What Color is That Star? Why?

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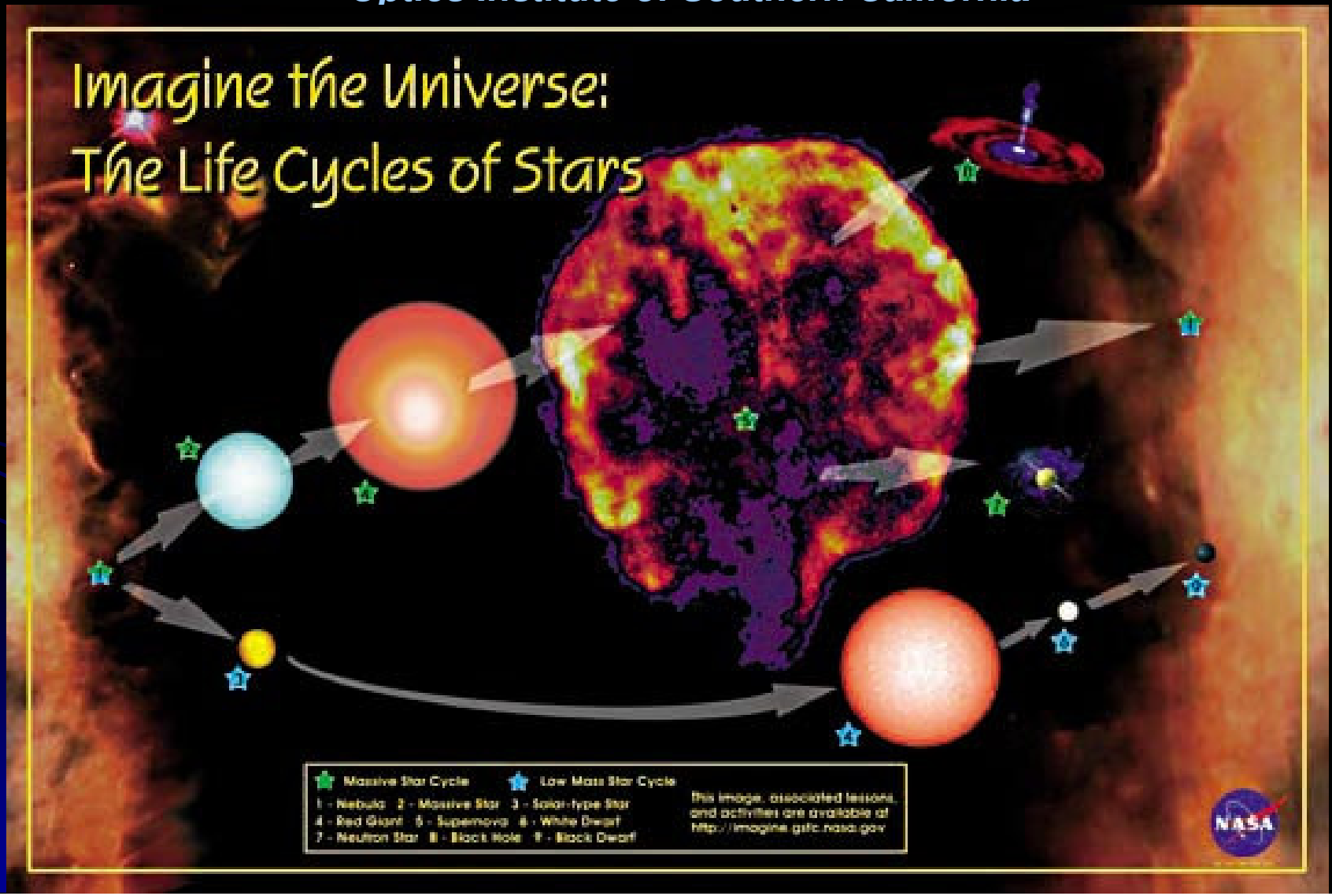
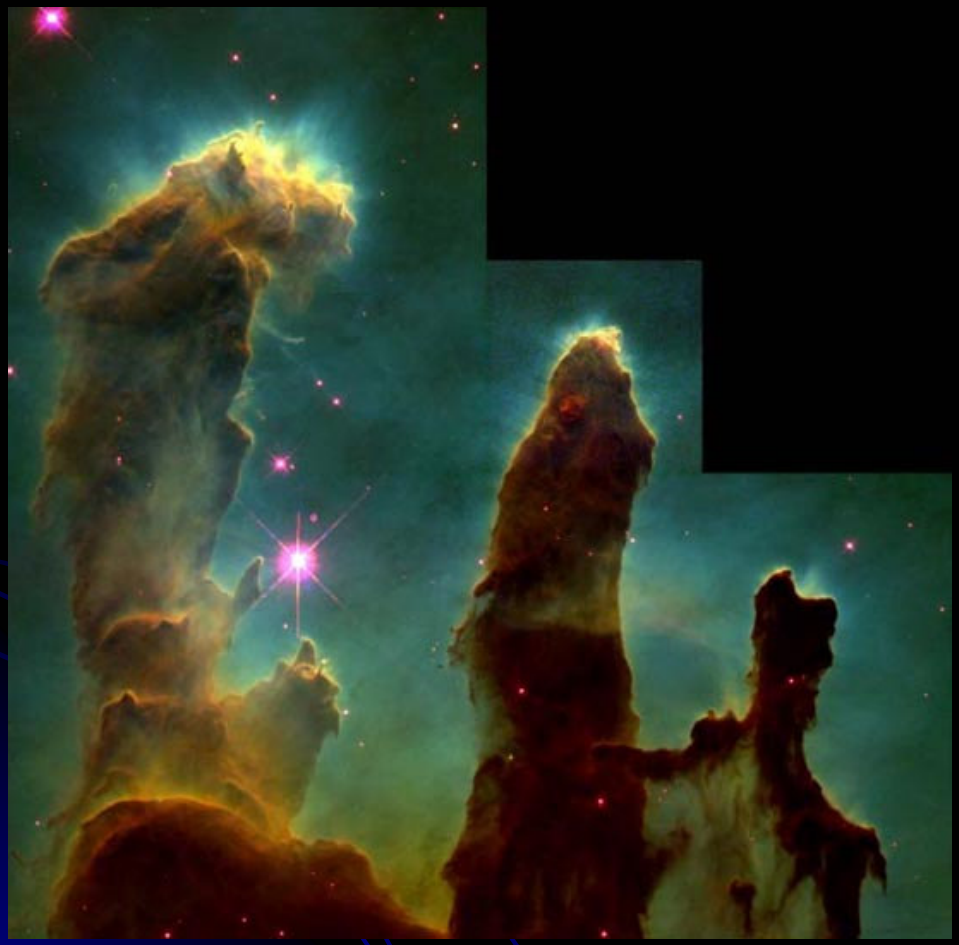


Twinkle, Twinkle, Little Star ... How I Wonder What You Are ...

- Did you ever wonder what stars are?
- Did you notice that stars have different colors?
  - The different colors indicate different:
    - Temperatures
    - Sizes
    - Masses
- The bigger it is, the hotter and the faster a star burns its life away.

Stellar Nursery



Space is filled with the stuff to make stars.

Stars start from clouds

Clouds provide the gas and dust from which stars form.

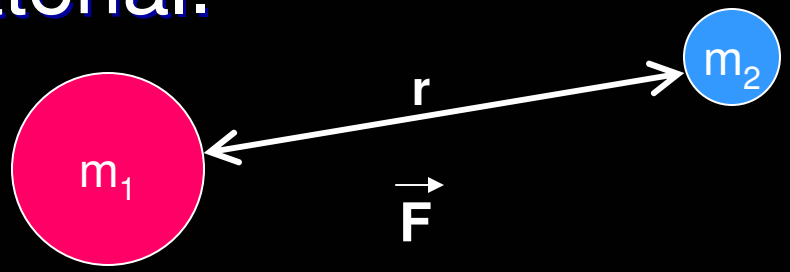
But not this kind of dust

Rather: Irregular Grains Of Carbon or Silicon

Collapse to Protostar

- Stars begin with slow accumulation of gas and dust.
- Gravitational attraction of Clumps attracts more material.

$$F = \frac{Gm_1m_2}{r^2}$$

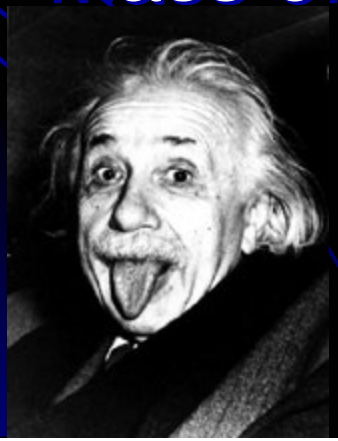


- Contraction causes Temperature and Pressure to slowly increase.

"**G**" is the universal gravitational constant!!

Nuclear Fusion !

- At 15 million degrees Celsius in the center of the star, fusion ignites !
- 4 (^{1}H) --> ^{4}He + 2 e^{+} + 2 neutrinos + energy
  - Where does the energy come from ?
    - Mass of four ^{1}H > Mass of one ^{4}He

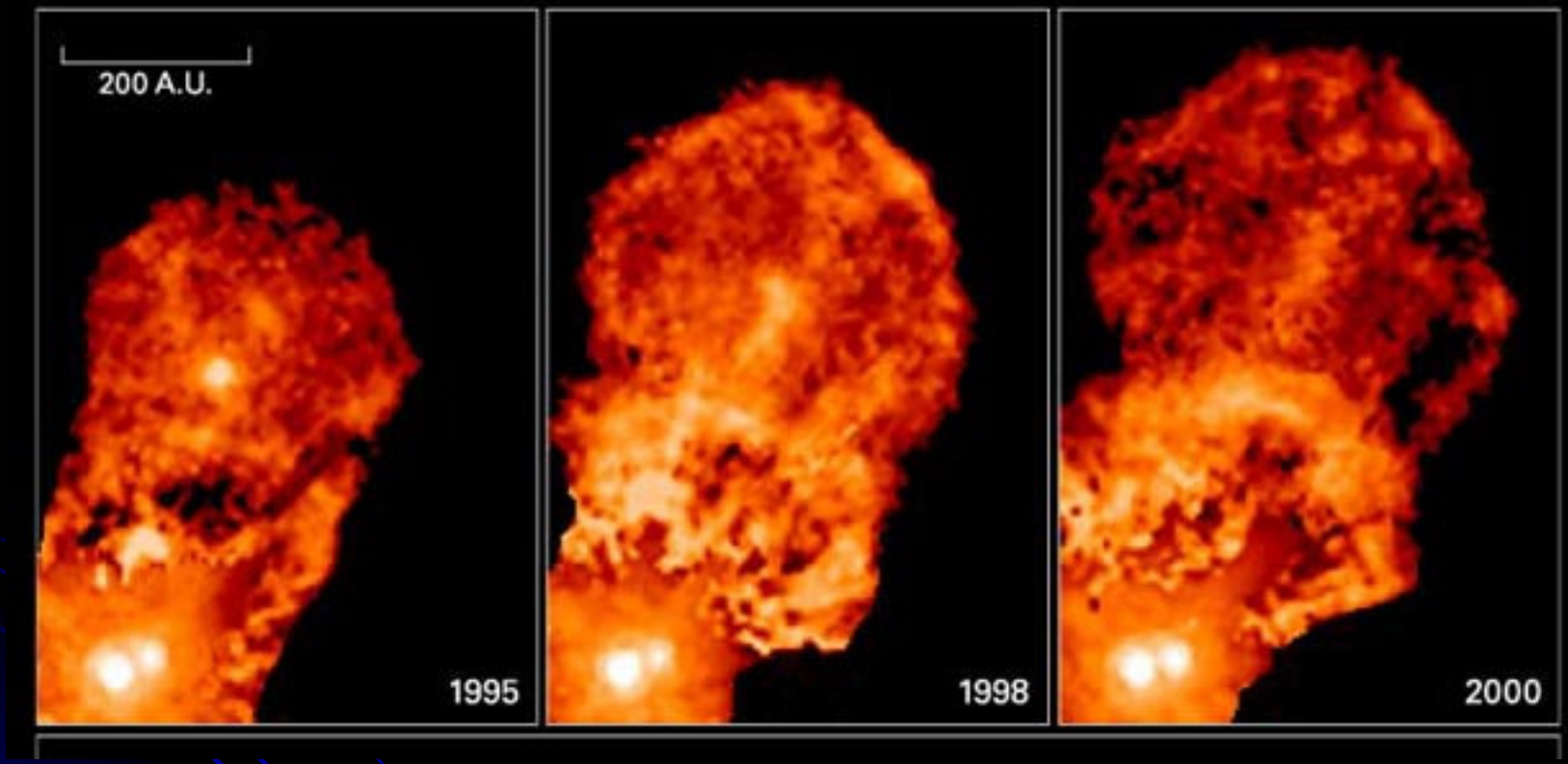


$$E = mc^2$$

A Balancing Act

- Energy released from nuclear fusion counter-acts inward force of gravity.
- Throughout its life, these two forces determine the stages of a star's life.

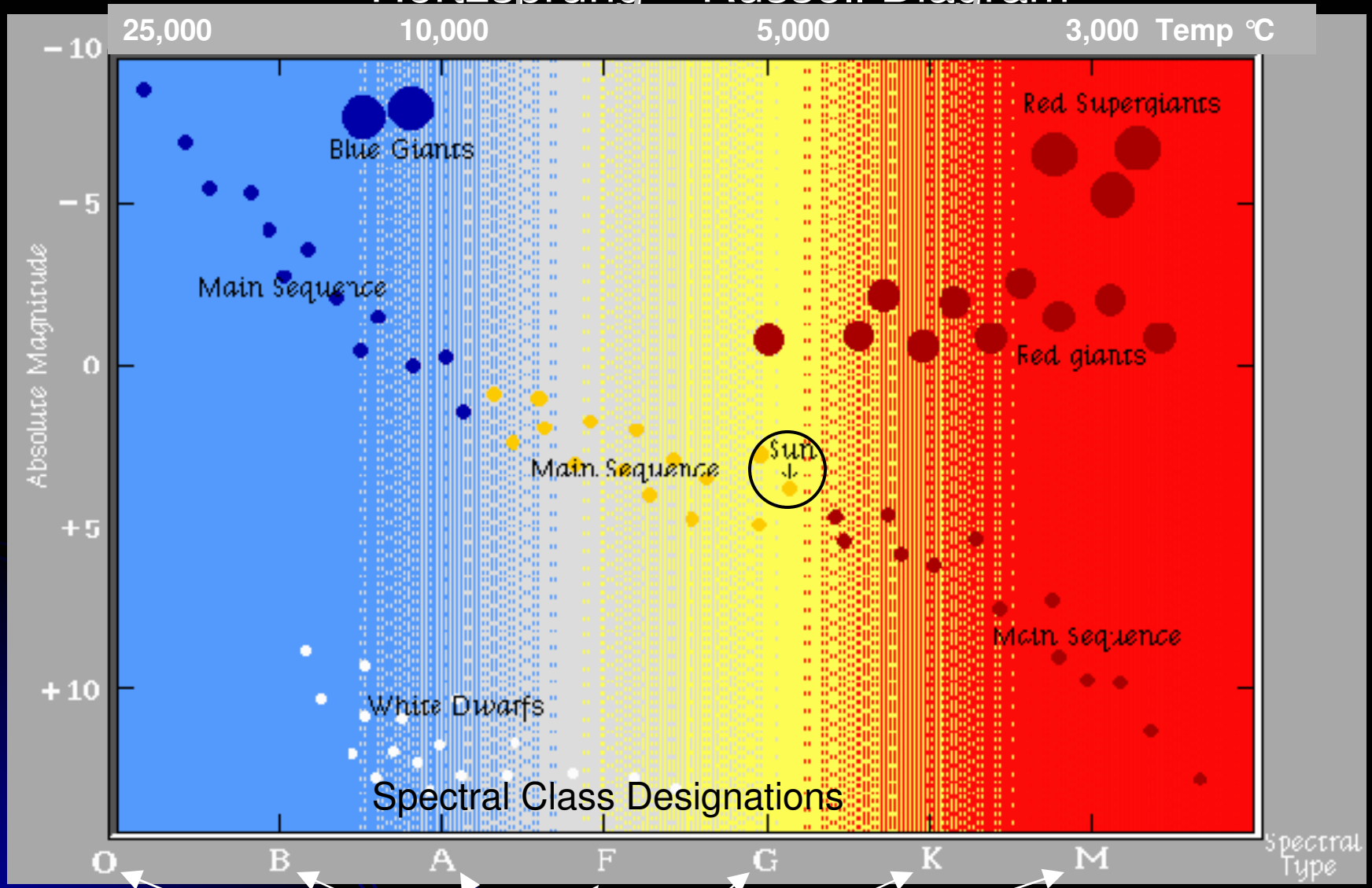
New Stars are not quiet !



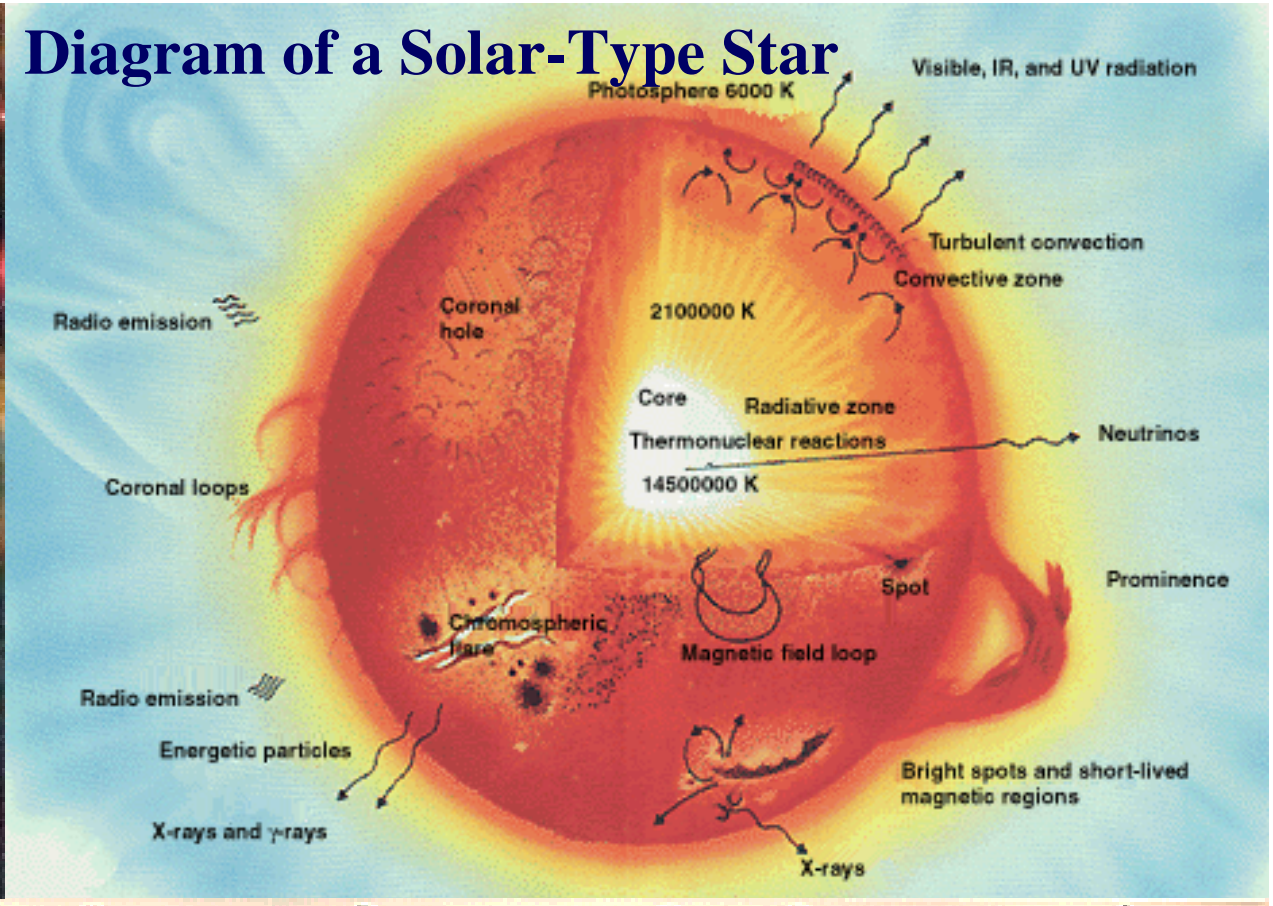
Expulsion of gas from a young binary star system

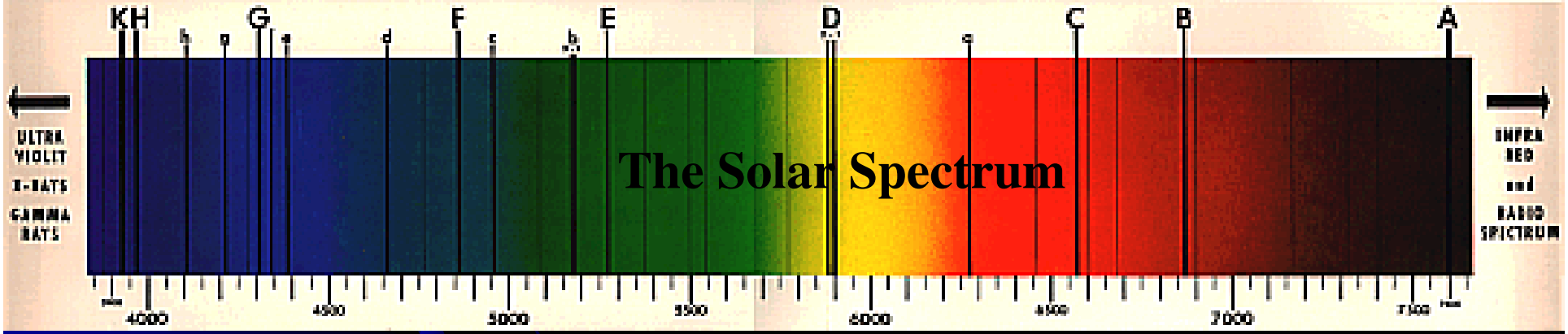
All Types of Stars – Different Colors

Hertzsprung – Russell Diagram



Oh! **B**e **A** **F**ine **G**irl - **K**iss **M**e !





The Optics Institute
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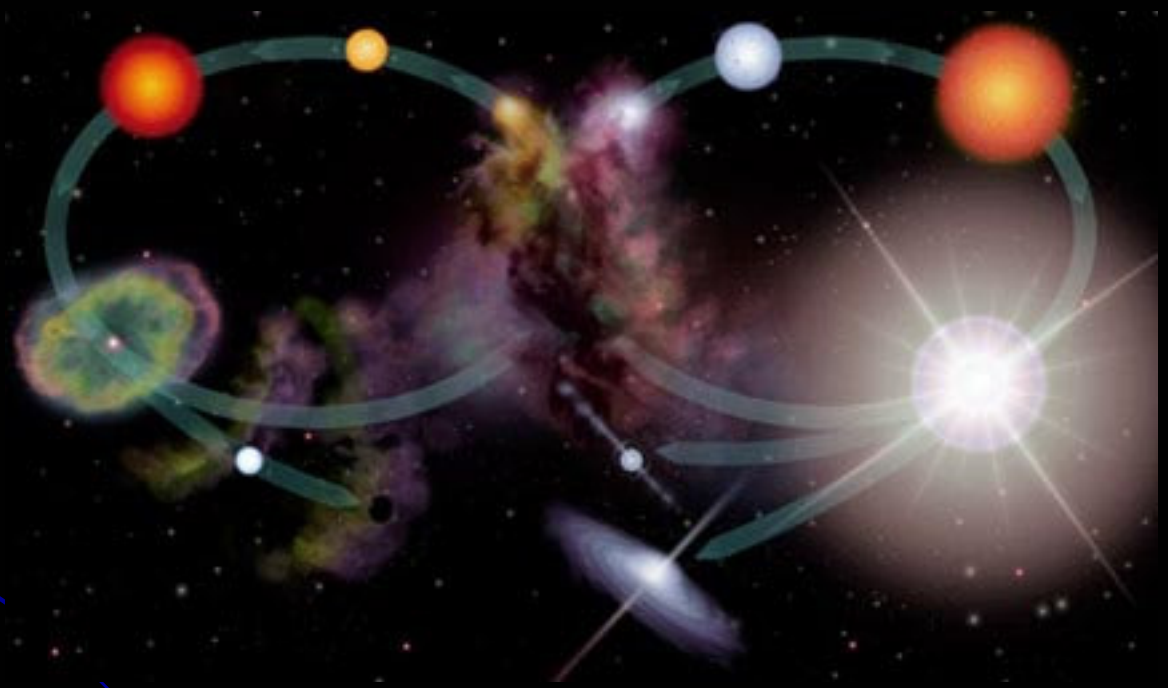
Reprise: the Life Cycle



Sun-like Stars

Massive Stars

The end for solar type stars

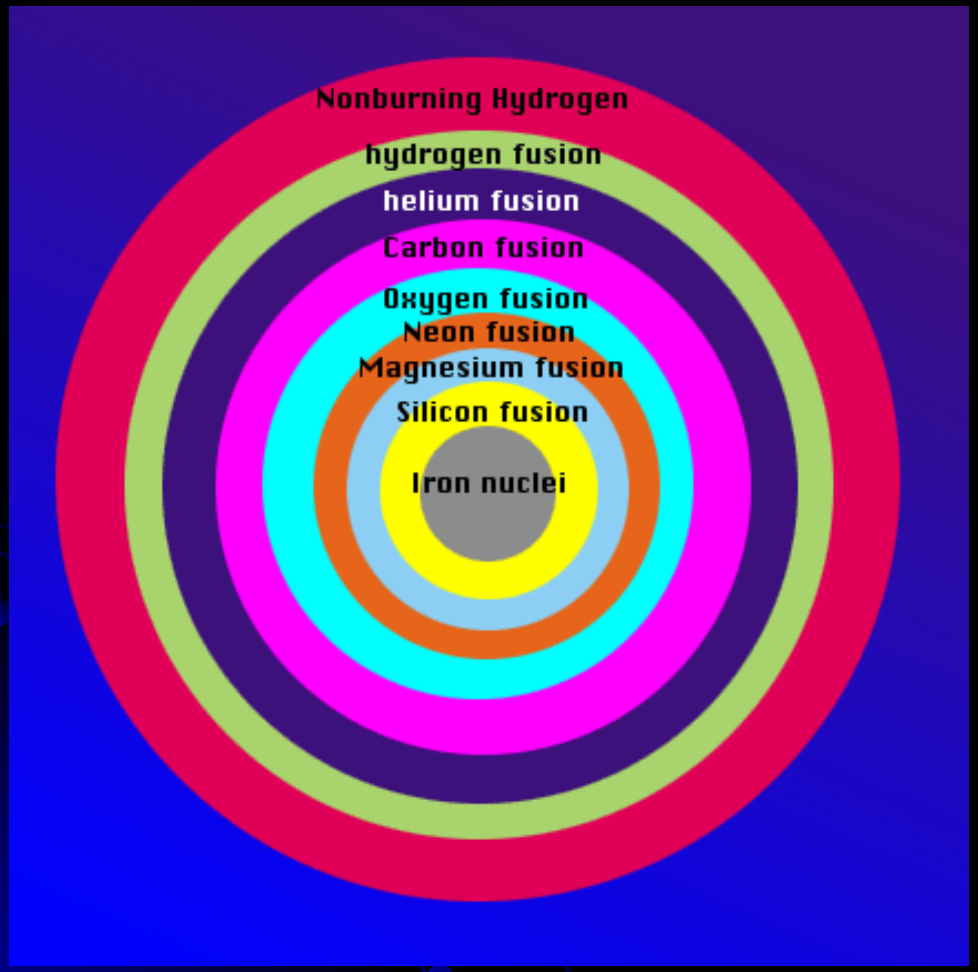
After Helium exhausted, outer layers of star expelled

Planetary Nebulae

White dwarfs

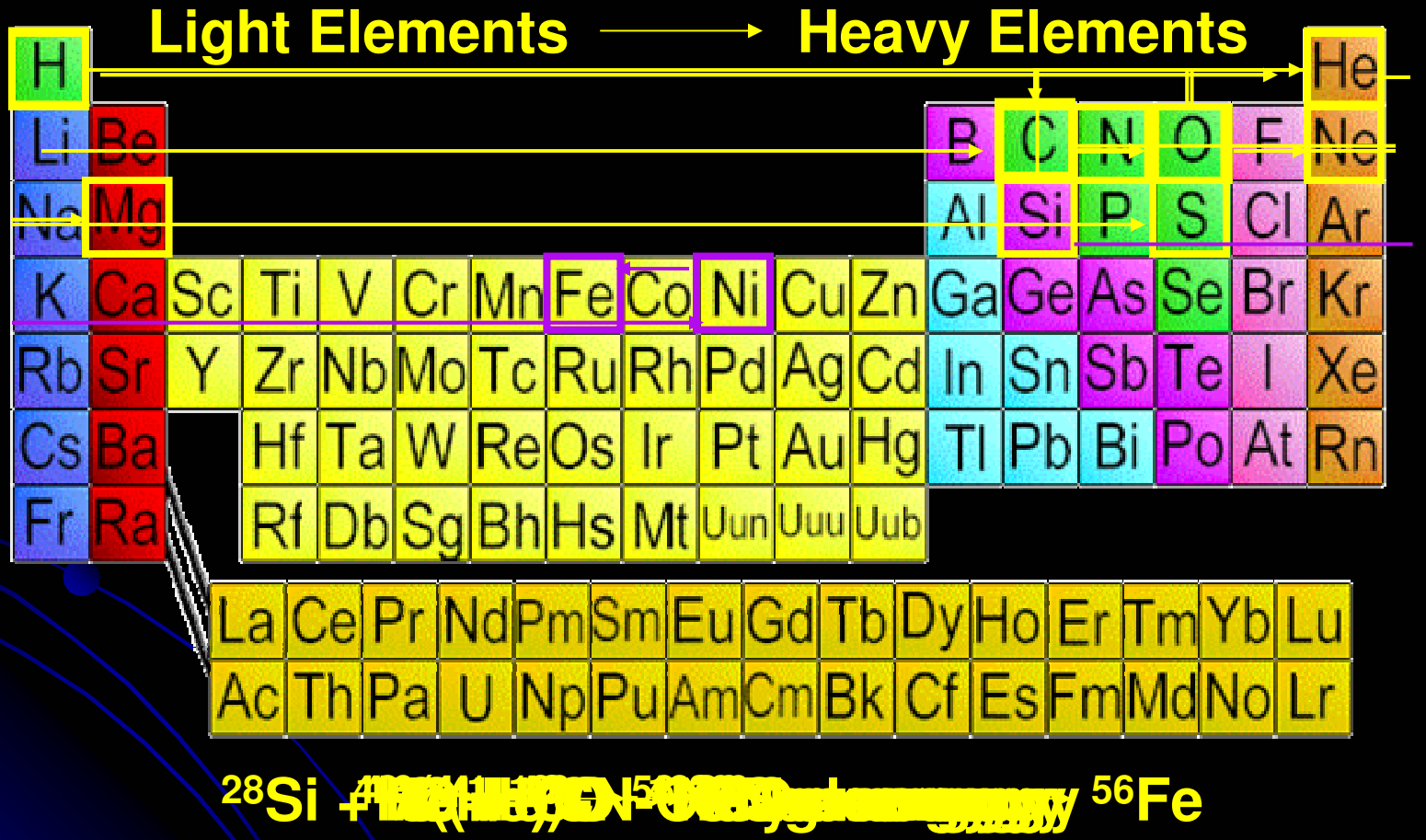
- At center of Planetary Nebula lies a
- White Dwarf.
- Size of the Earth with Mass of the Sun
  "A ton per teaspoon"
- Inward force of gravity balanced by repulsive force of electrons.

The End of the Line for Massive Stars

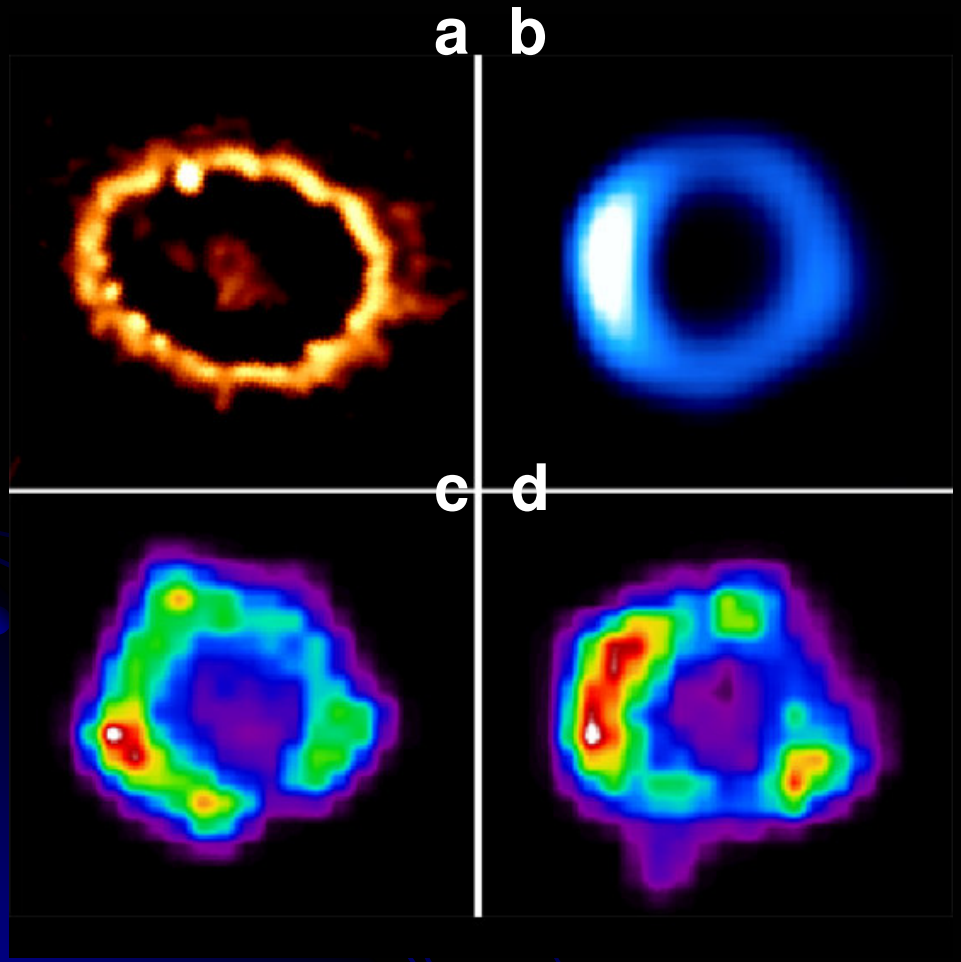


- Massive stars burn a succession of elements.
- Iron is the most stable element and cannot be fused further.
  - Instead of releasing energy, it uses energy.

Periodic Table



Supernova Remnants: SN1987A



a) Optical - Feb 2000

- Illuminating material ejected from the star thousands of years before the SN

b) Radio - Sep 1999

c) X-ray - Oct 1999

d) X-ray - Jan 2000

- The shock wave from the SN heating the gas

What is Light??

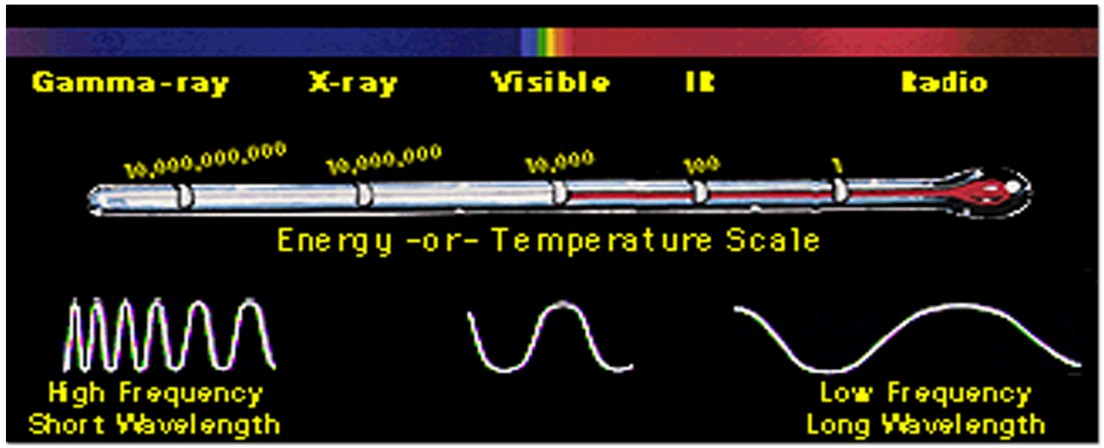
Light is Like a Vibrating Wave

- We can make a slinky vibrate like a wave of light.
- A slinky vibrating with one length is like light of one wavelength.
- We can stretch the slinky to make longer wavelengths or different colors of light.
- Light is like pure energy with no rest mass (because it is never at rest!!)

It takes more than one kind of telescope to see the light

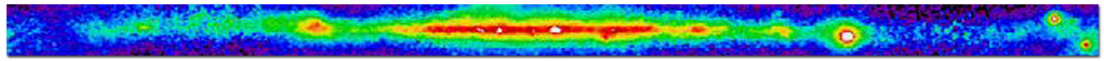
Why we need different types of telescopes to look at outer space

SPACE SCIENCE NEWS
science.nasa.gov
Marshall Space Flight Center



The electromagnetic spectrum. Radio has long wavelengths and low energies, while gamma rays have very short wavelengths and high energies.

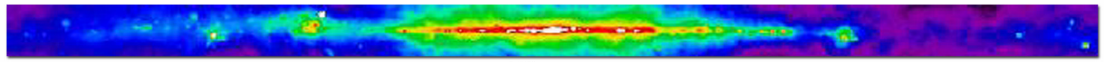
The Multi-Wave Milky Way Galaxy



radio

infrared

visual



X-ray

gamma ray

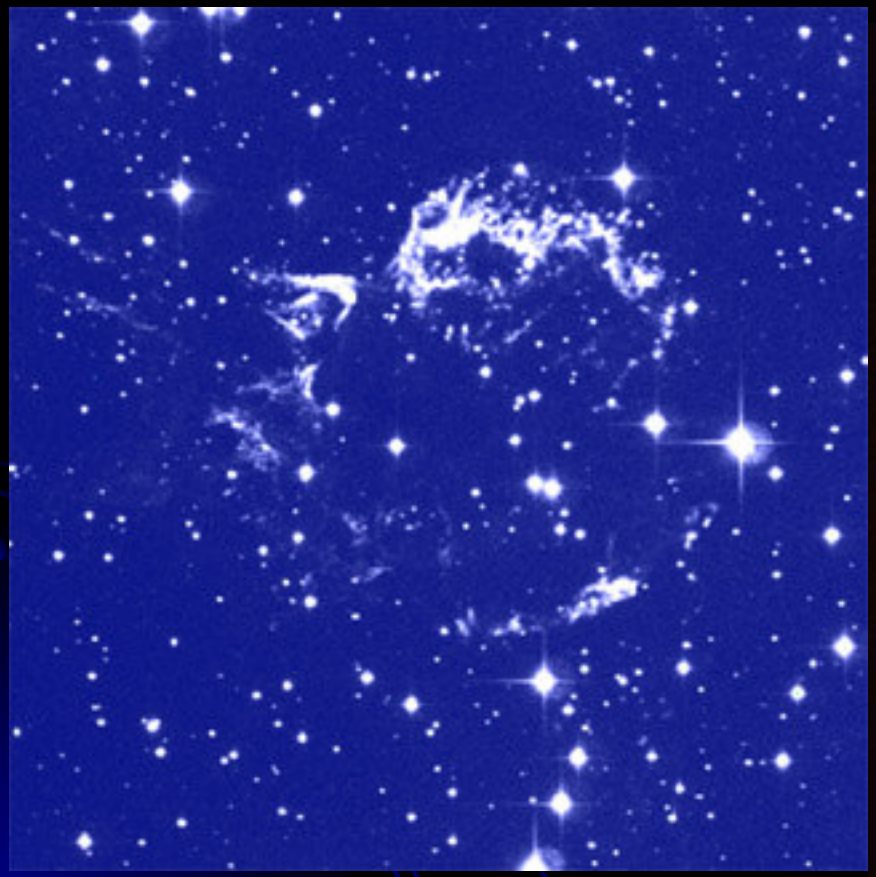
http://science.nasa.gov/newhome/headlines/features/ast20apr99_1.htm

NRAO operates the 140 Foot
Robert C. Byrd Green Bank Radio Telescope

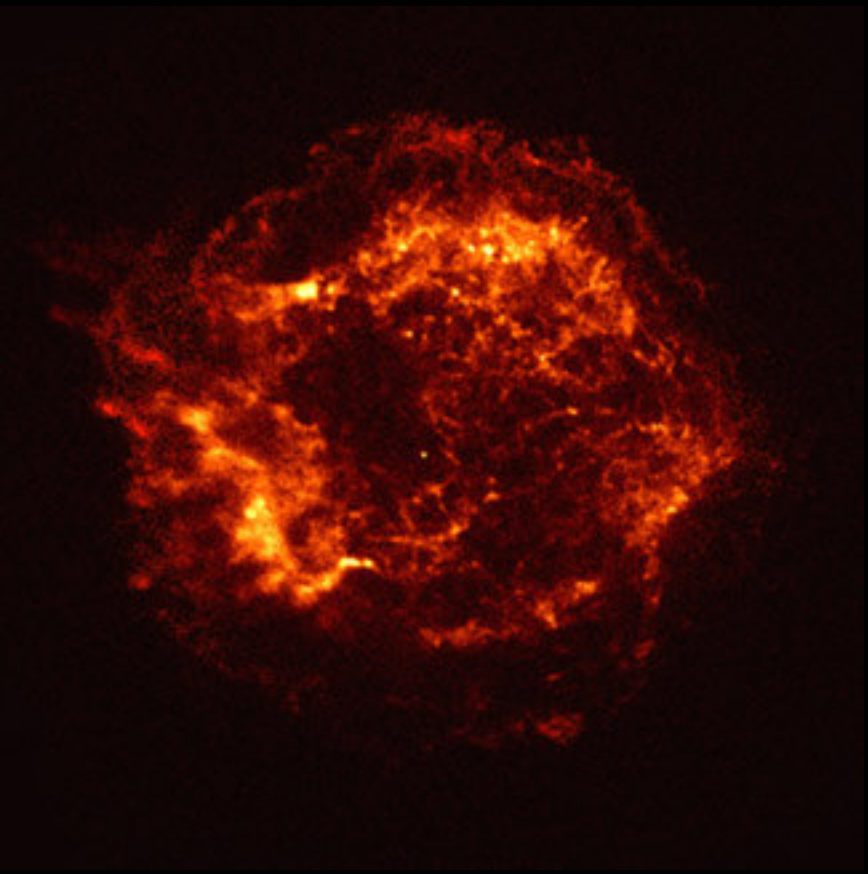
The Arecibo radio telescope is currently the largest single-dish telescope in the world.

Supernova Remnants: Cas A

Optical



X-ray



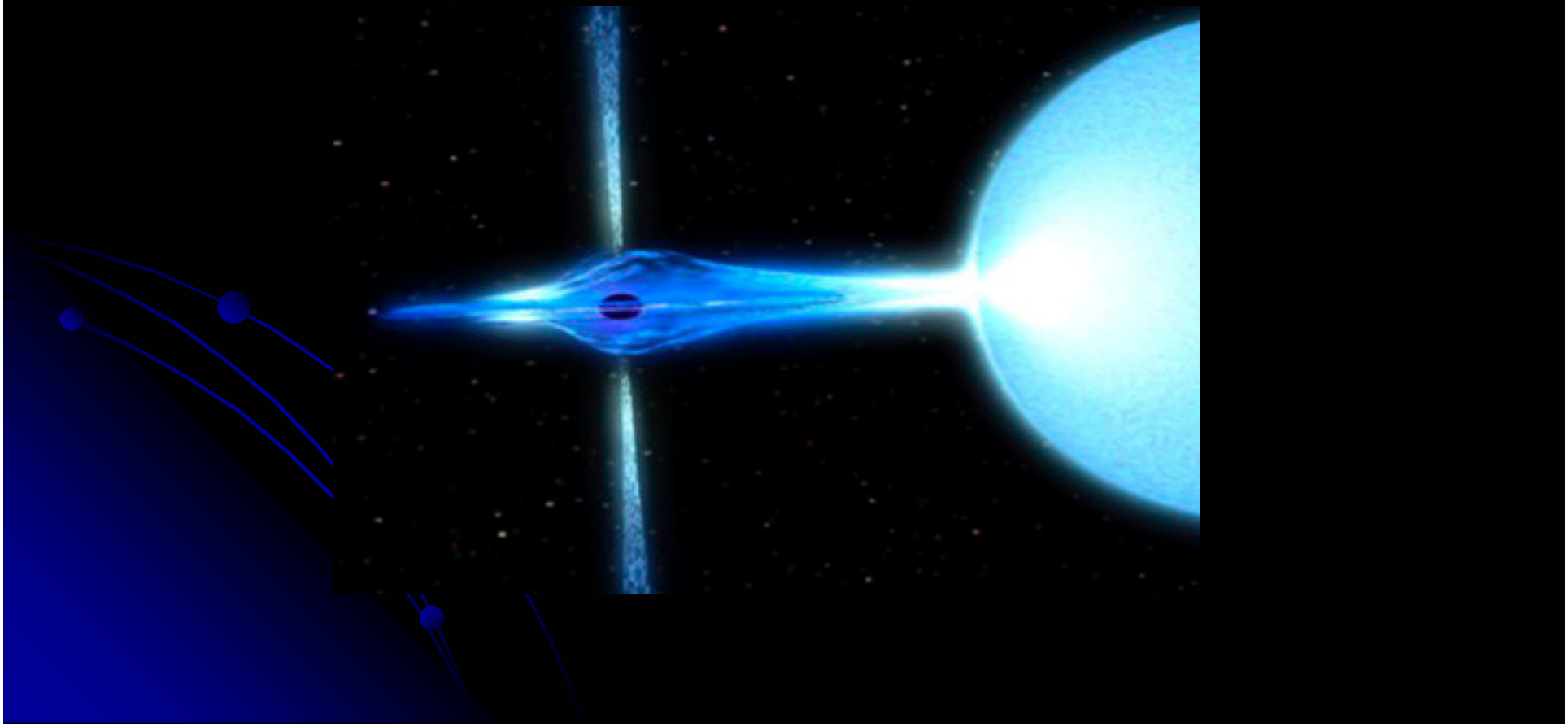
What's Left After the Supernova

- Neutron Star (If mass of core < 5 x Solar)
- Under collapse, protons and electrons combine to form neutrons.
- 10 Km across

- Black Hole (If mass of core > 5 x Solar)
- Not even compacted neutrons can support weight of very massive stars.

A whole new life: X-ray binaries

In close binary systems, material flows from normal star to Neutron Star or Black Hole. X-rays emitted from disk of gas around Neutron Star/Black Hole.

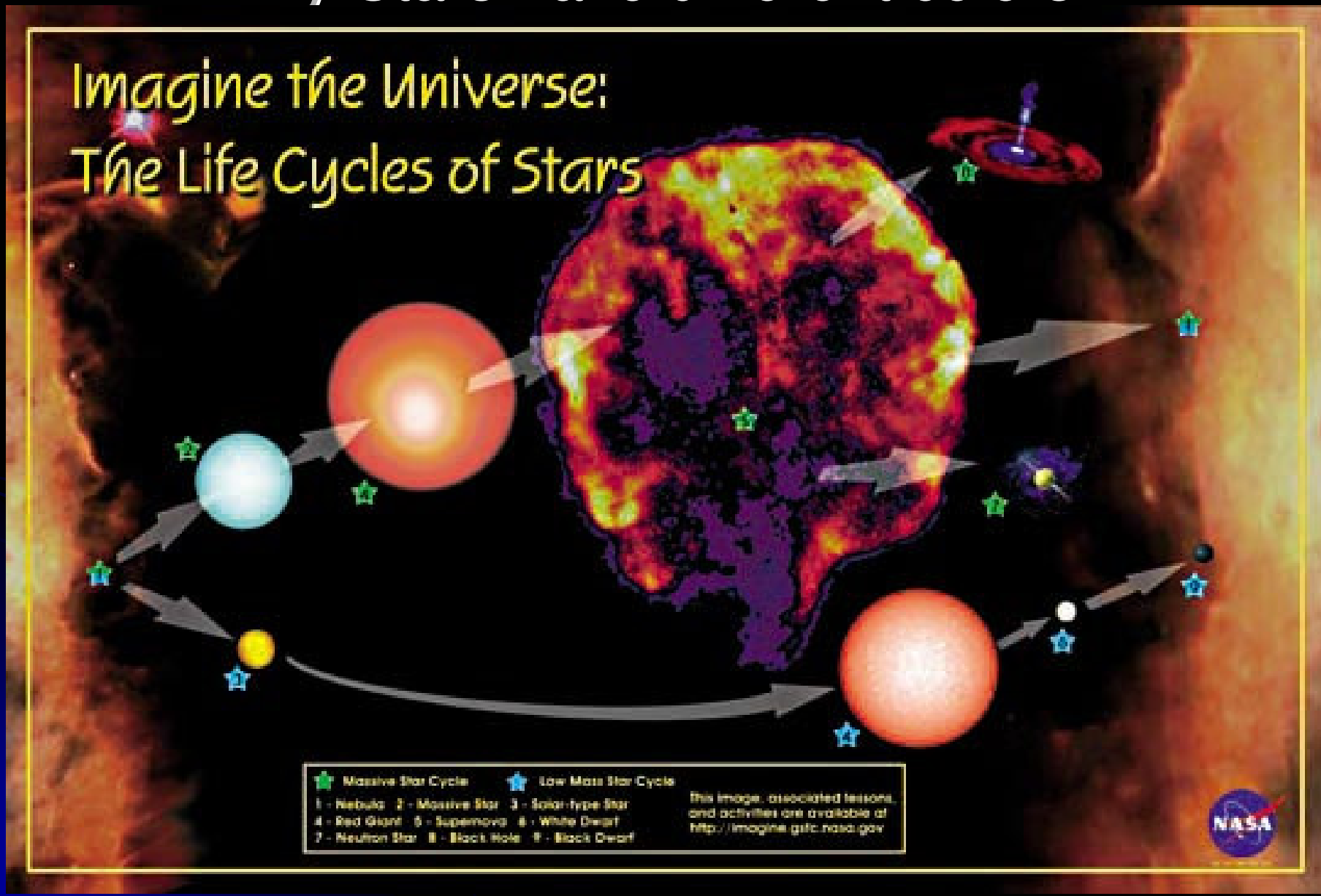


SN interaction with ISM

Supernovae compress gas and dust which lie between the stars. This gas is also enriched by the expelled material.

This compression starts the collapse of gas and dust to form new stars.

Which Brings us Back to ...
Why Stars have different colors!



Thank You from

Questions, comments, ……

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