



BOMBS IN THE UNIVERSE

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A vibrant, multi-colored supernova explosion with a central bright core and radiating filaments of red, orange, yellow, and green against a dark blue background. A large, light-colored oval with a dark red border is centered over the image, containing the text.

SUPERNOVA EXPLOSION

Outline

- What are Supernovae?
- How we study them?
- Why we study them?
- What about us?

What are supernovae?

DEATH OF A MASSIVE STAR

How big???



100,000,000,000,000,000,000,000,000

0,000,000,000,000

(10^{29}) times more

energy. Single Supernova can

sh


in a

nuc **100**

As much energy as
sun will give in

10,000,000,000

(10^{10}) years.

The background of the image is a deep space scene filled with numerous stars of varying colors, including bright white and yellow, and cooler blue and red. A prominent purple nebula or galaxy structure is visible in the upper right quadrant. In the center, a large, dark purple oval with a thin blue border contains white text.

In universe 8 new
supernovae explode every
second.

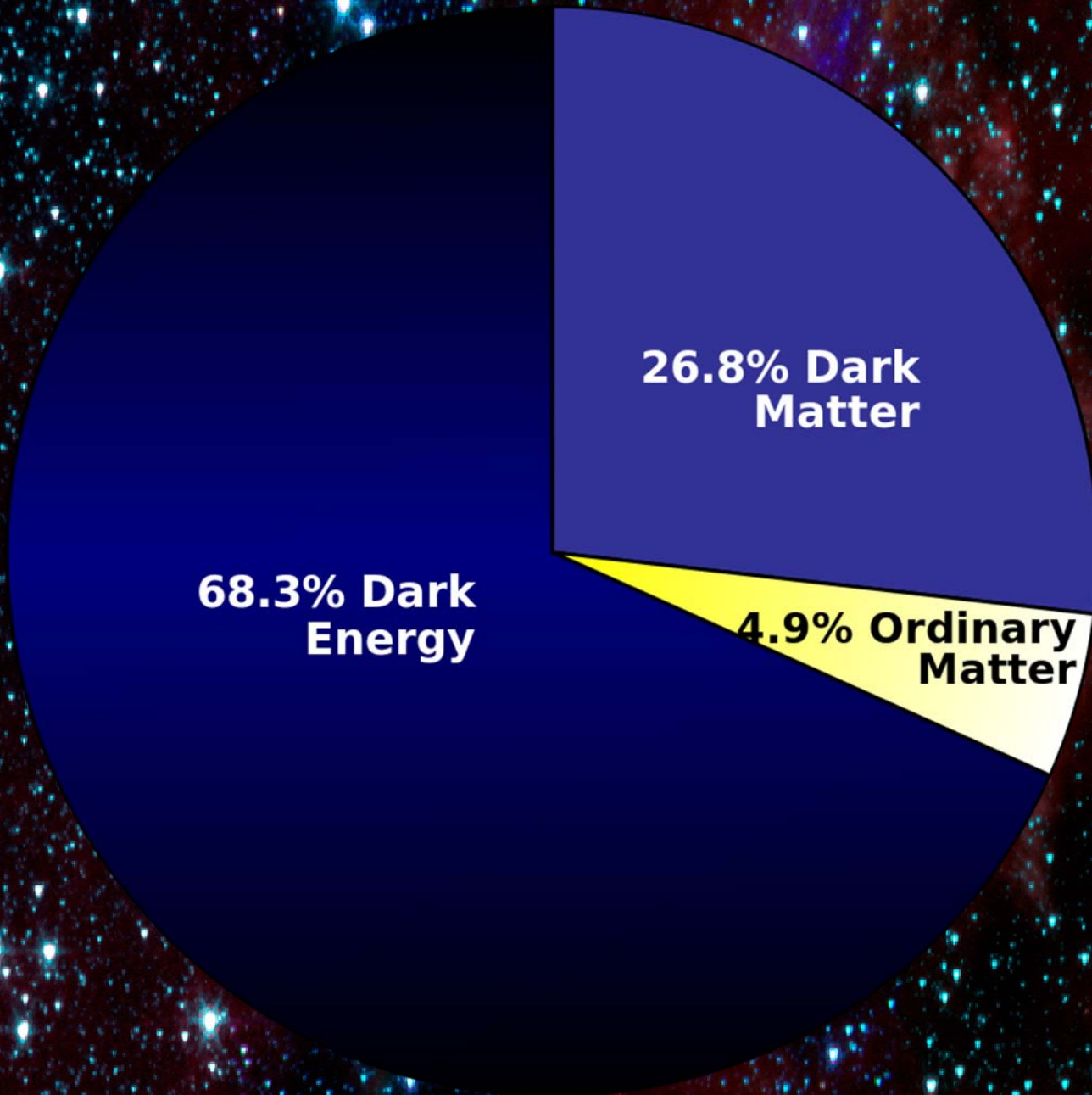
MILKY WAY



Universe has more than
125 billion galaxies

Each galaxy has more than 100 billion stars

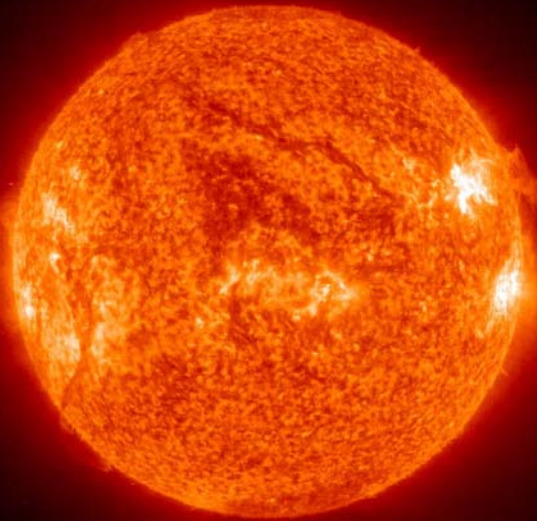




The background of the image is a deep space scene filled with numerous stars of varying colors, including bright blue, cyan, and white. A prominent feature is a vertical band of reddish-pink and orange light, likely representing a nebula or the aftermath of a stellar event. In the center of the image, there is a rectangular box with a gradient from light pink at the top to a darker orange at the bottom. Inside this box, the text "DEATH OF A MASSIVE STAR" is written in a bold, black, sans-serif font, centered horizontally and vertically.

**DEATH OF A
MASSIVE STAR**

FATE OF SUN



2005/01/19 19:19

SUN



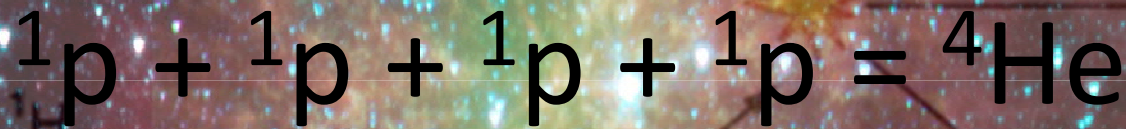
White Dwarf

The Sun

Luminosity = 3.846×10^{26} W

Main Form of Proton-Proton (pp) Chain in Sun

Nuclear fusion reactions



Key

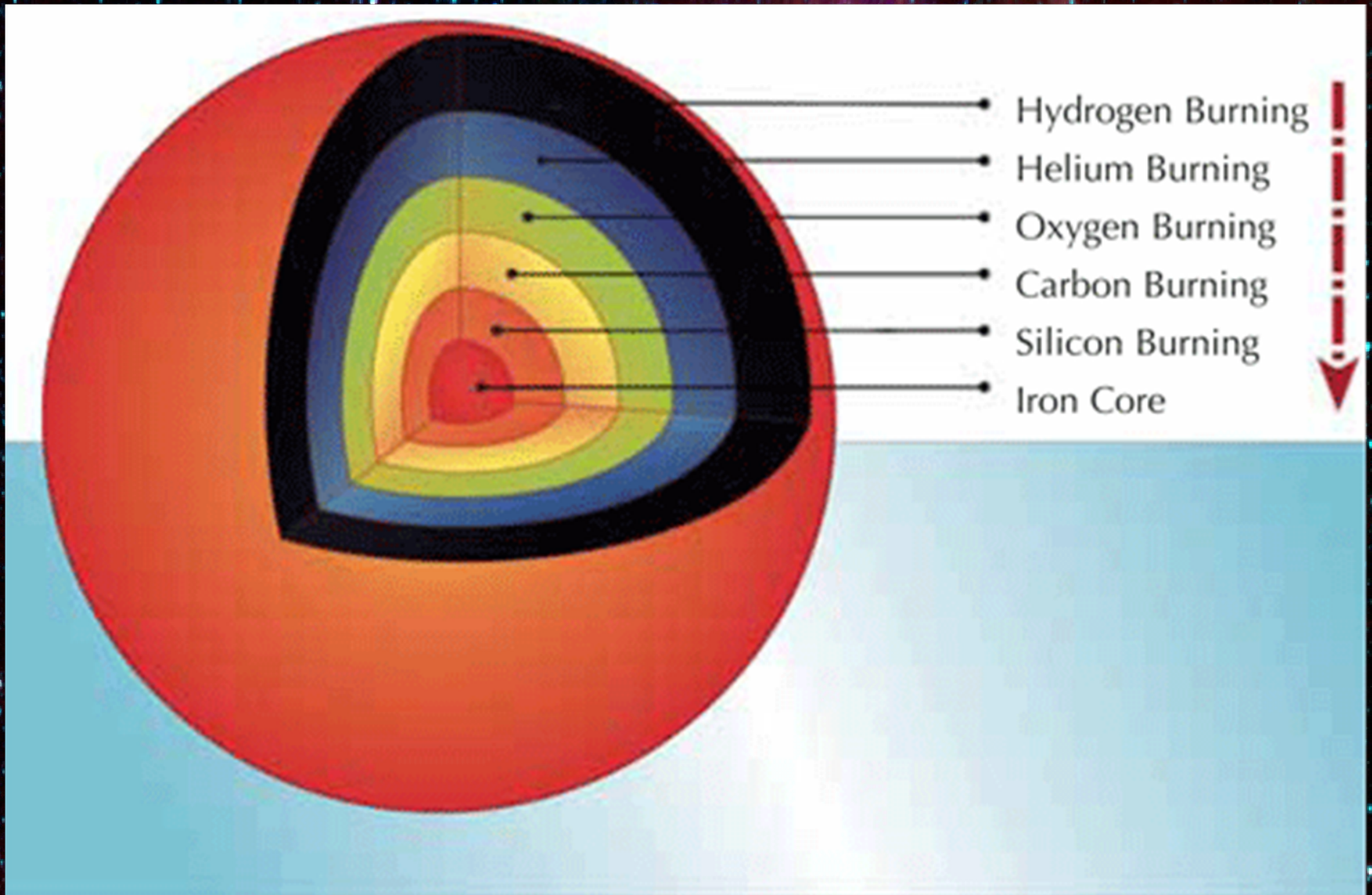
- proton
- neutron
- positron
- ν neutrino
- γ photon

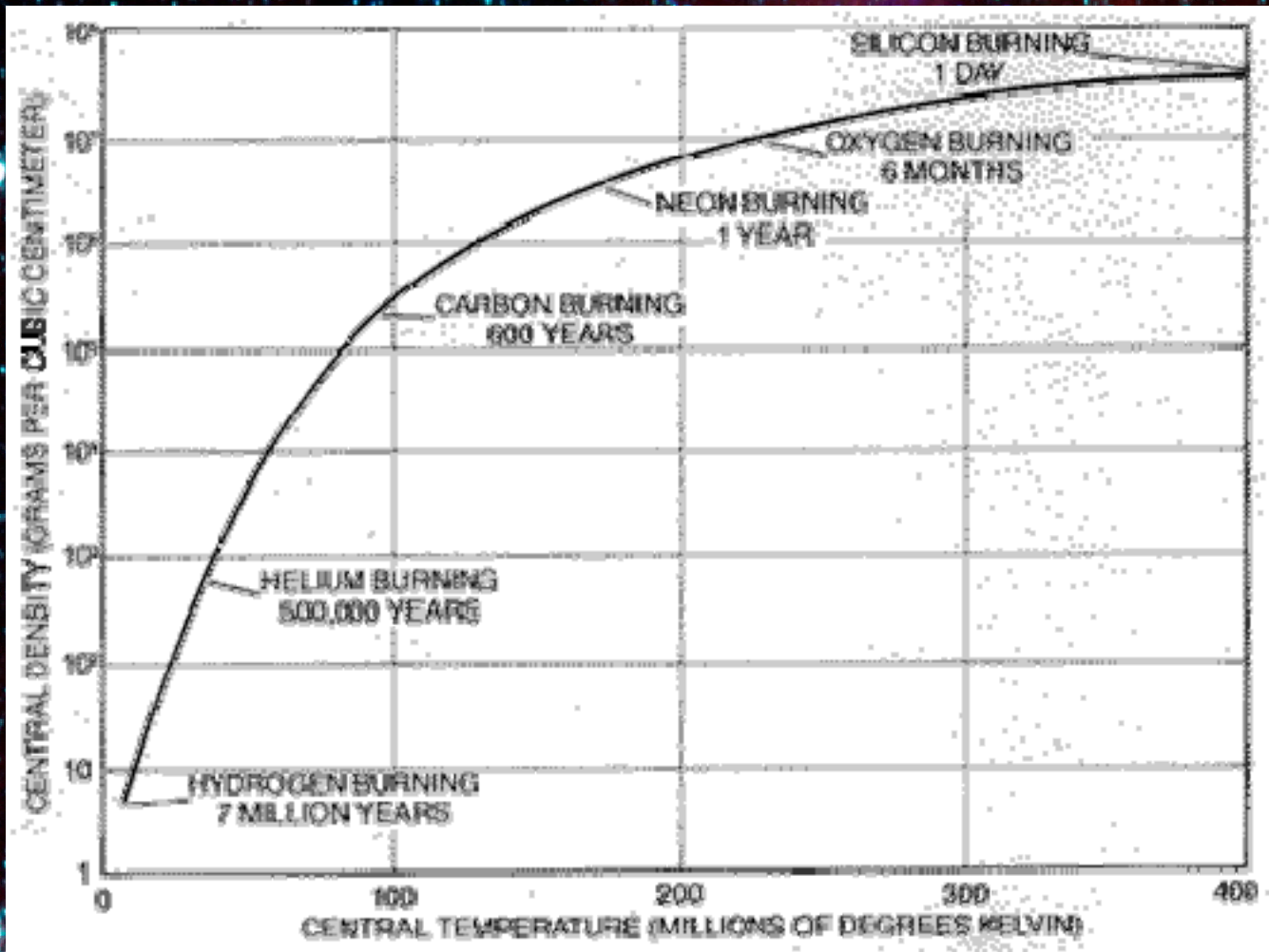
Chemical reactions inside every star



More chemical reactions in heavy stars (10-50 M_{sun})

Nuclear reactions inside a heavy star







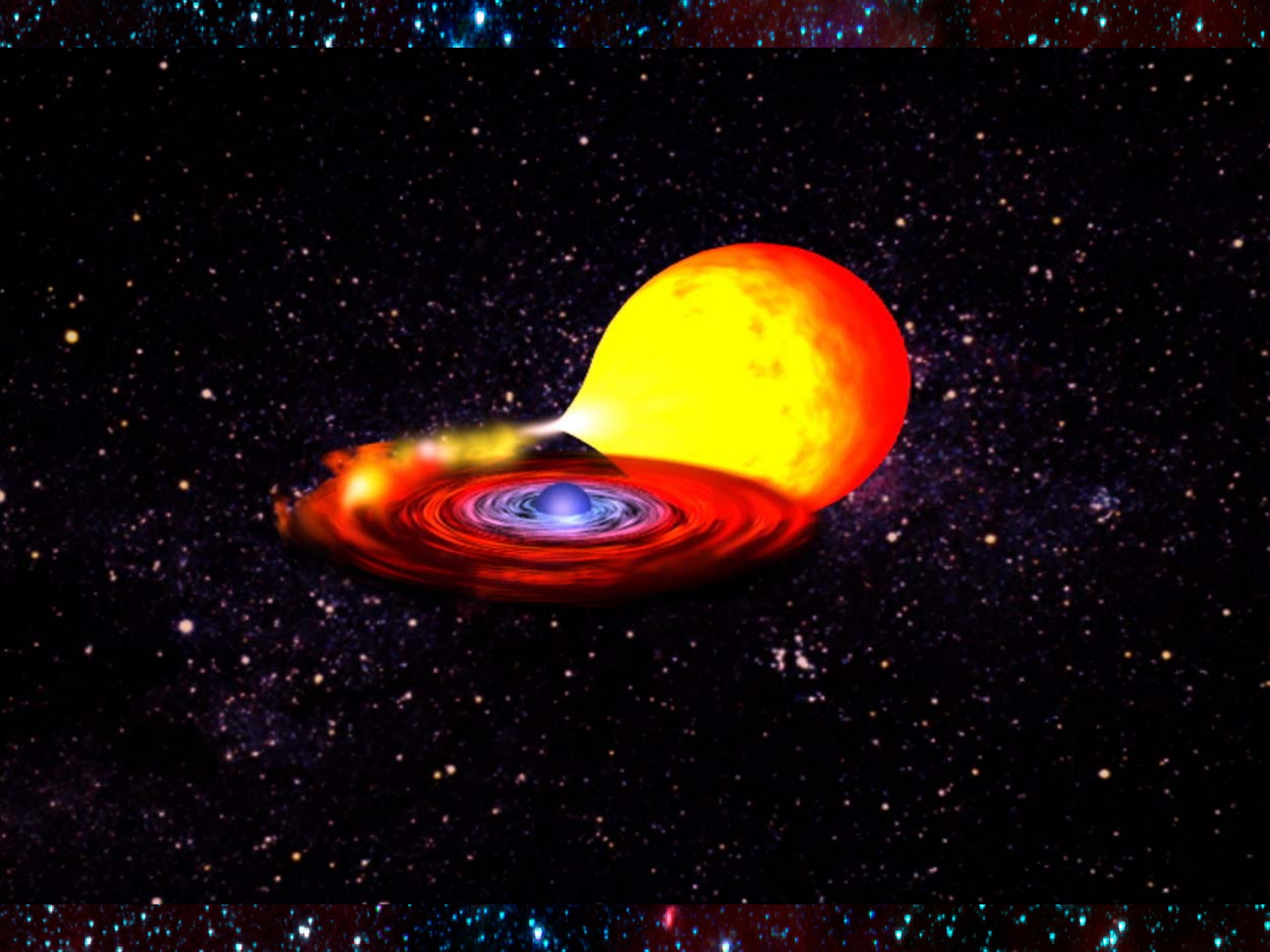


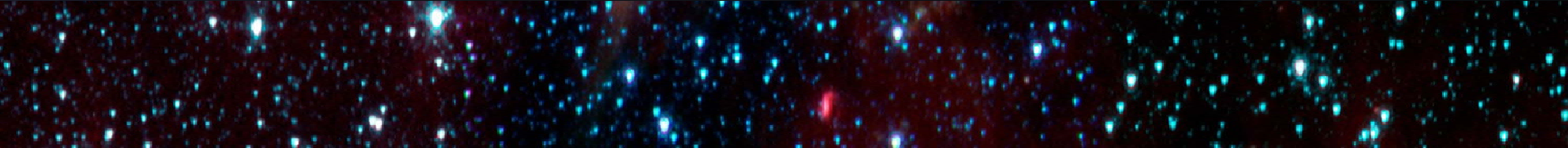
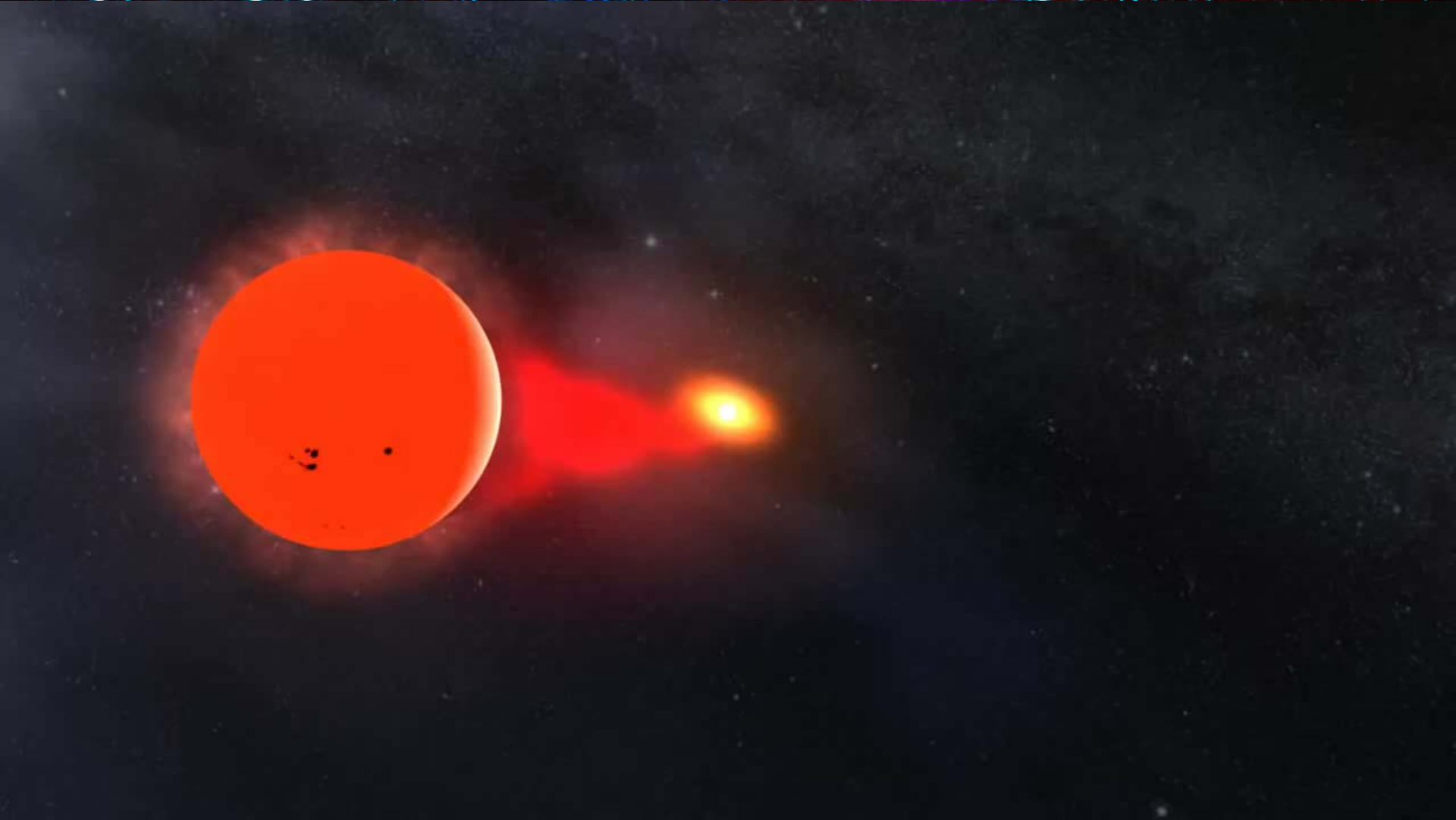
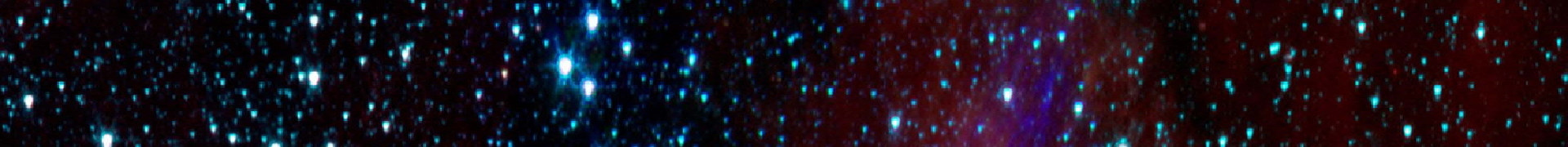
Gravitational Collapse



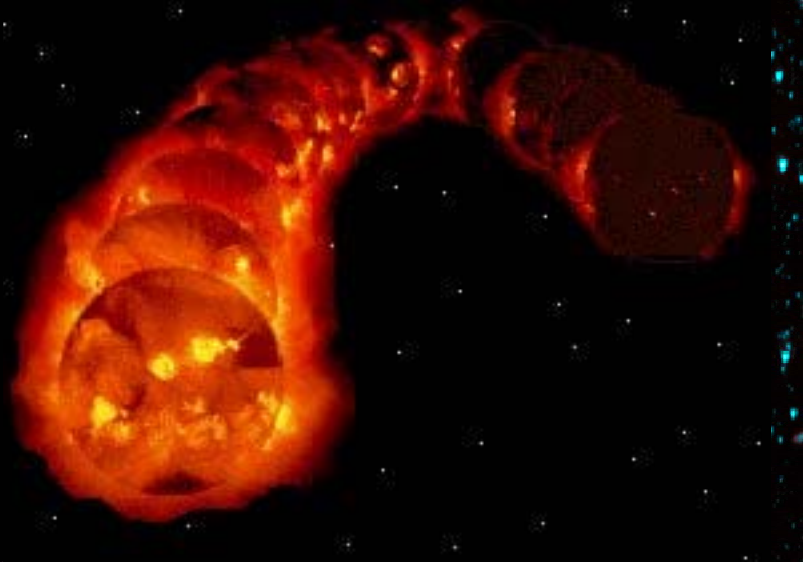
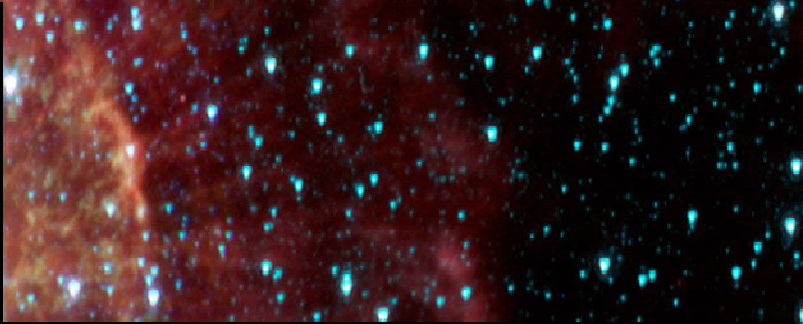
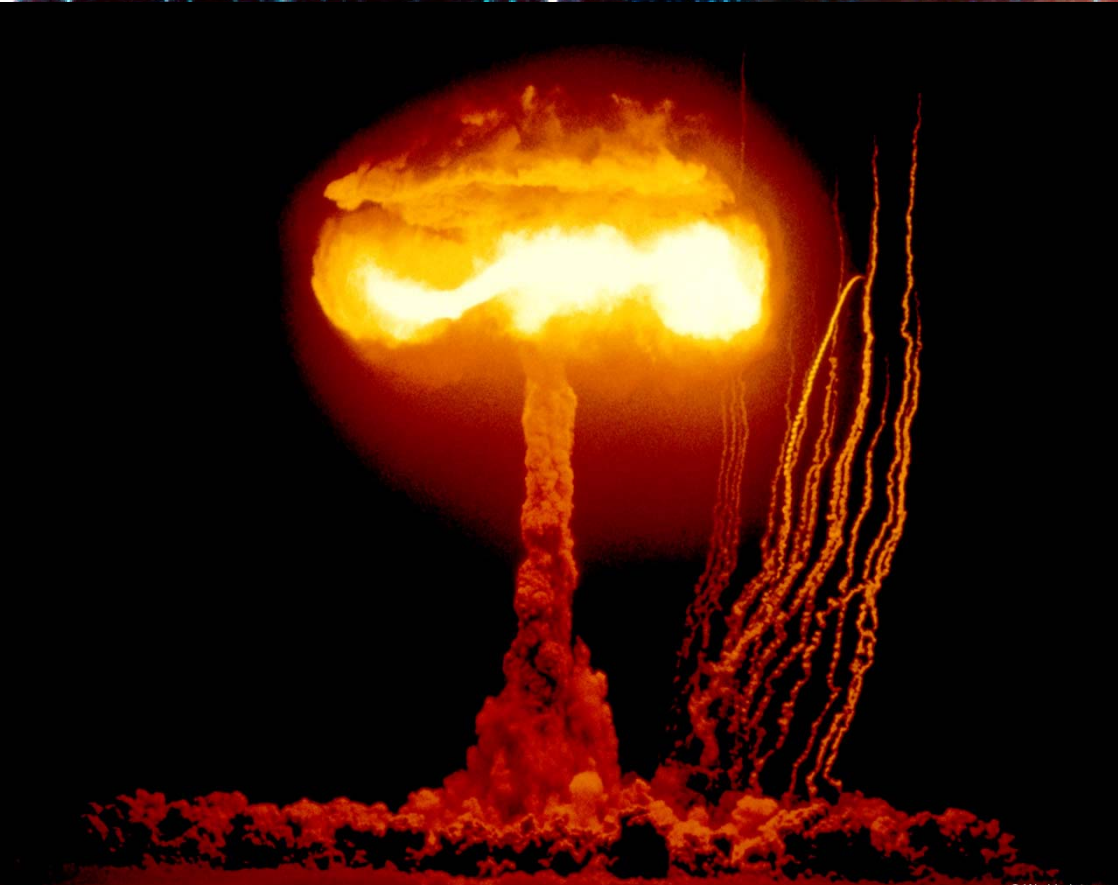
Supernovae







Thermonuclear Supernovae

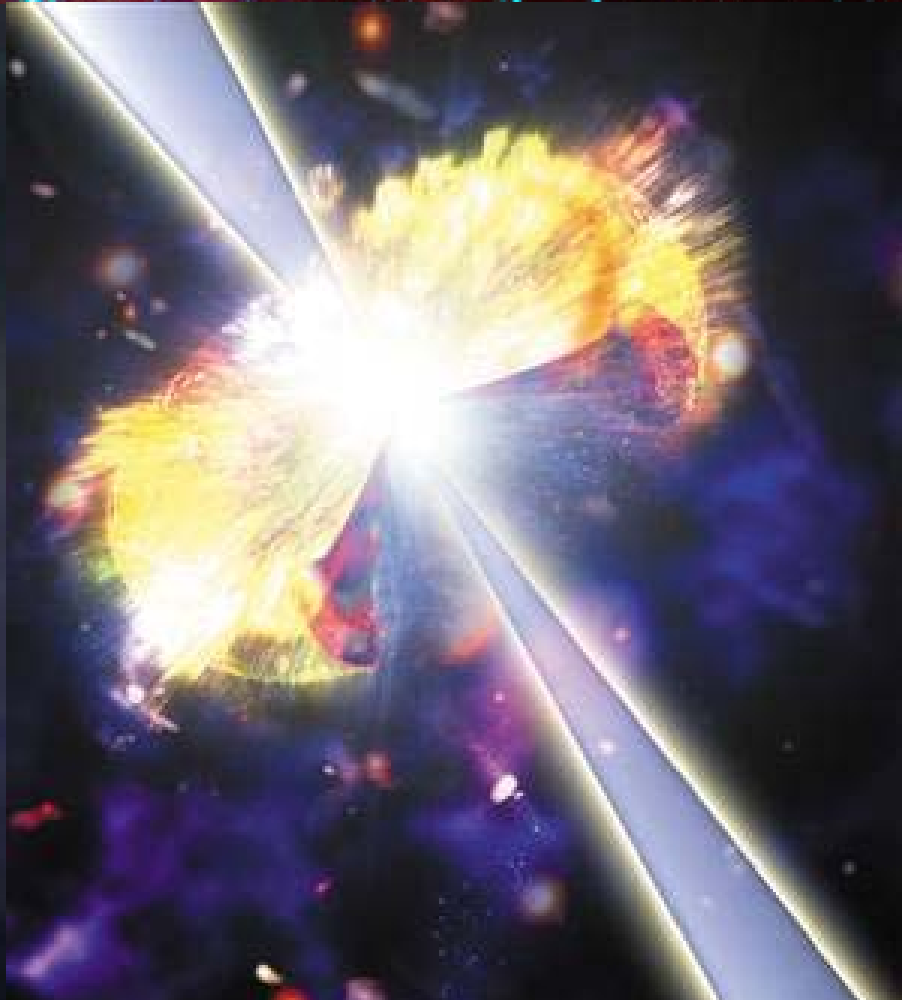
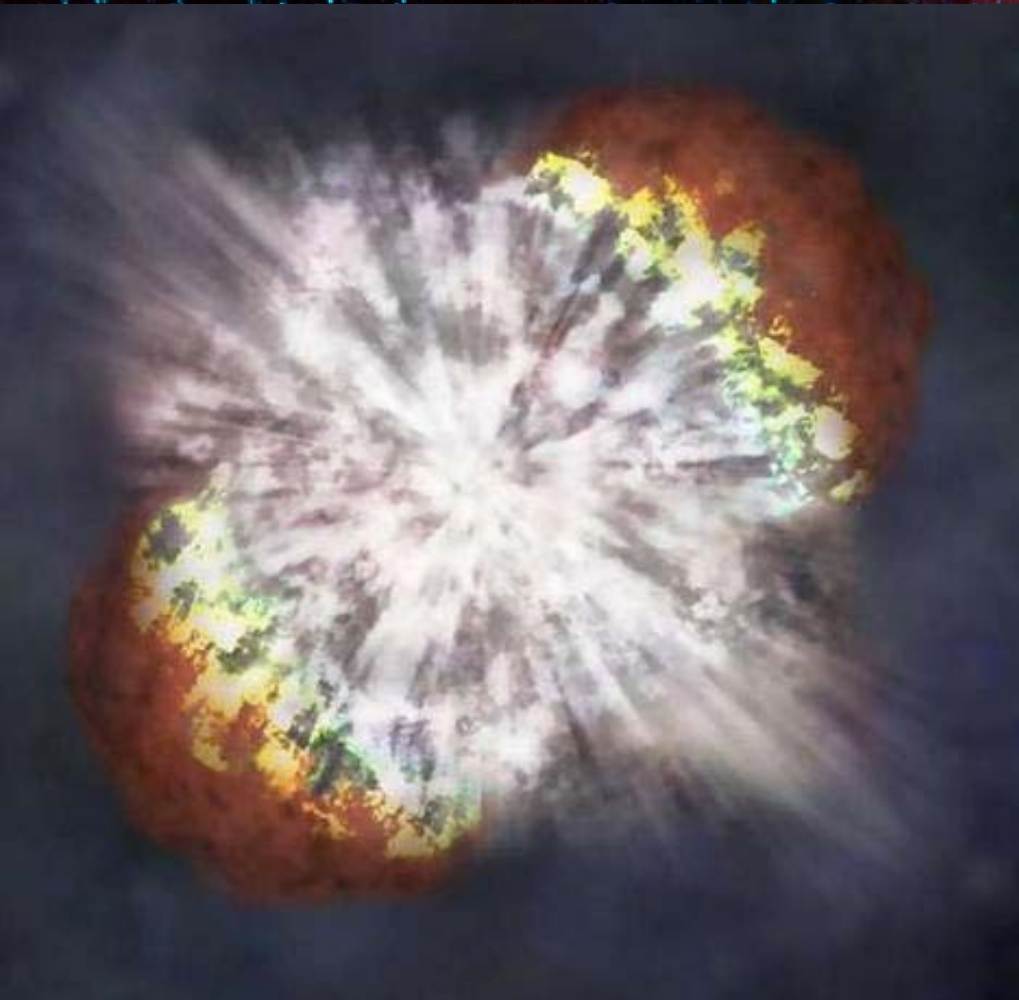


$8M_{\odot} \leq M \leq 30M_{\odot}$

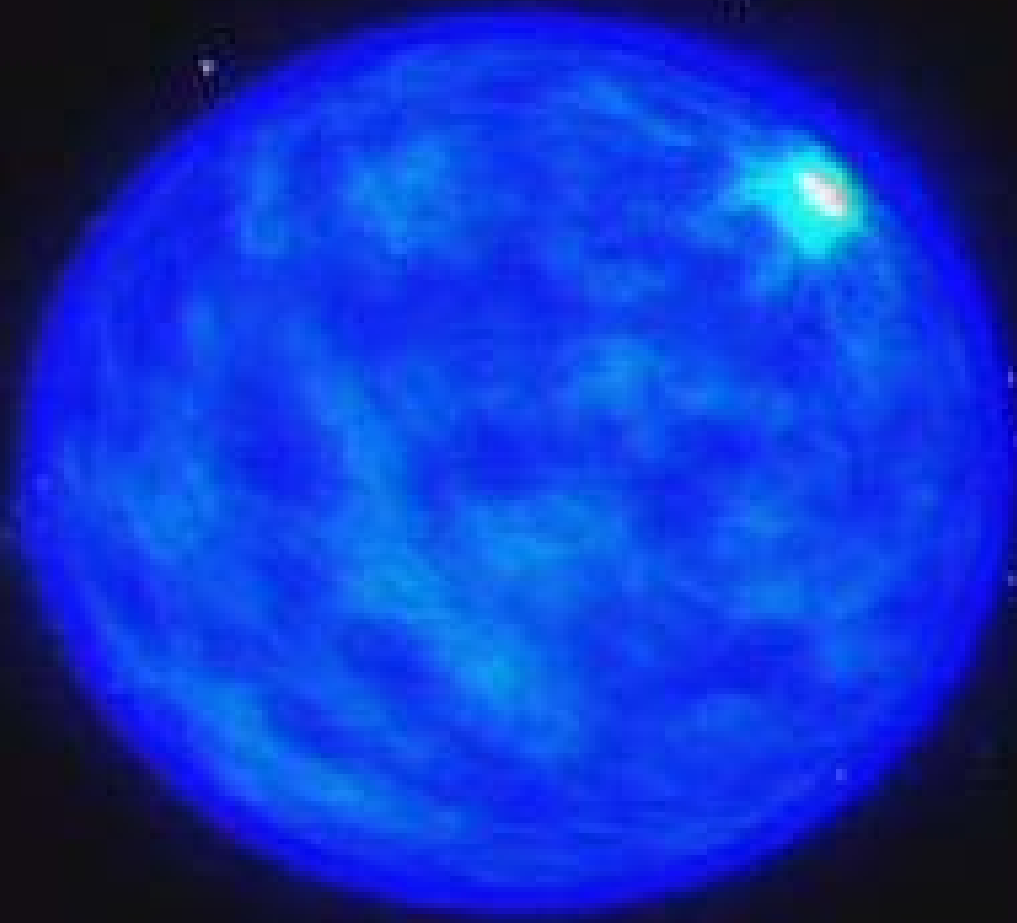
Supernova

$M \geq 30M_{\odot}$

Gamma Ray Burst

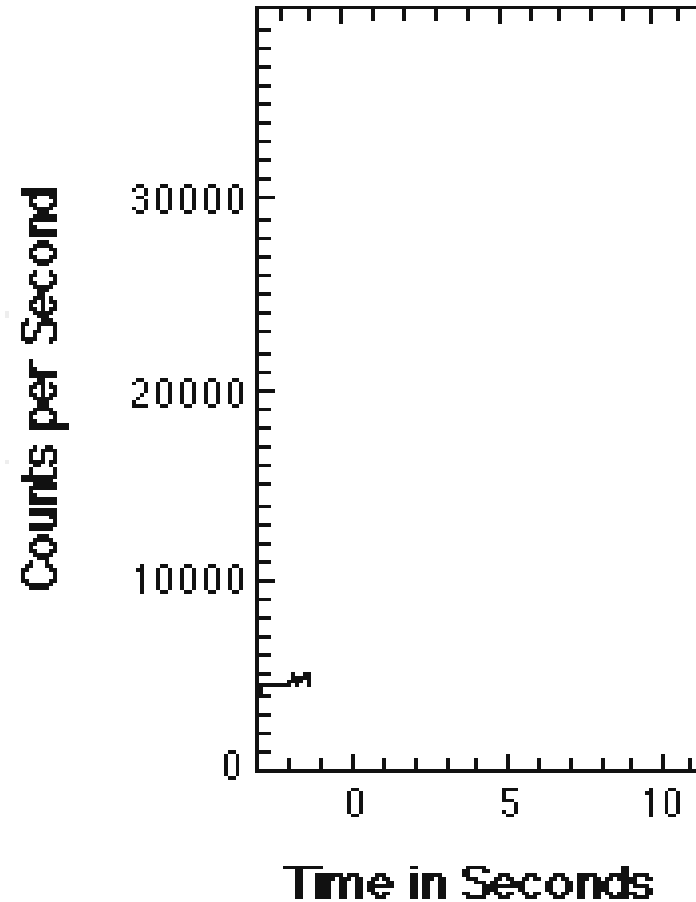
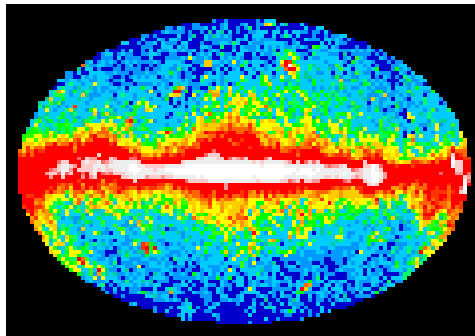


Gamma Ray Burst



What are Gamma Ray bursts (GRBs)?

Most energetic events in the universe



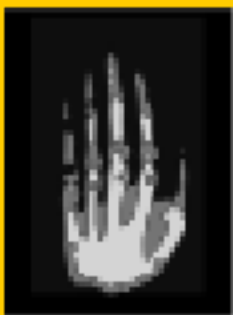
The background of the slide is a deep space image filled with numerous stars of varying colors, including blue, white, and red. A large, dark purple oval with a thin blue border is centered on the slide. Inside this oval, the text "We detect roughly one GRB per day." is written in a white, serif font, centered horizontally and vertically.

We detect roughly one
GRB per day.

How do we study them?



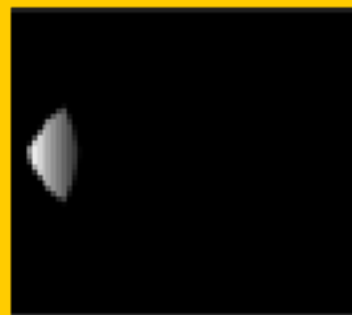
0.01nm



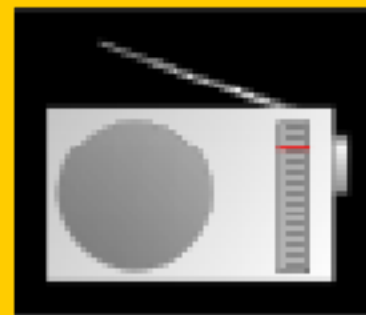
1m



100nm



1mm

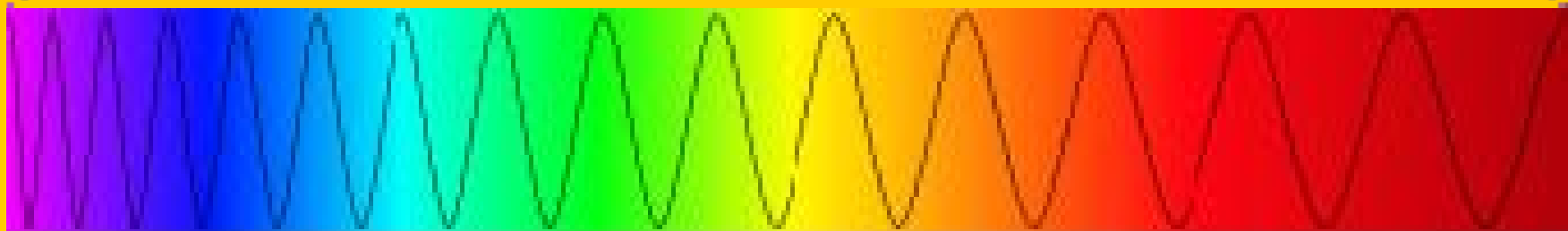


1m

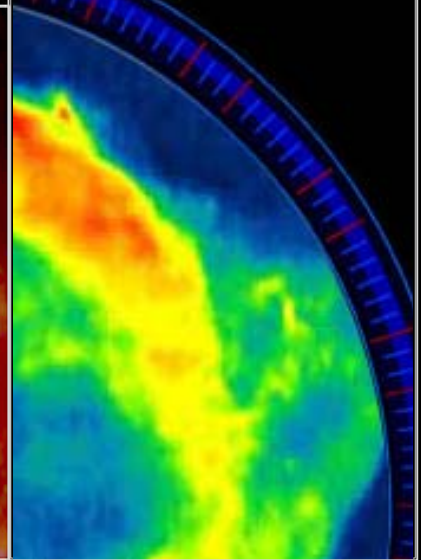
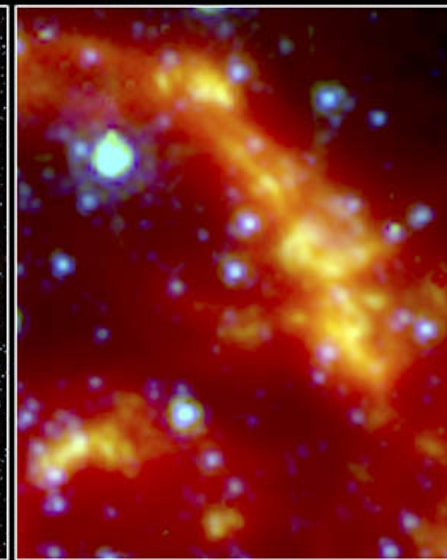
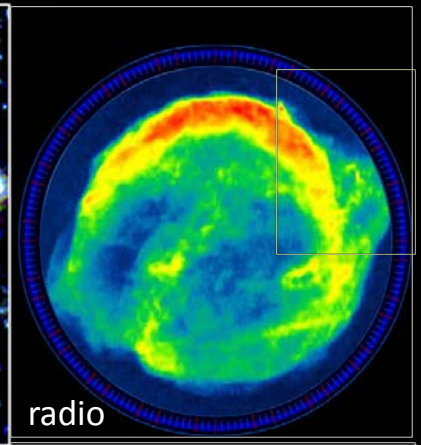
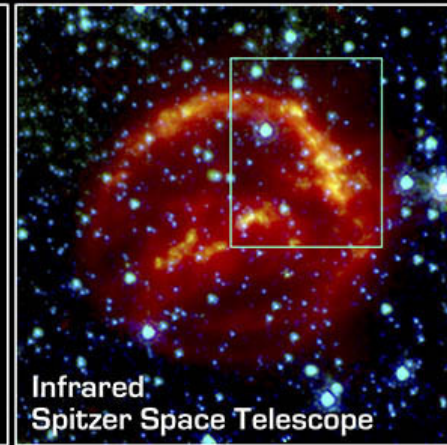
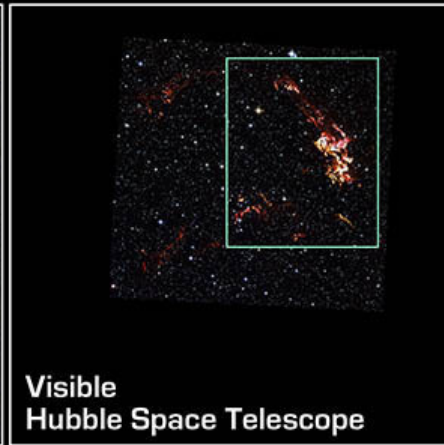
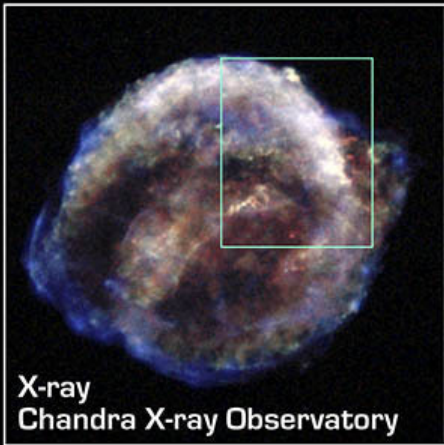
1km

400nm

700nm







Kepler's Supernova Remnant • SN 1604

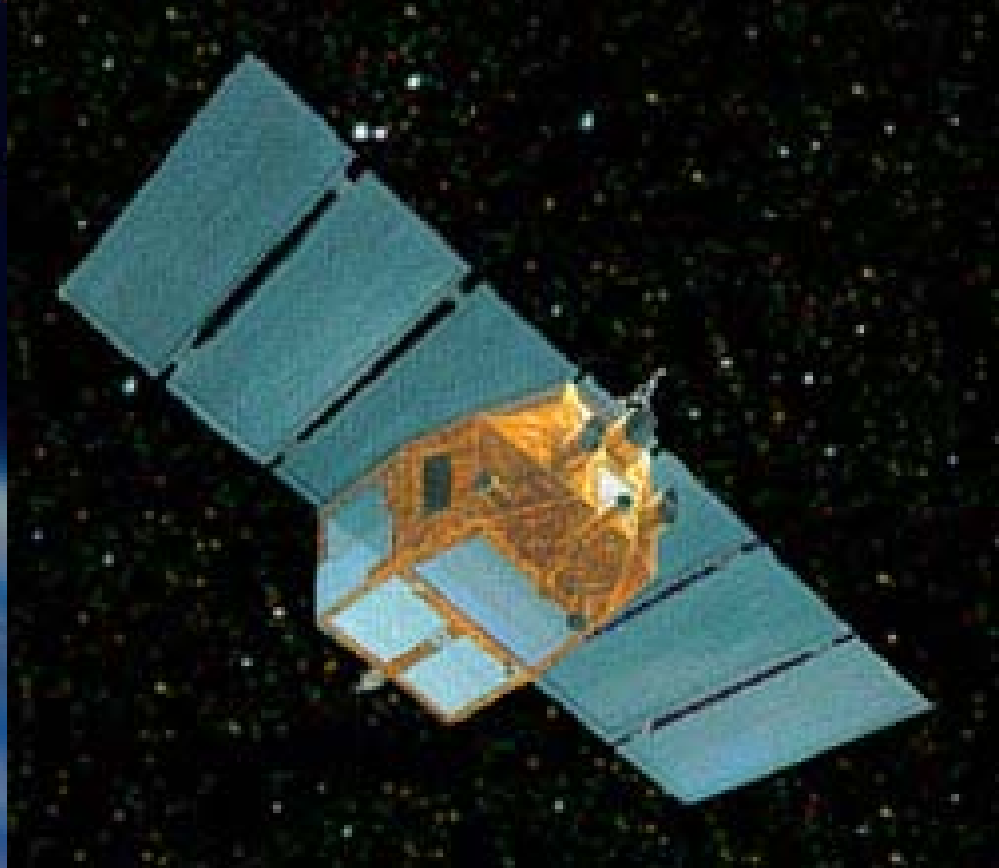
NASA, ESA / JPL-Caltech / R. Sankrit & W. Blair (Johns Hopkins University)

ssc2004-15b

GRB Missions



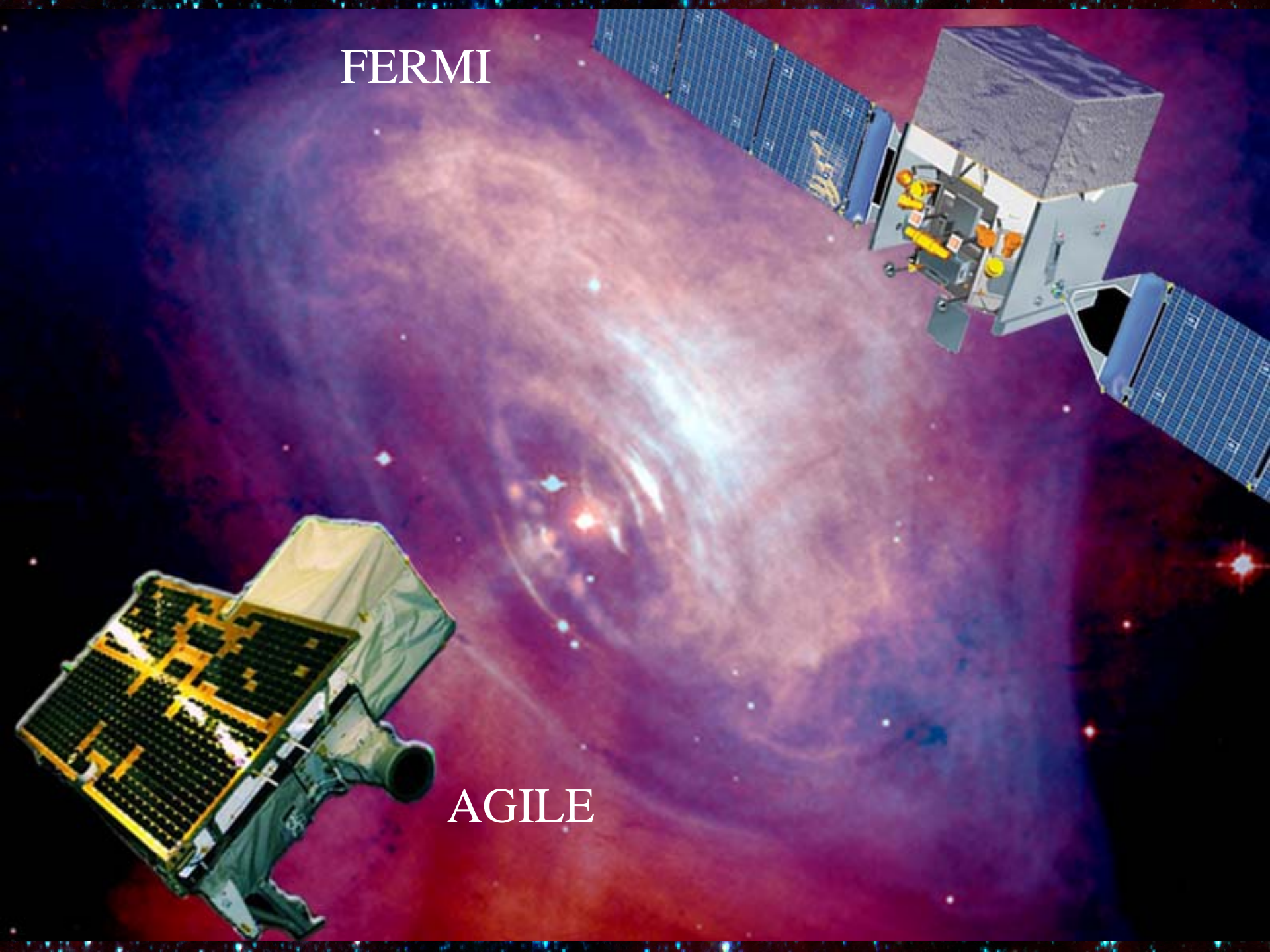
BATSE



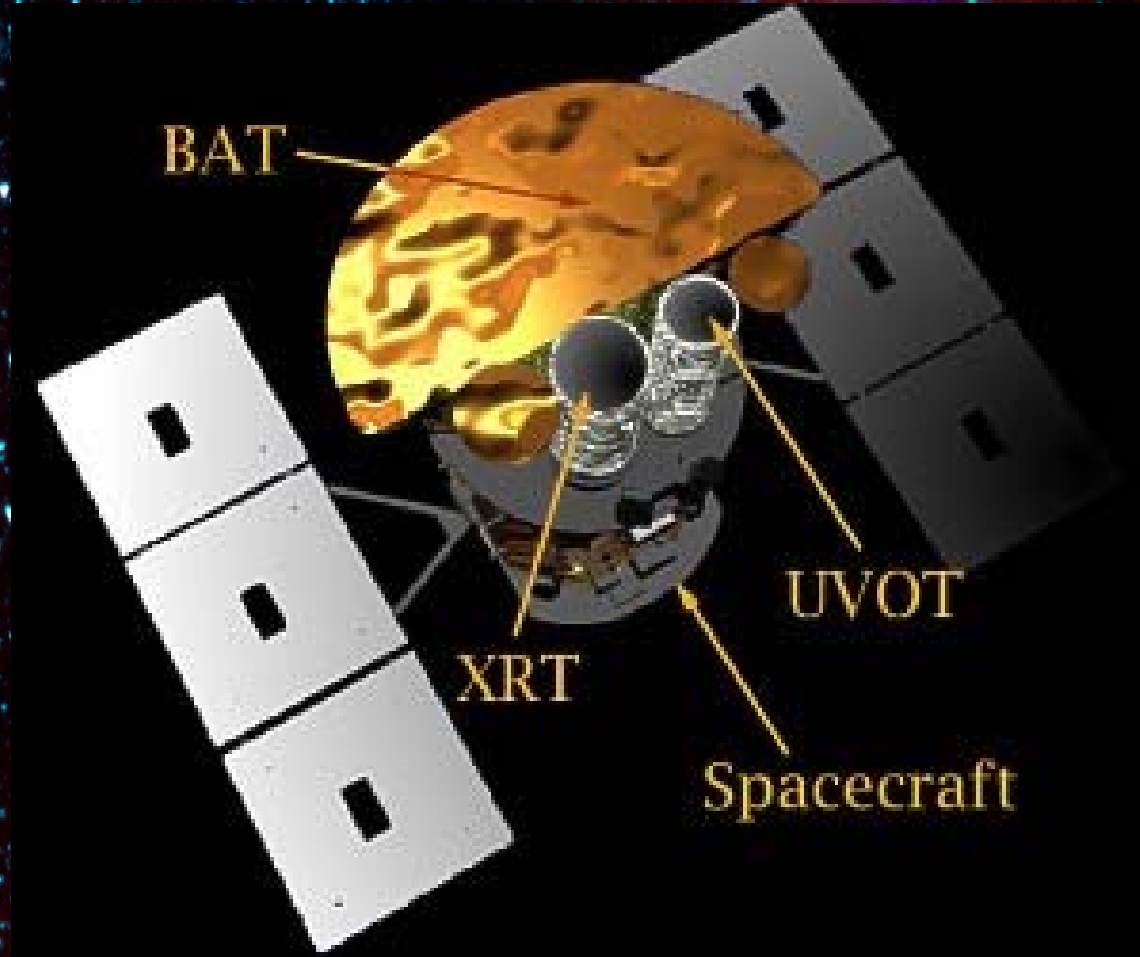
BeppoSAX

FERMI

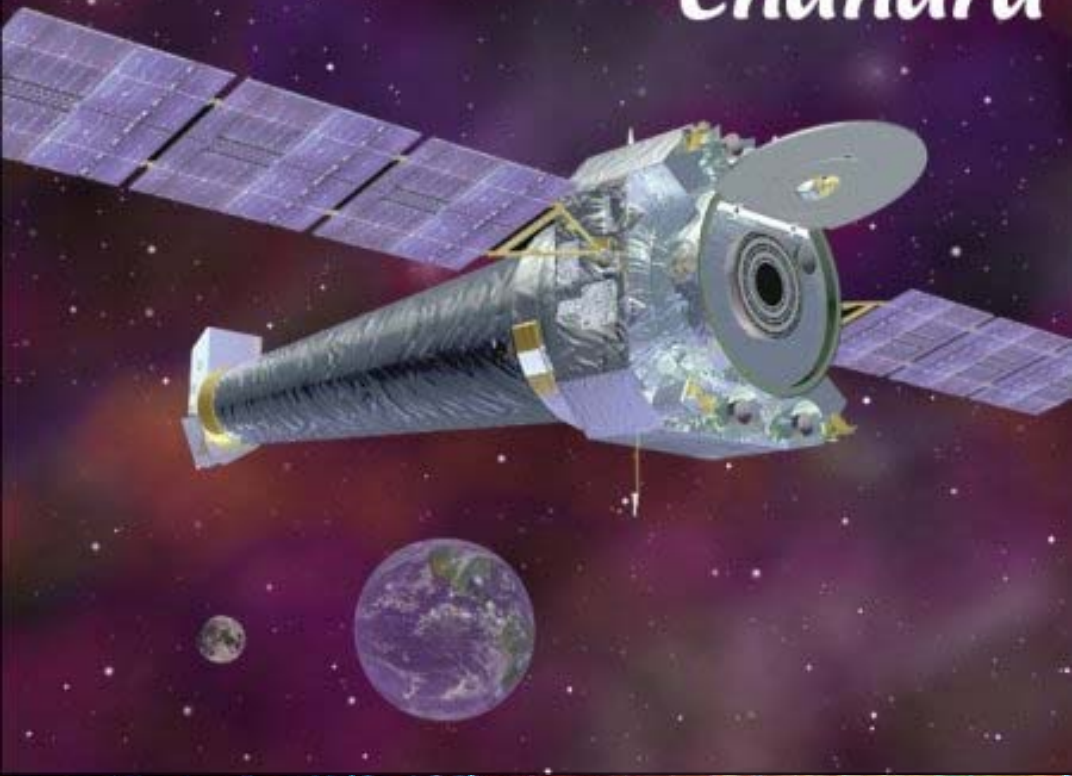
AGILE



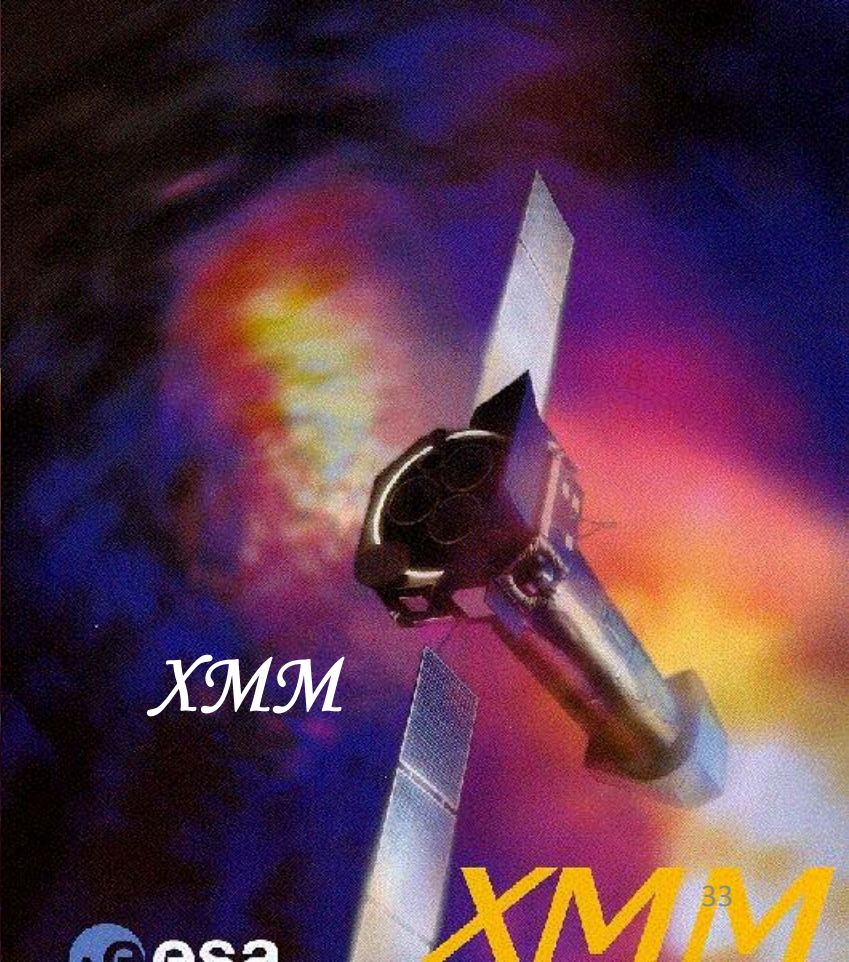
SWIFT



Chandra



X ray telescopes



XMM

Chandra



XMM

33

Atacama Large Millimeter Array



VLA



RADIO TELESCOPES

GMRT

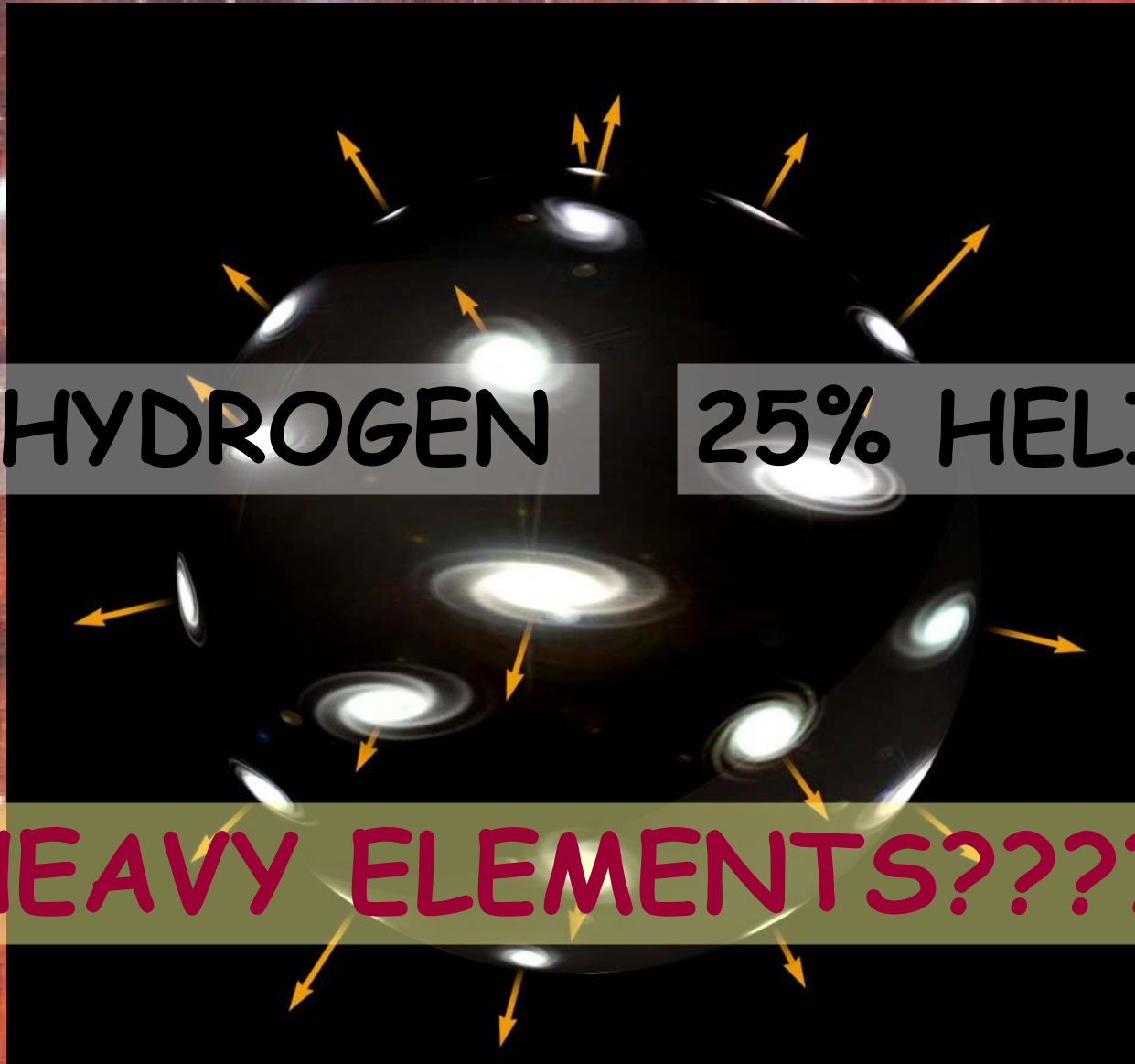


Why we study them?



Supernovae: the seeds of life

BIG BANG

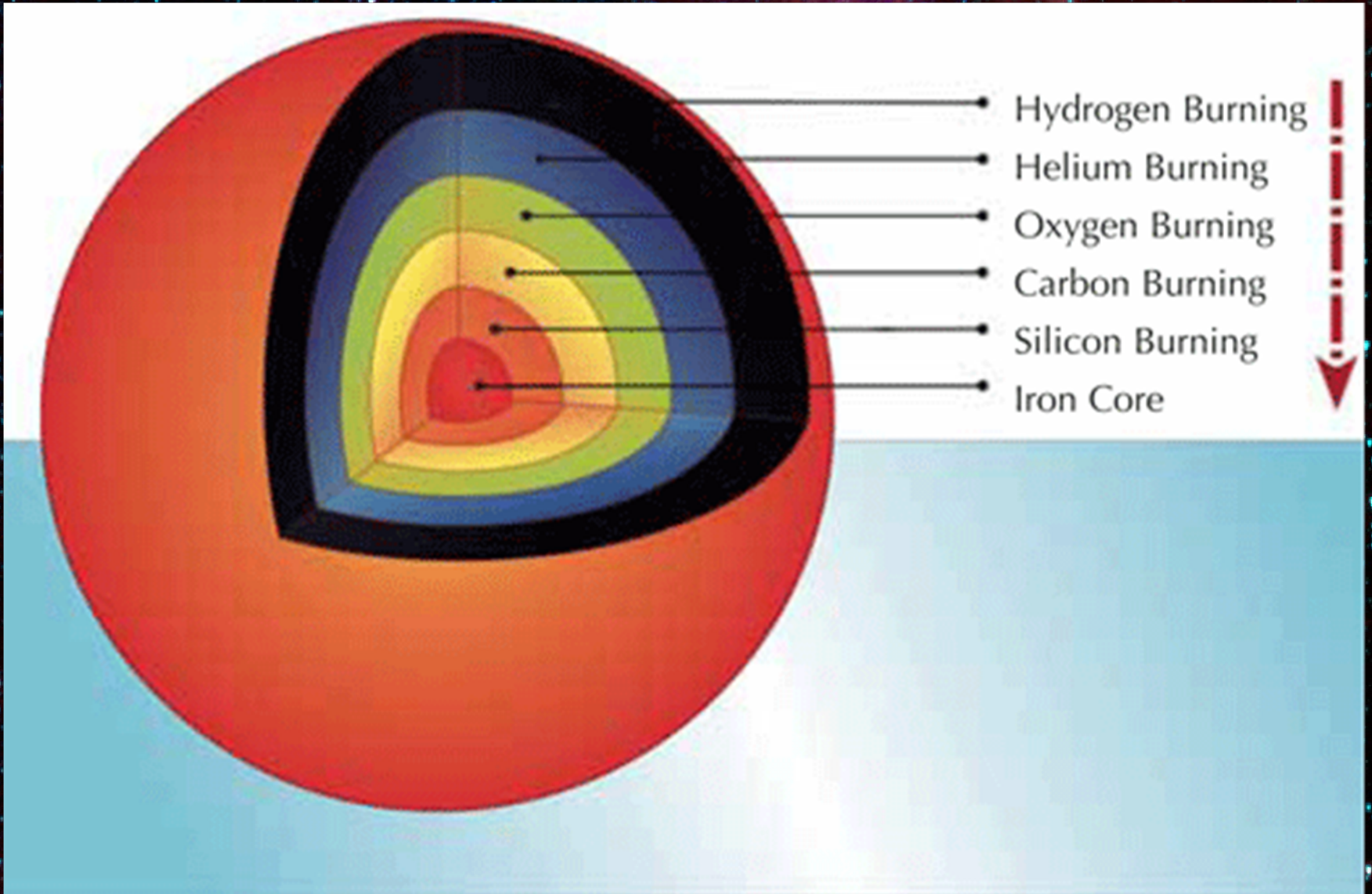


75% HYDROGEN

25% HELIUM

HEAVY ELEMENTS????

Nuclear reactions inside a heavy star





Supernovae: seeds of life

Calcium in our bones

Oxygen we breathe

Iron, Aluminium
our cars



Supernova and our Universe

Everything going away from us?

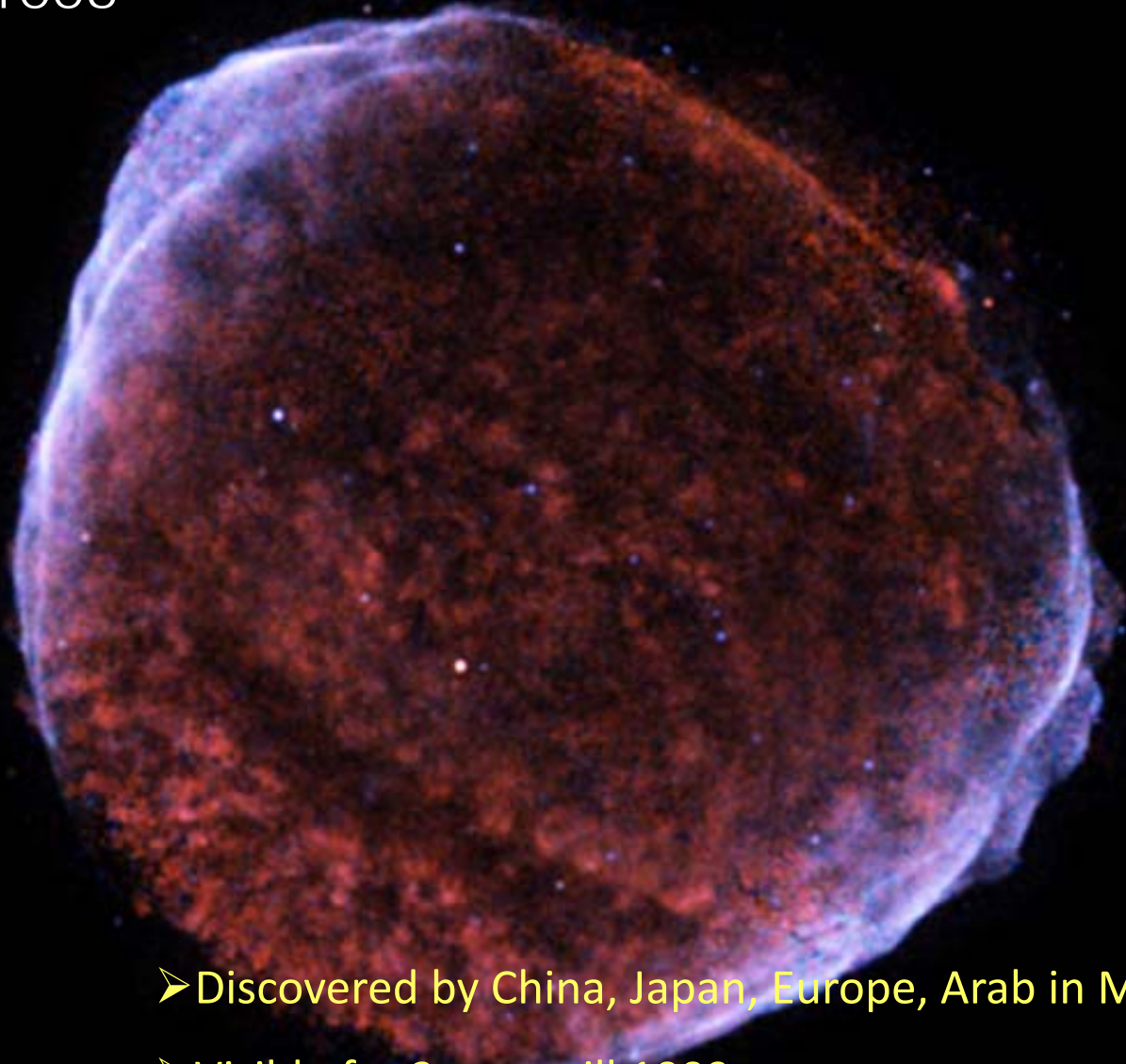


What about us?

- We?
- Our Earth?
- Our Solar System?
- Our Galaxy?

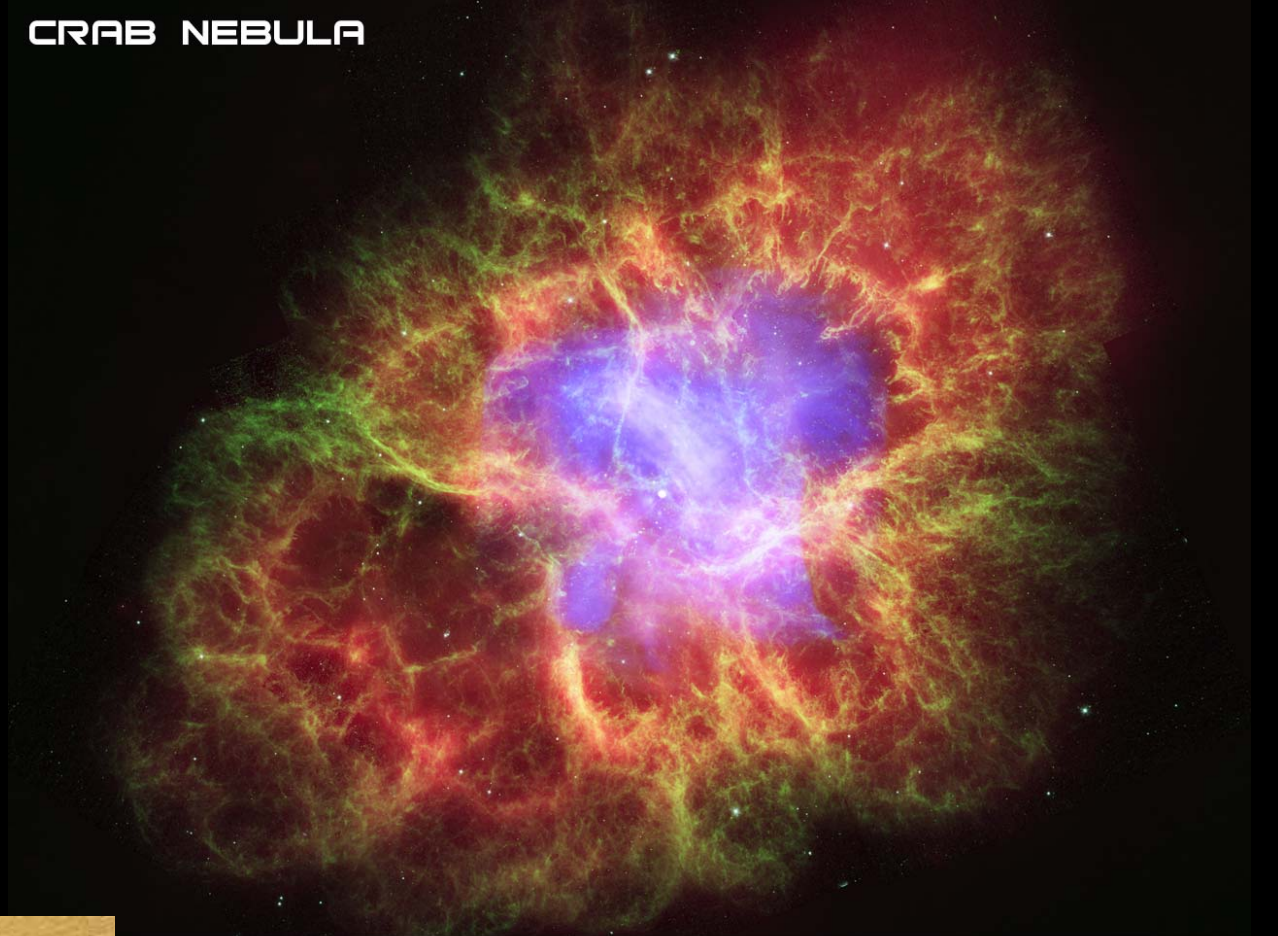


SN 1006



- Discovered by China, Japan, Europe, Arab in May , 1006.
- Visible for 3 years till 1009.
- Very bright Supernova in Lupus constellation.

CRAB NEBULA

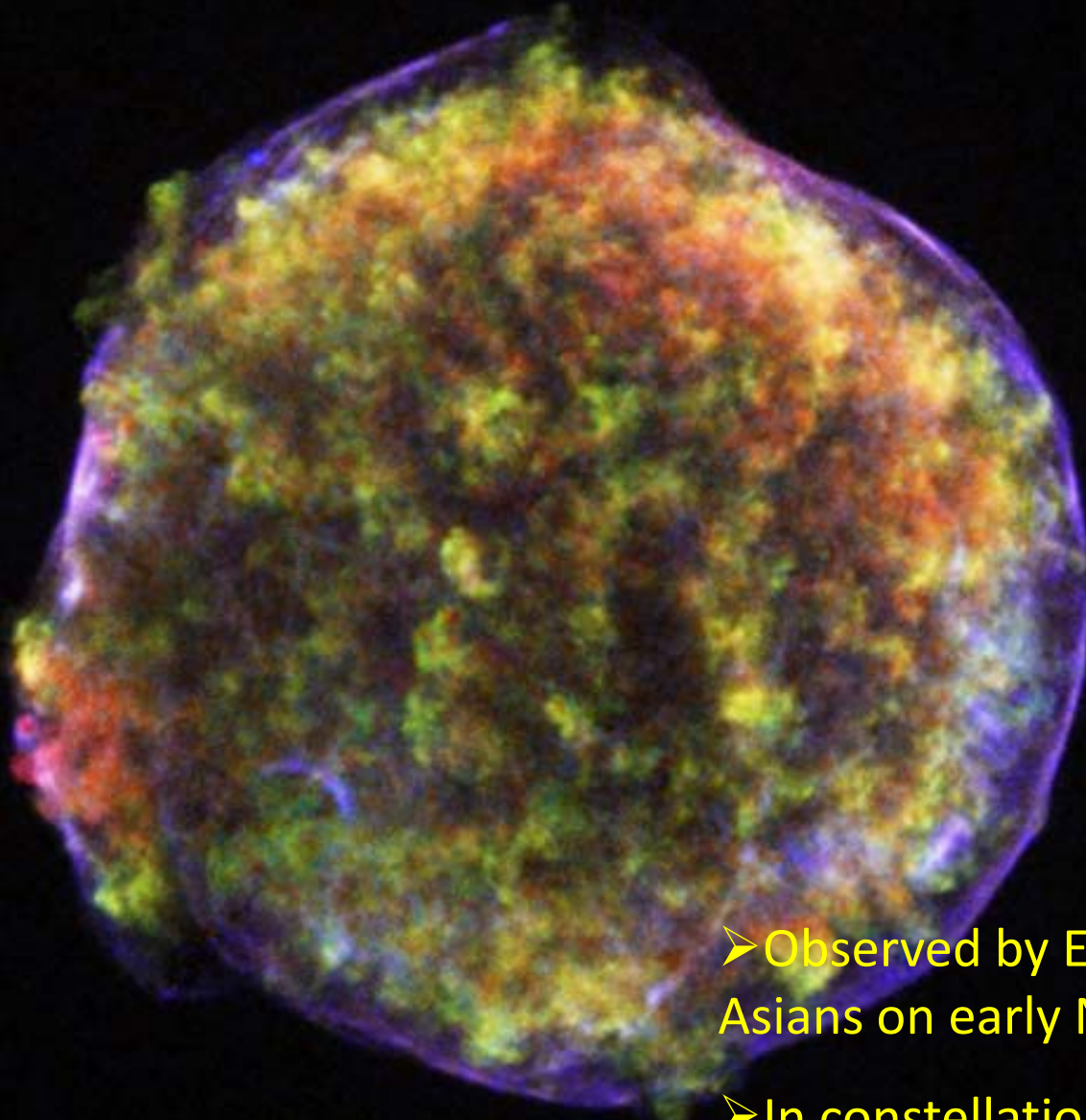


[HTTP://CHANDRA.HARVARD.EDU](http://chandra.harvard.edu)



- Observed by Chinese on May 1, 1054.
- Bright enough to cast shadow on earth.
- Brighter than $\frac{1}{4}$ moon.
- In Taurus Constellation.

Tycho



- Observed by Europeans and east Asians on early November, 1572.
- In constellation Cassiopeia.
- As bright as Venus.

Kepler



- Discovered by Europeans and Chinese on Oct 9, 1604.
- Visible on earth for 1 year.
- 3 degrees NW of Mars-Jupiter conjunction.

CAS A



- Observed by Flamsteed?
- Exploded in 1658?

III Effects?

- Biological damage if too close.
Mass extinction of dinosaurs due to SN?
- DNA damage due to high-energy particles (neutrinos)
- Radiation damage to atmosphere
Destruction of ozone layer Which gives us UltraViolet protection.



How Close is Too Close?



30 light years

Nearest star is 4 light years

Nearest
Supernova
Candidate



BETELGEUSE

500 light years away

Our Earth is
Safe...





THANKS

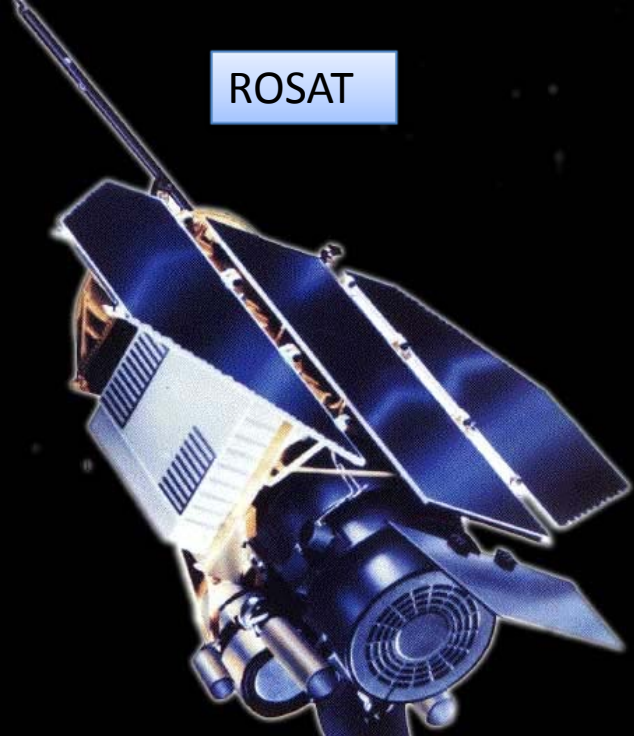
NASA

- <http://science.nasa.gov/researchers/education-public-outreach/>

Energy scales in various explosions

Chemical explosives	$\sim 10^{-6}$ MeV/atom
Nuclear explosives	~ 1 MeV/nucleon
Novae explosions	\sim few MeV/nucleon
Thermonuclear explosions	\sim few MeV/nucleon
SGR giant flares	$\sim 15 (B/10^{15}G)$ Mev/electron
Core collapse supernovae	~ 100 MeV/nucleon

ROSAT



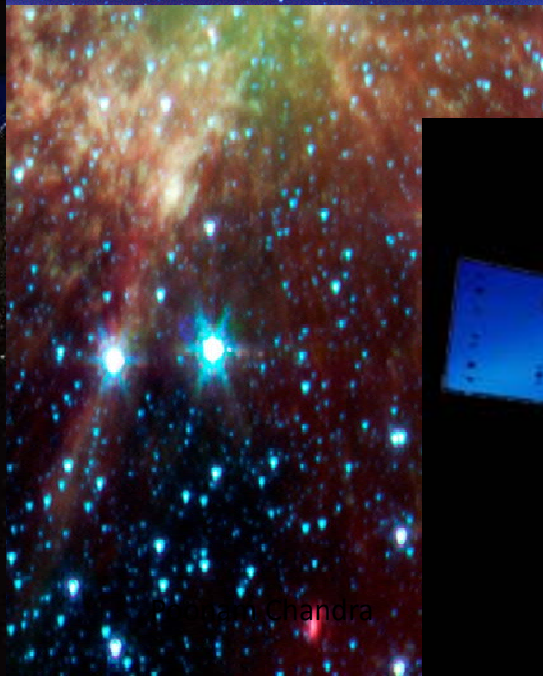
ASCA



Swift



XMM



Chandra



Chandra

Life Cycle of a Star

