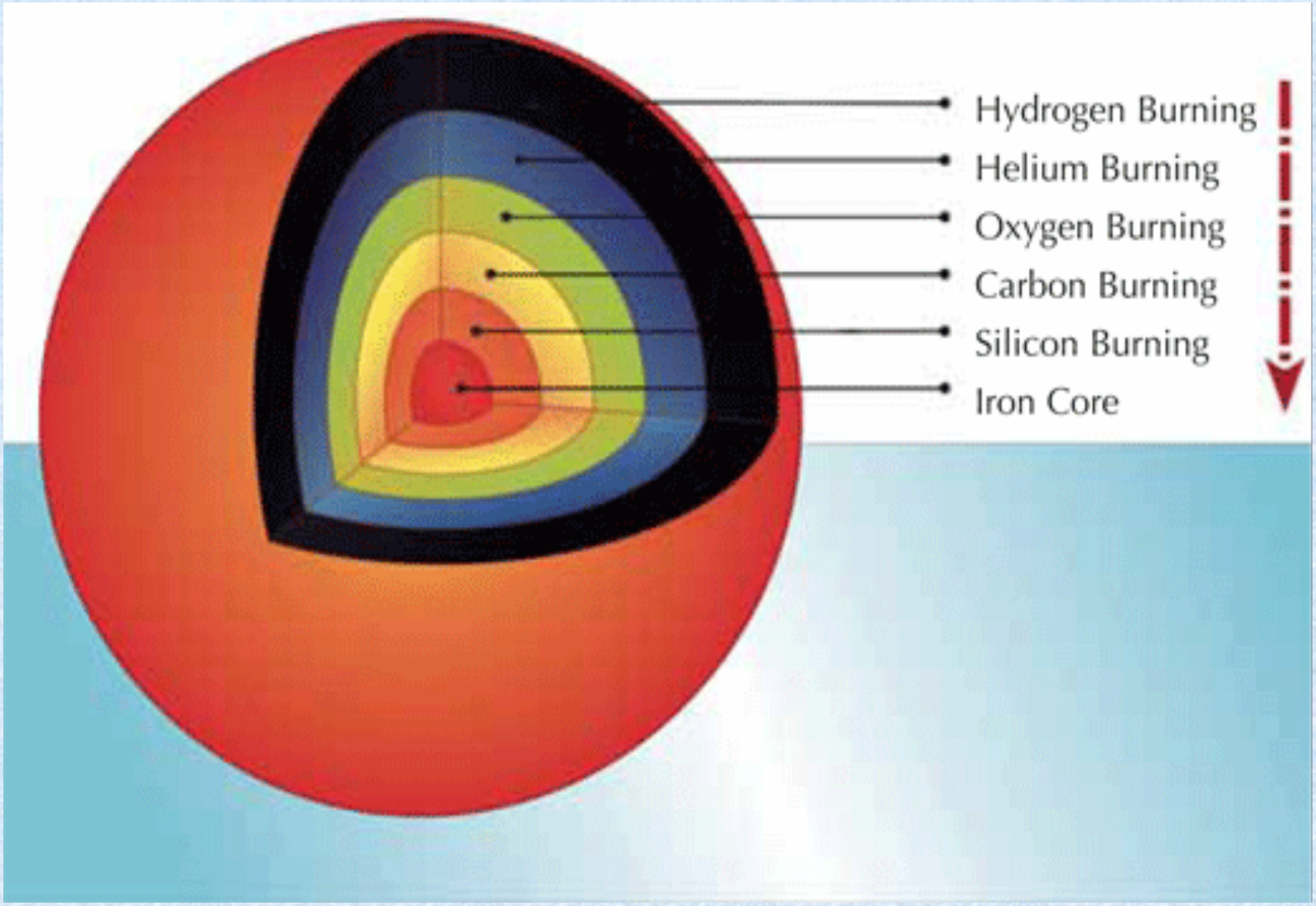
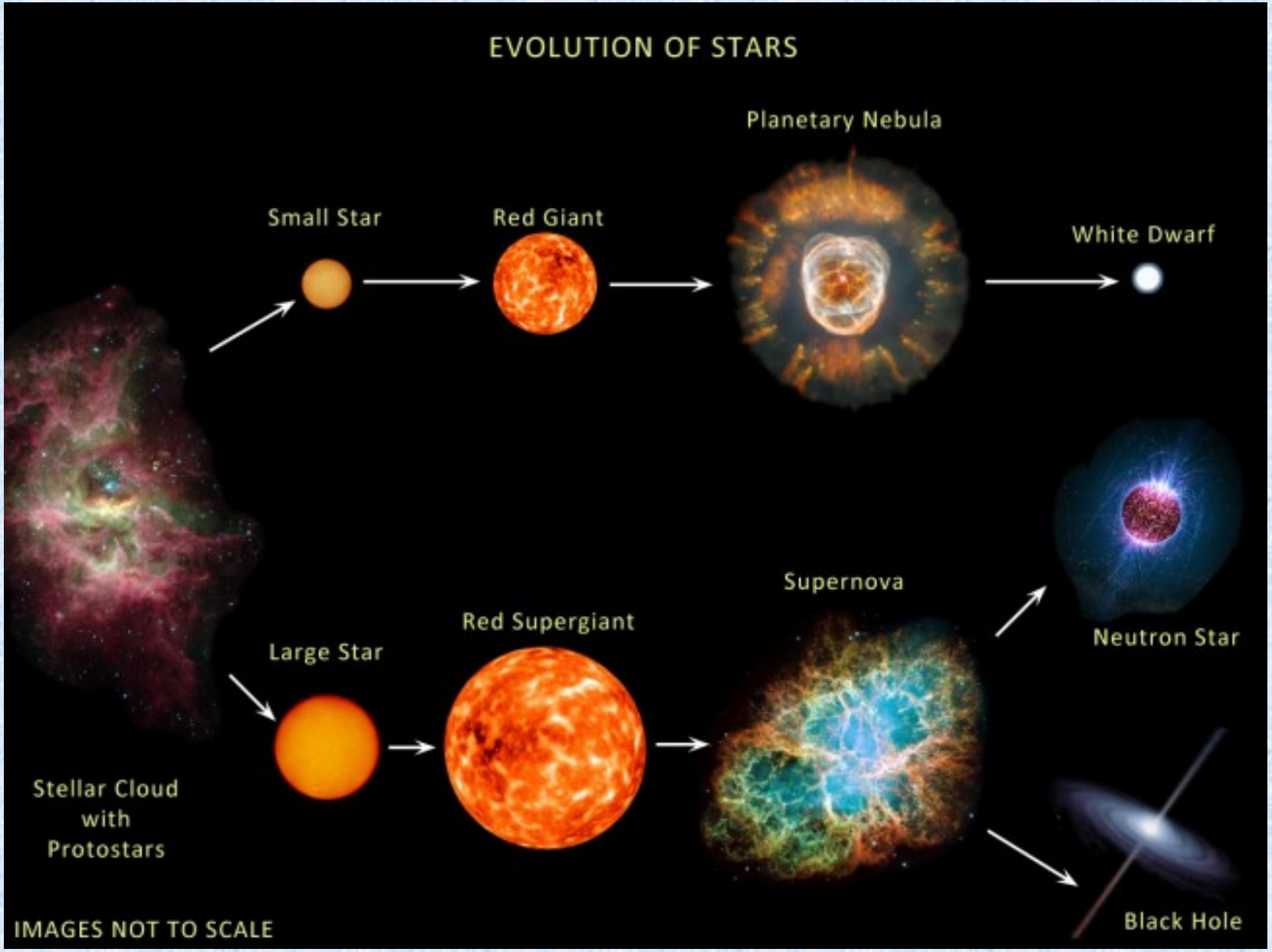
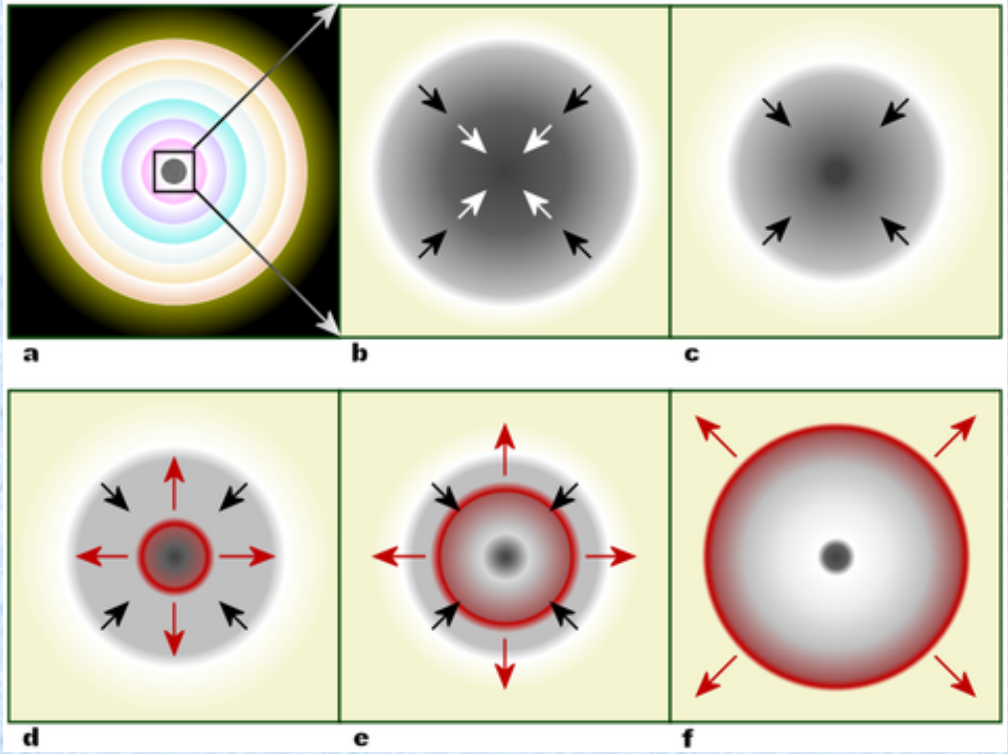
"Onion Structure"

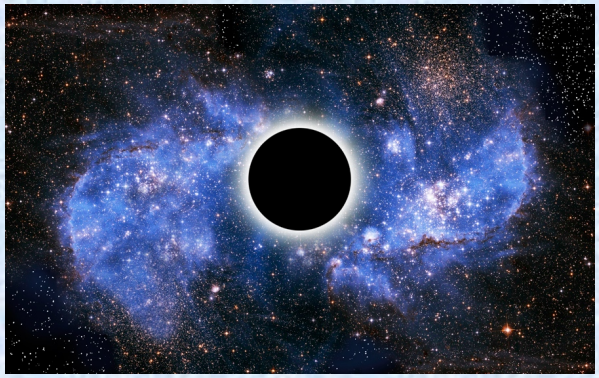


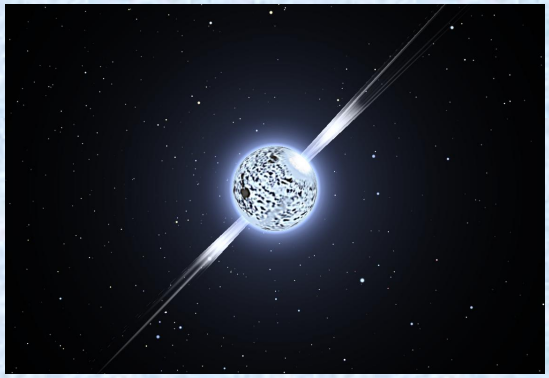
So, depending mainly on the initial mass, the stars have different "lifestyles" and end points…



"Type II" Supernova explosions

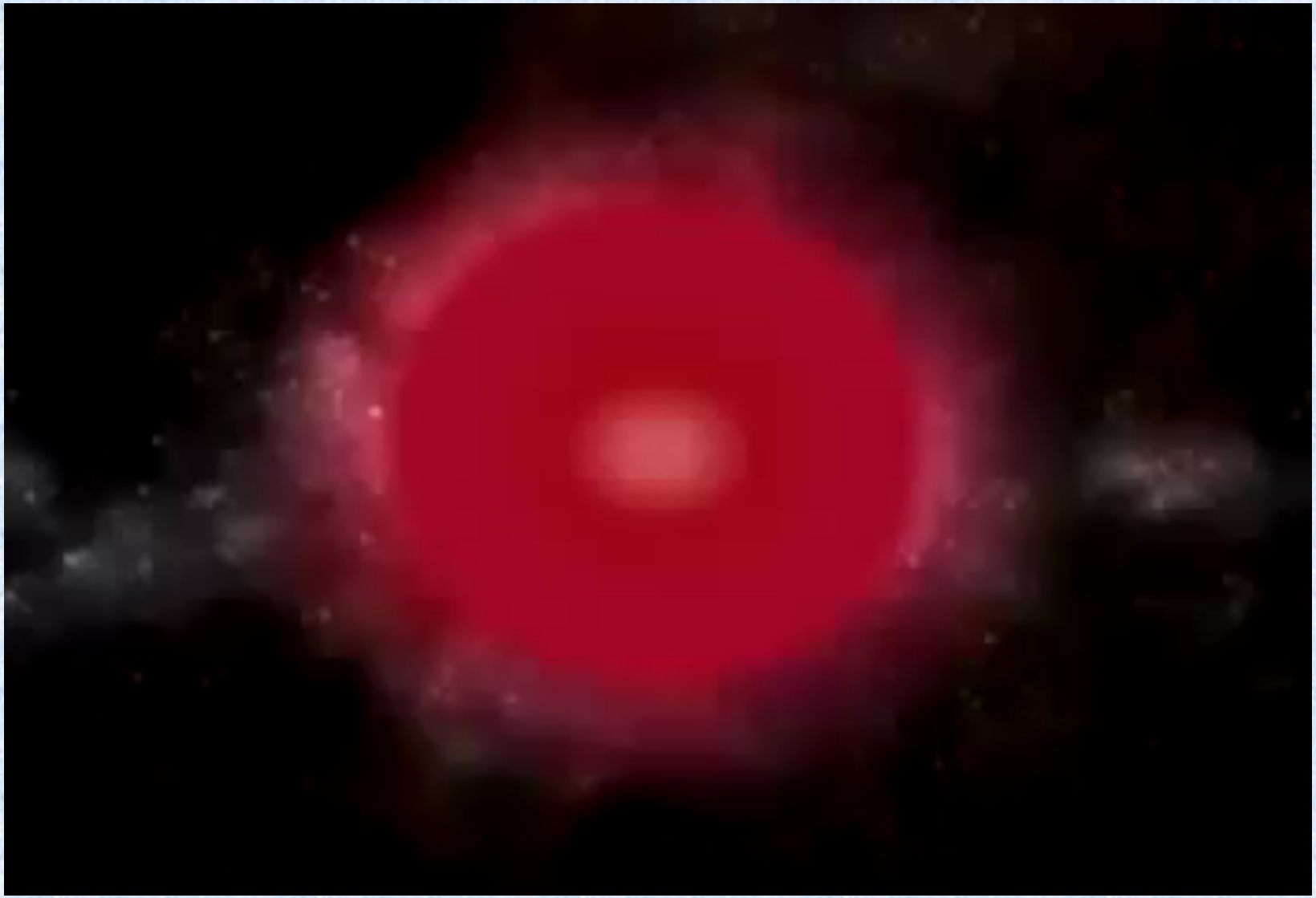




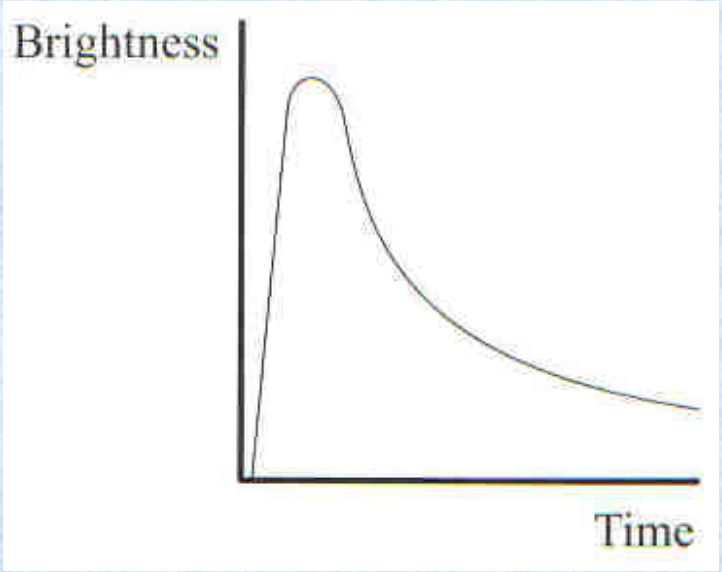


Typical neutron star density -> Take the sun and compress it down the size of downtown Chicago!

"Type II" Supernova explosions – an animation



How bright Supernovae really are

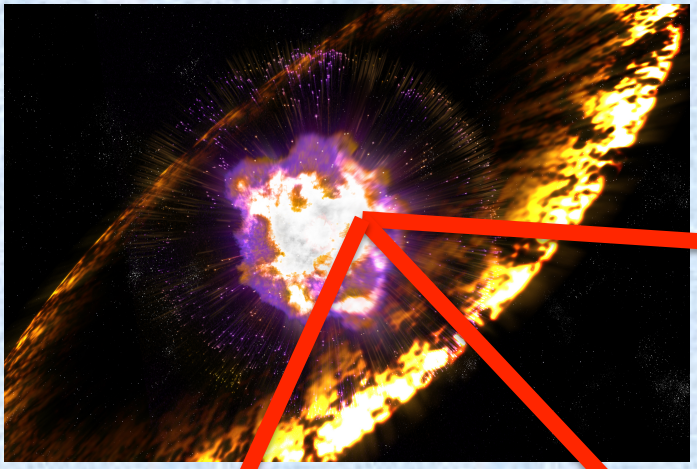


- At peak luminosity a typical Type II supernova can be as bright as 1 billion of suns combined!

Some "super-luminous" supernovae can even outshine their host galaxy!

Energy from a single supernova could power the entire US energy grid for 10^{22} years!!!

Why are Supernovae important?

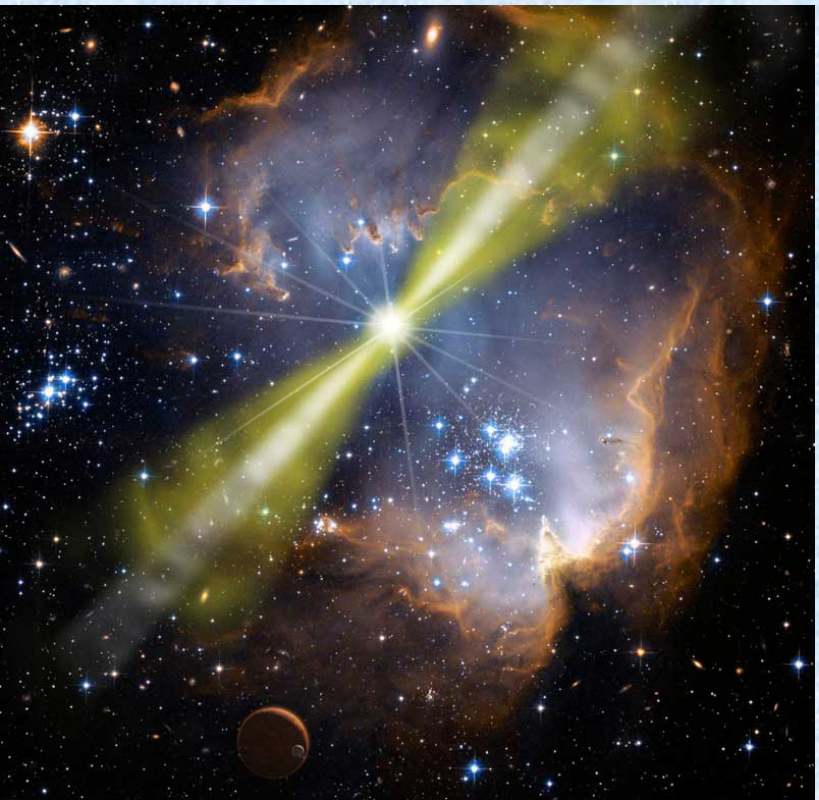


- WE ARE ALL MADE OF STARDUST! THE FORMATION AND EVOLUTION OF COMPLEX LIFE IN THE UNIVERSE WOULD BE IMPOSSIBLE WITHOUT SUPERNOVAE PROVIDING THE BUILDING BLOCKS!

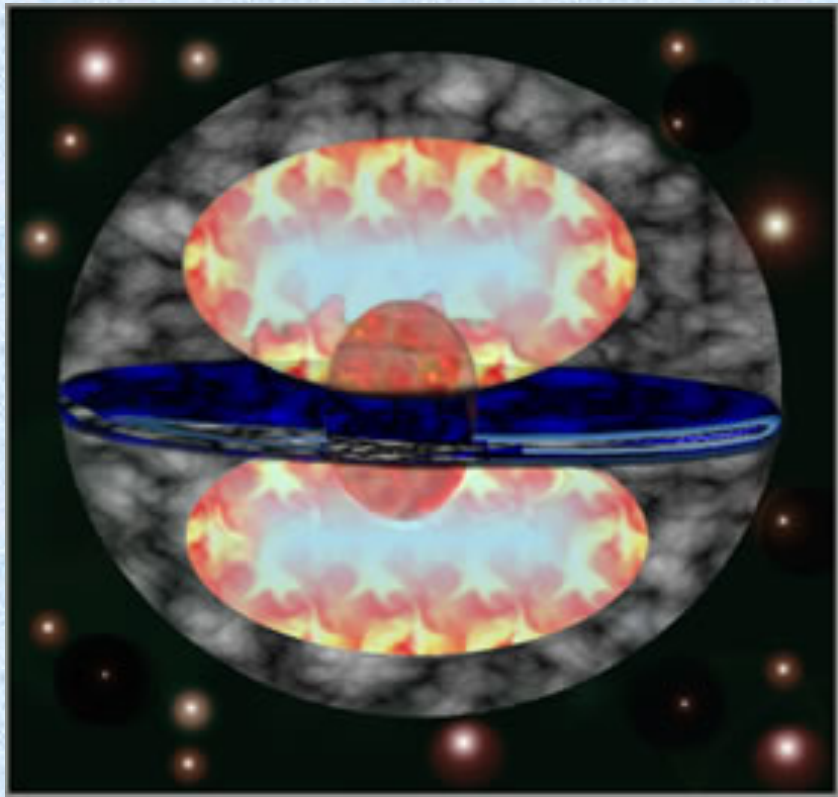
Alternative supernova explosion mechanisms

- In reality the complex details of the structure of massive pre-supernova stars (mass, rotation, composition, binary evolution) lead to a variety of supernova outputs, in terms of luminosity and chemical composition -> need more explanations!

"Jet-induced" supernovae

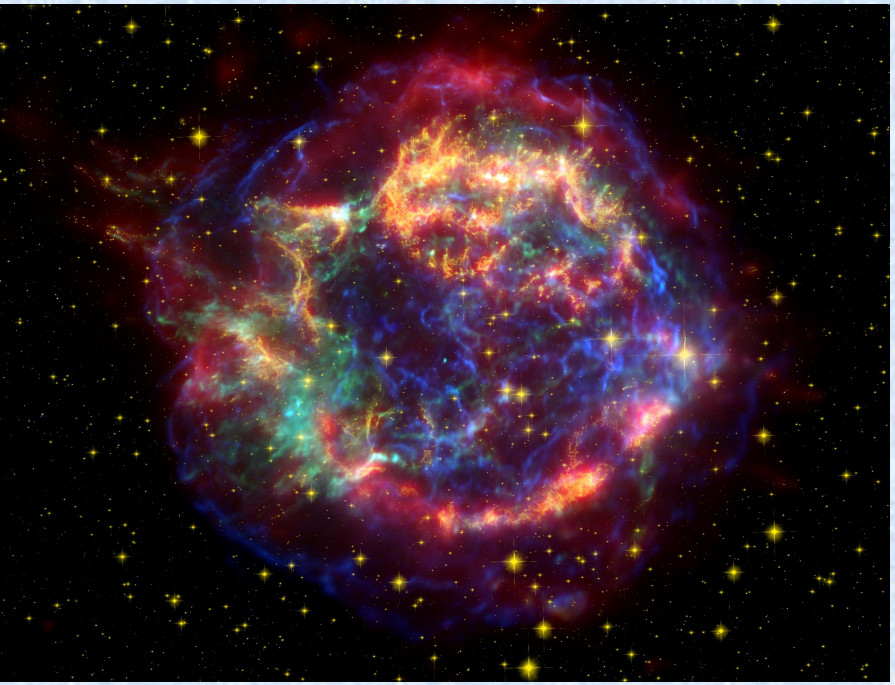


Supernova – surrounding debris interaction

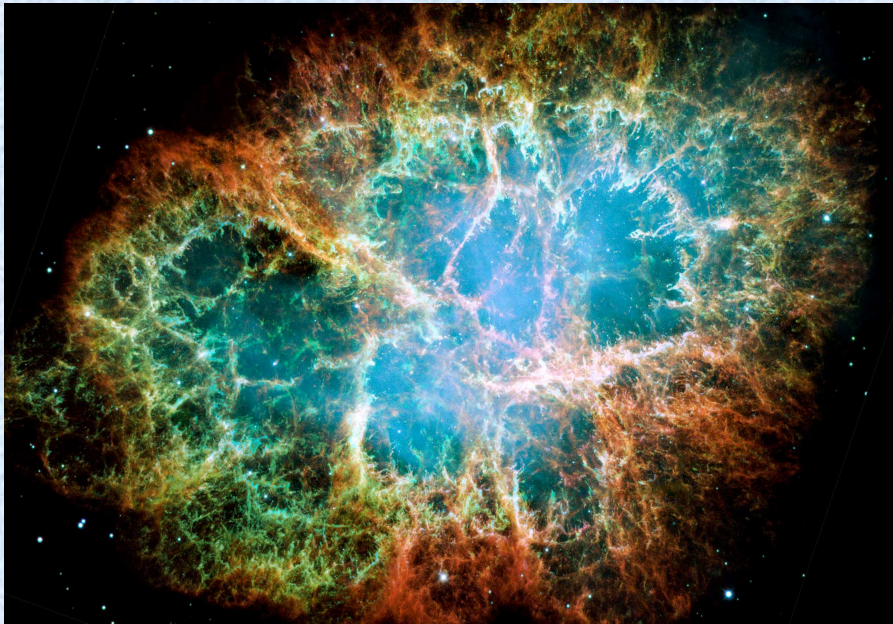


Asymmetric Supernova relics

Cassiopeia A



Crab nebula

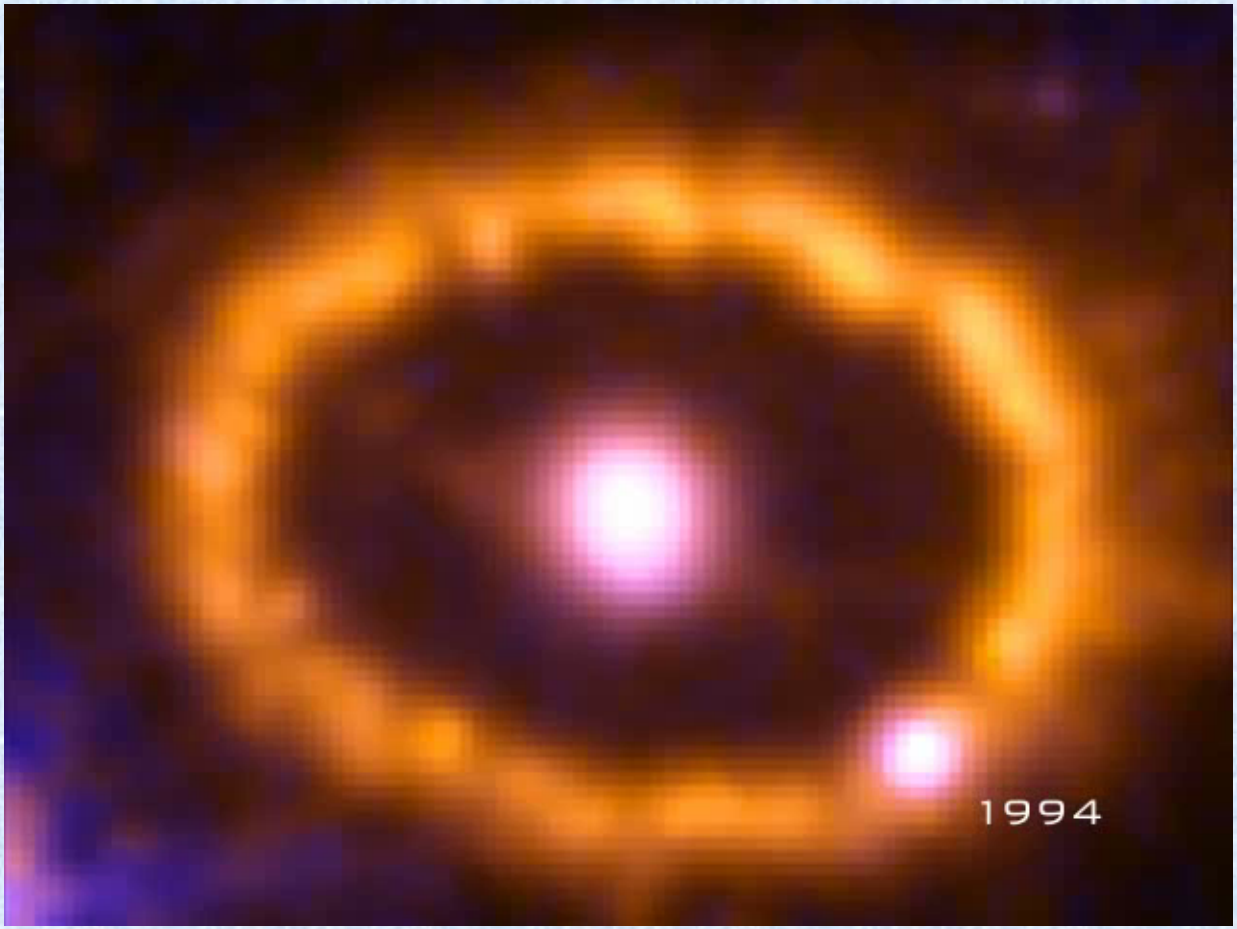


- The shape of real supernovae is not a simple sphere! Lots of complex geometric structure…

Supernovae colliding with the ashes of their own progenitor star…

- SN 1987A one of the nearest most well observed supernovae!
- Observed closely for 28 years now!
- Ejecta collides with surrounding material

SN 1987A

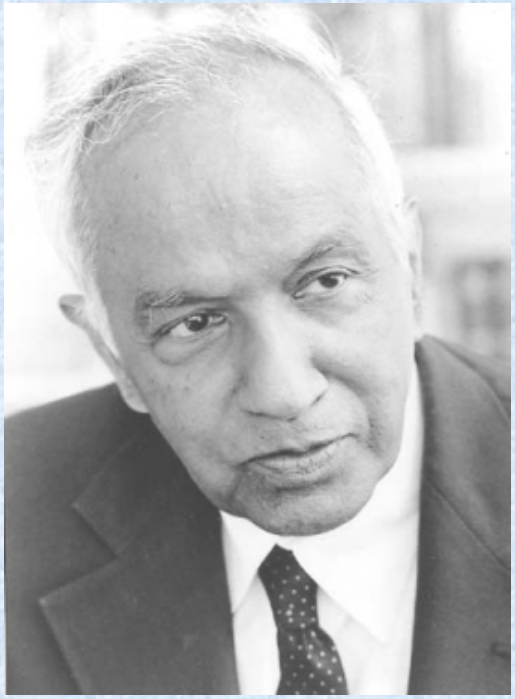


The environment around massive stars matters to the resulting supernova!

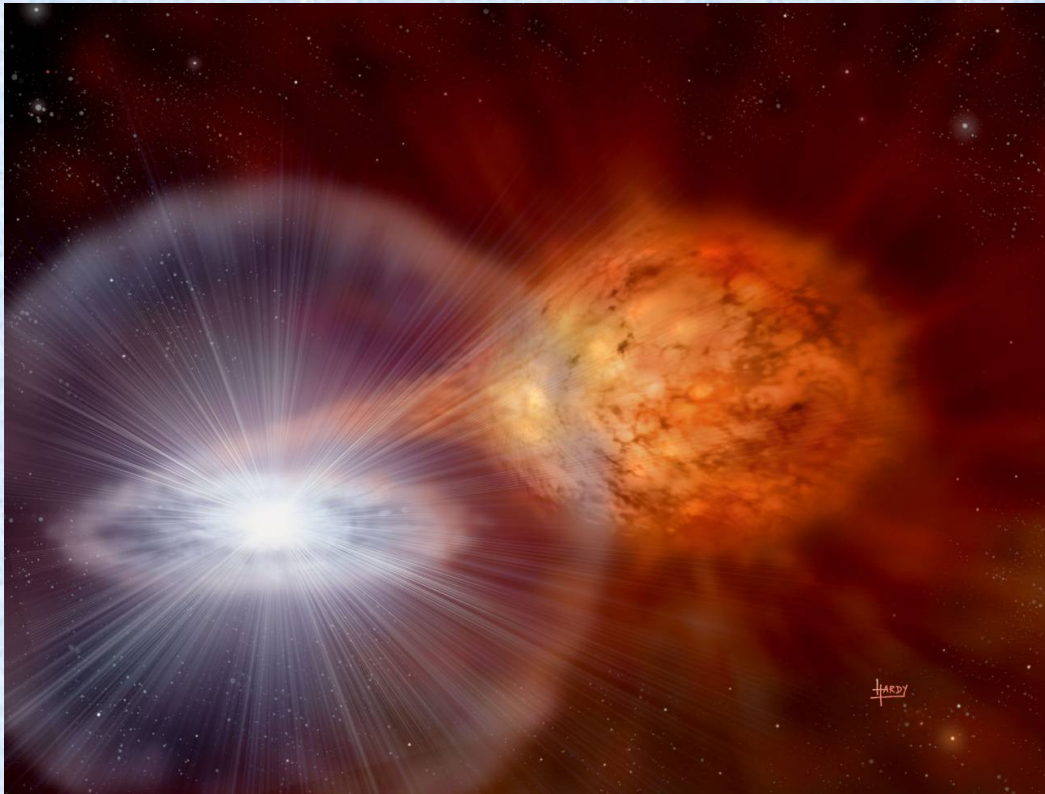
"Type Ia" Supernovae: Hanging out with bad company!

In some "binary" stellar systems mass is transferred from a large star to a compact companion (white dwarf).

White dwarfs are special in that they cannot exceed a certain mass limit (Chandrasekhar limit ~ 1 and a half times the sun).



S. Chandrasekhar



Happened last January! SN 2014J

Type Ia Supernovae: the distant light posts of the Universe

- Type Ia Supernovae are even brighter than Type II Supernovae by almost 100 times!
- As such, they can be found at great, cosmological distances.
- Observing Type Ia supernovae at large distances help constrain the properties of the Universe itself.
- Research led to Nobel prize in physics in 2011.

Type Ia Supernovae: the distant light posts of the Universe

But how do we study Supernova right here on Earth?

We run simulations of explosions on Supercomputers like Mira. Mira can do one simulation in less than a day while your personal computer would need thousands of years…

In the comfort of our office!

TAKE AWAY POINTS

- Massive stars die via energetic, luminous supernova explosions.
- The details of how supernova explosions occurs are still a subject of study pioneered by the University of Chicago.
- Supernovae are important because they form elements necessary for life.
- Supernovae are very, very bright and can be observed at great distances in the Universe.


It is clear to everyone that astronomy at all events compels the soul to look upwards, and draws it from the things of this world to the other.
-Plato
THANK YOU FOR YOUR ATTENTION!