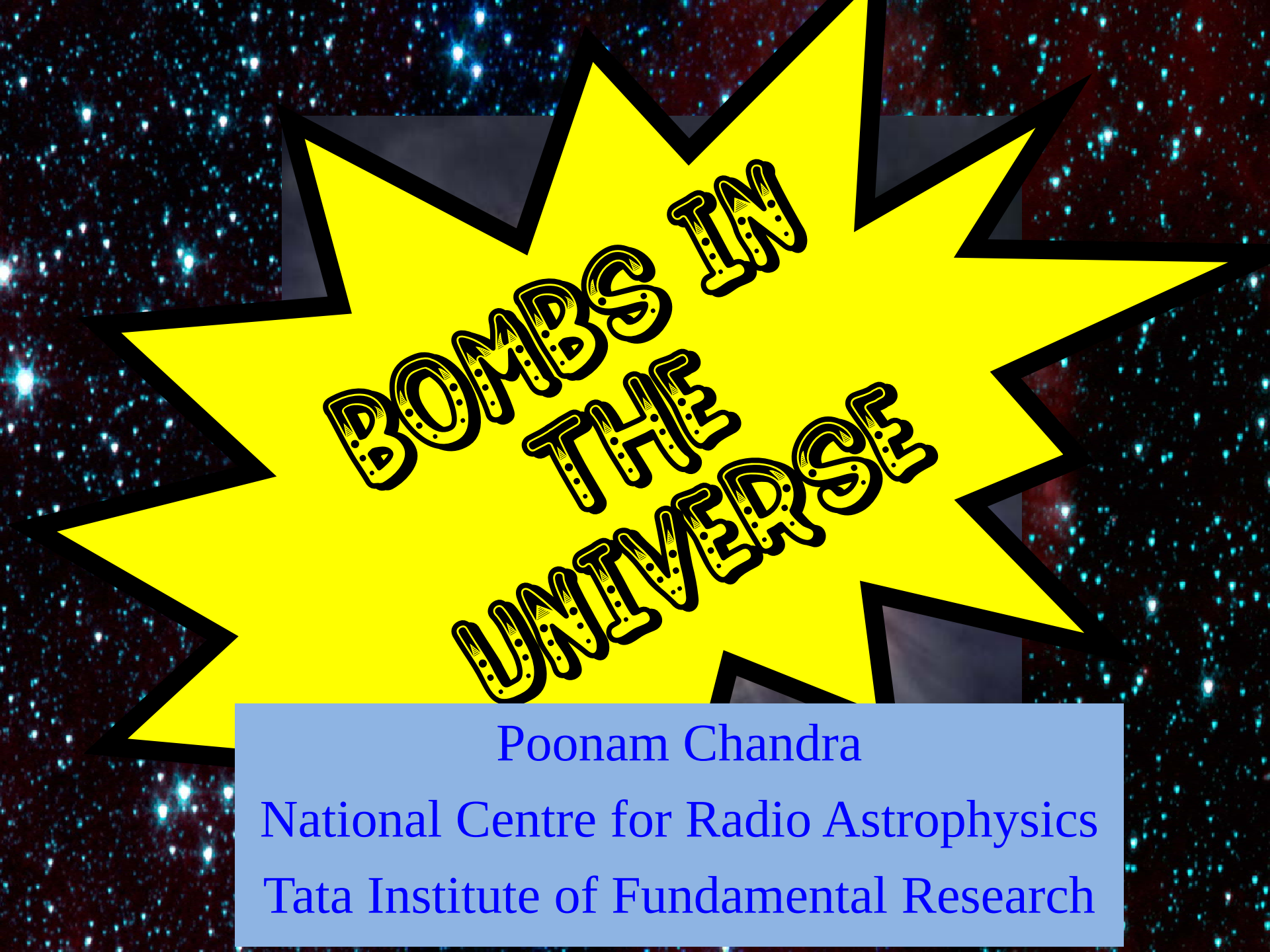


Poonam Chandra

National Centre for Radio Astrophysics

Tata Institute of Fundamental Research


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???

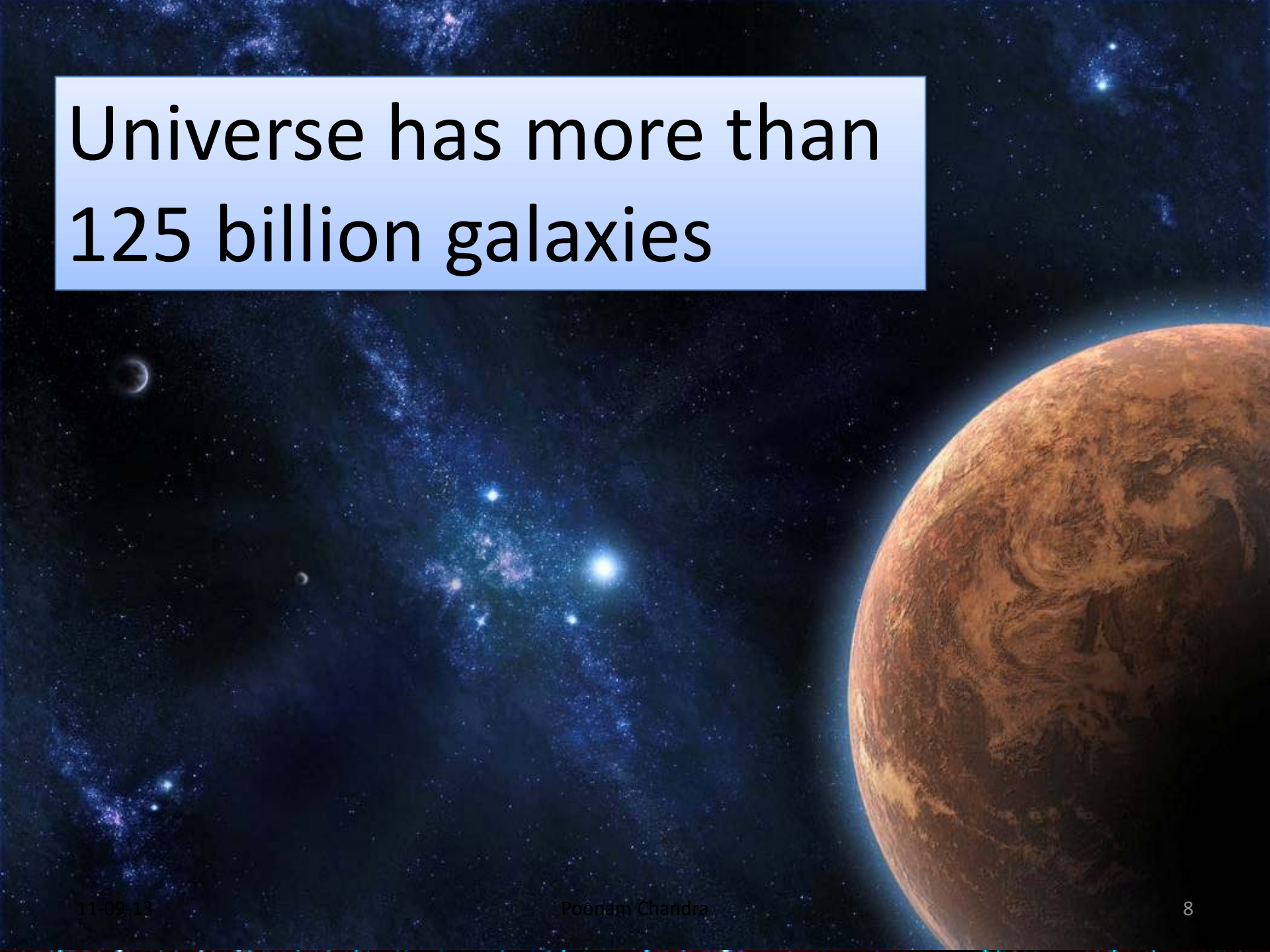
100,000,000,000,000,00
0,000,000,000,000
(10[29]) times more
energy
in a
nuc

Single Supernova can
sh
100

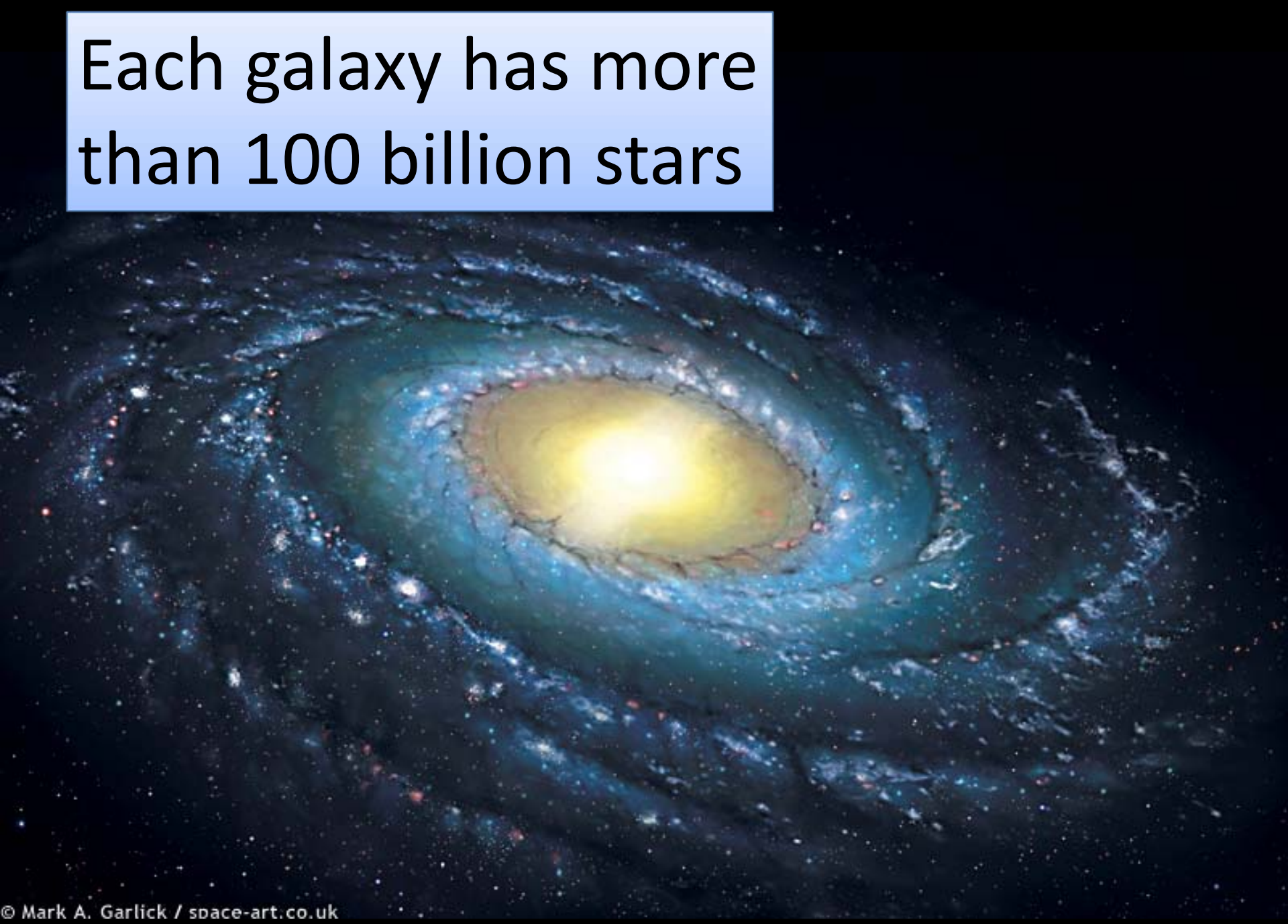
As much energy as
sun will give in
10,000,000,000
(10[10]) years.

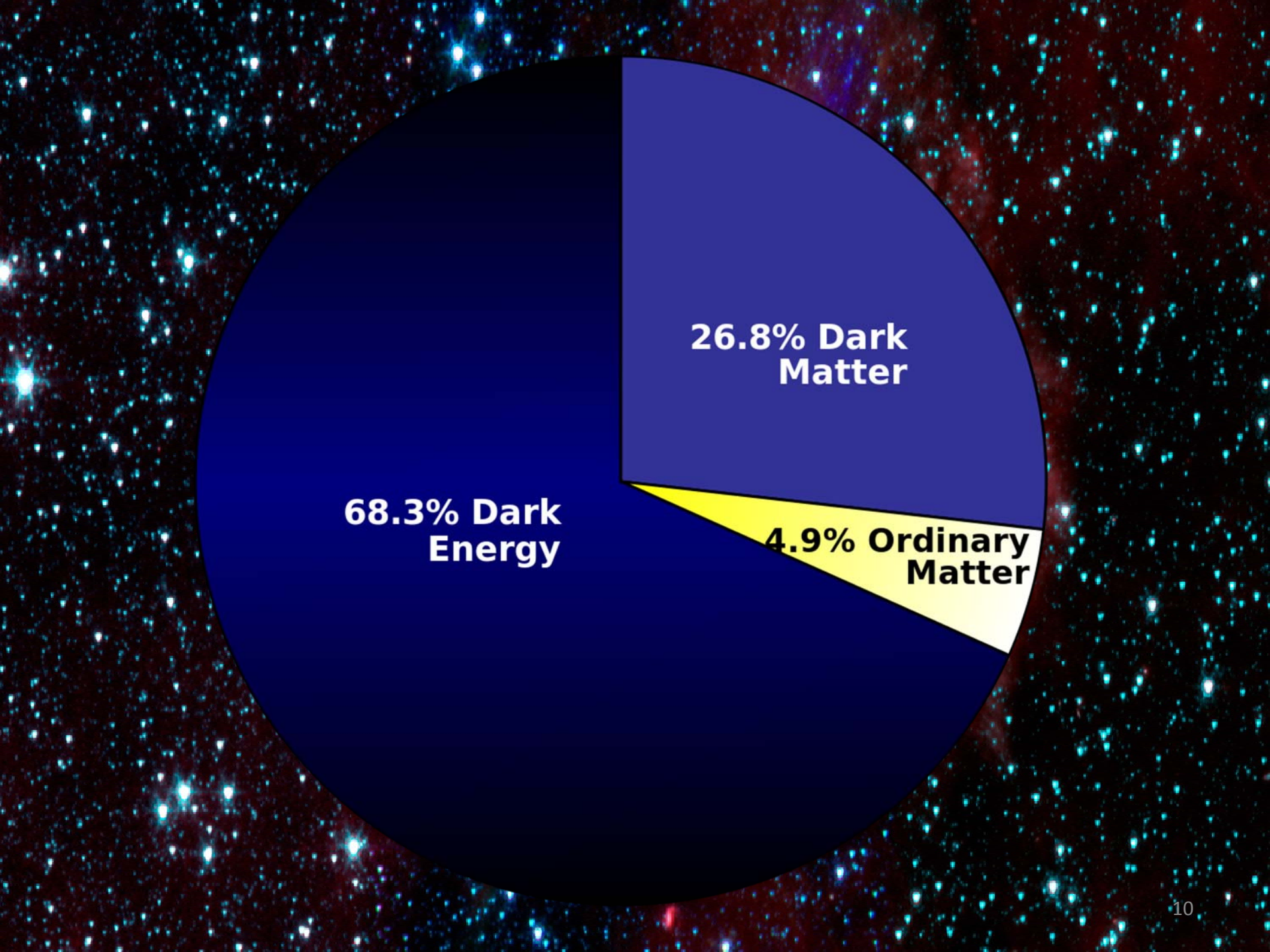

In universe 8 new supernovae explode every second.

MILKY WAY


Universe has more than
125 billion galaxies

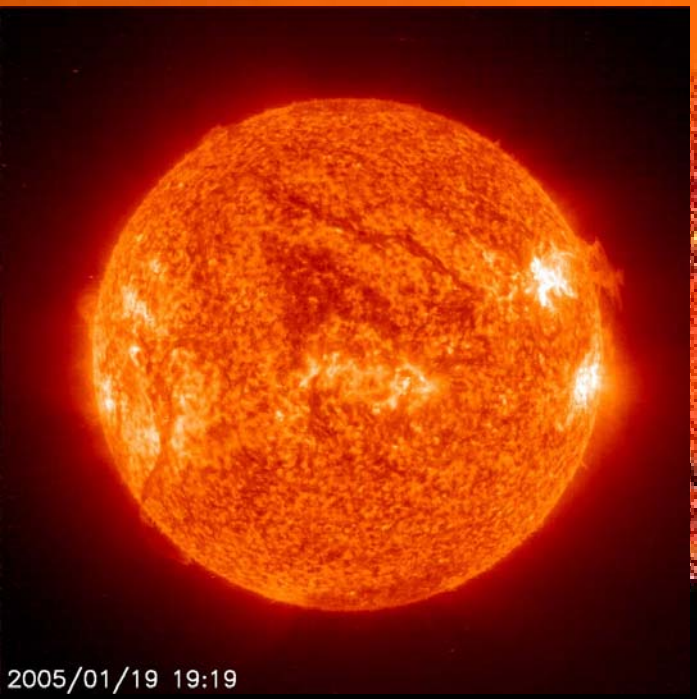
Each galaxy has more than 100 billion stars




26.8% Dark Matter
4.9% Ordinary Matter
68.3% Dark Energy

DEATH OF A MASSIVE STAR

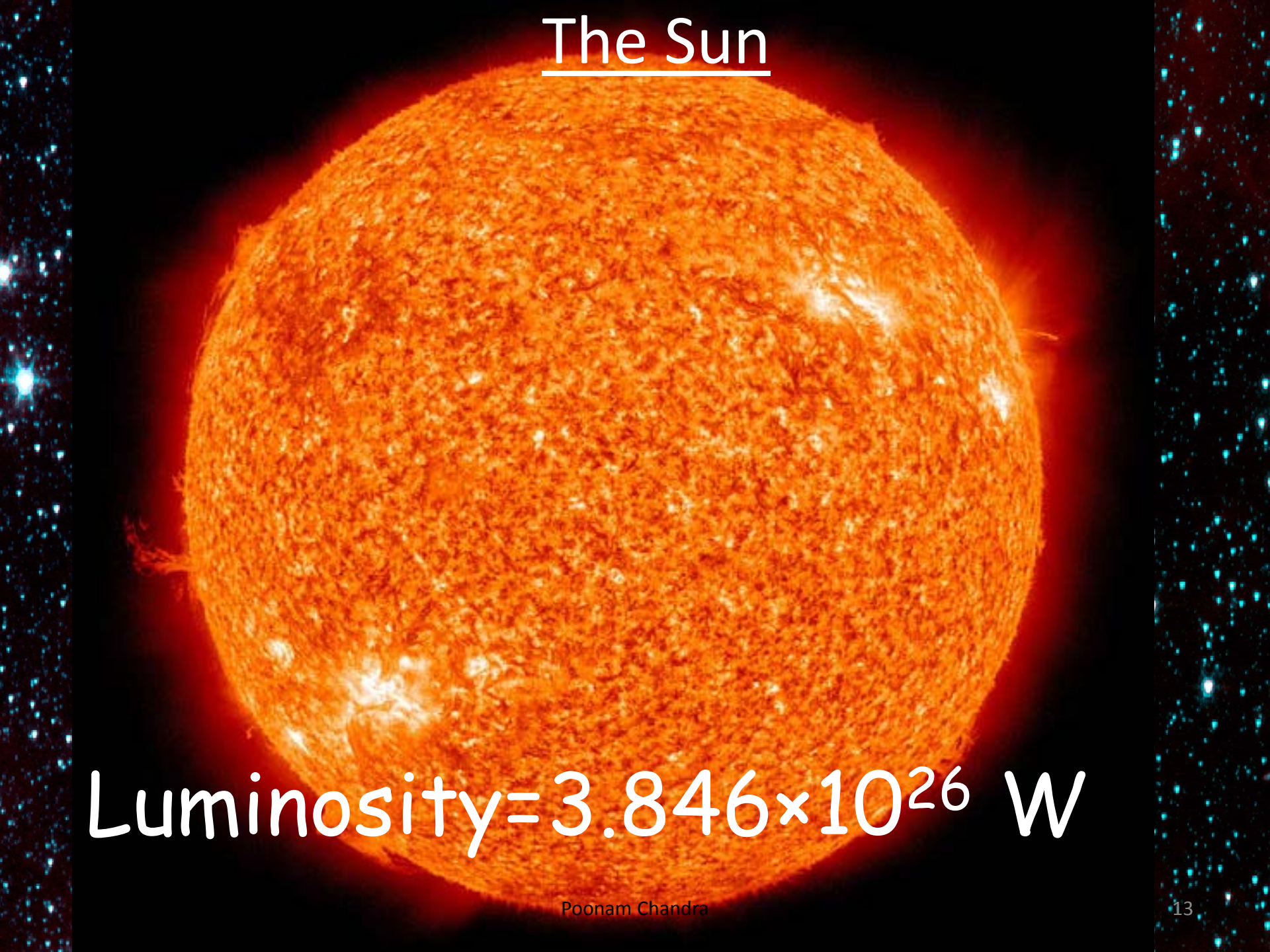
FATE OF SUN



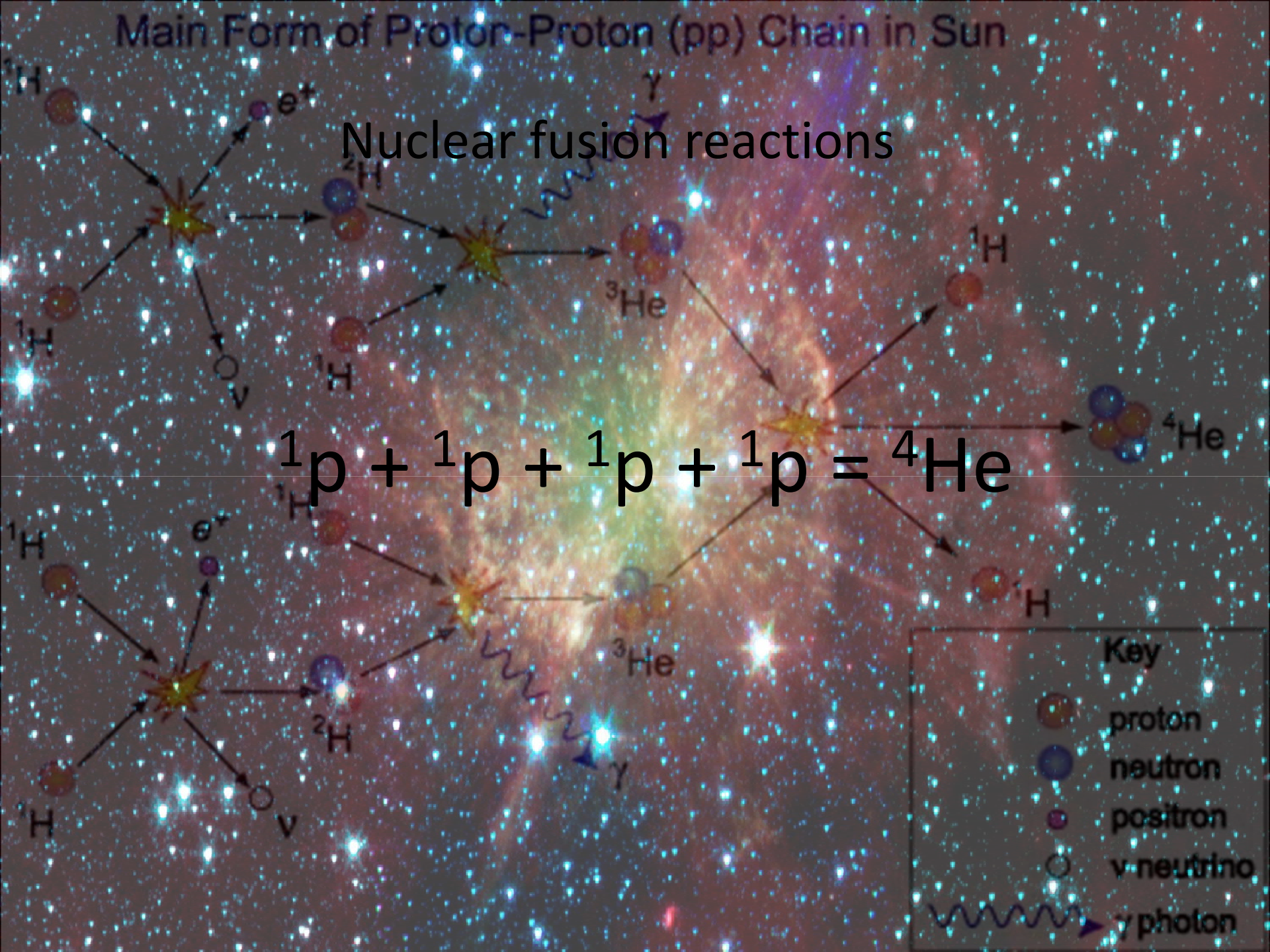
SUN

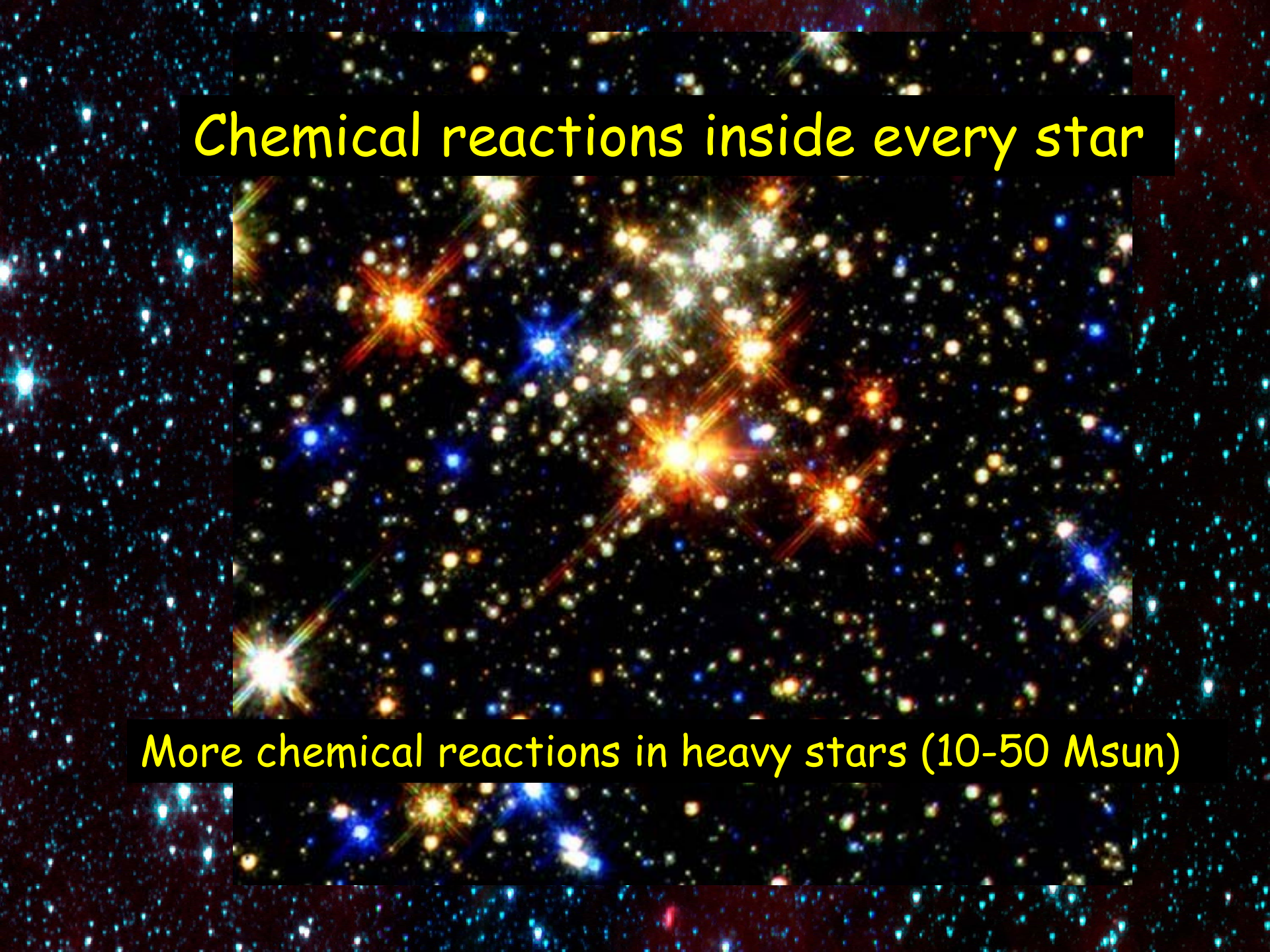
White Dwarf

The Sun

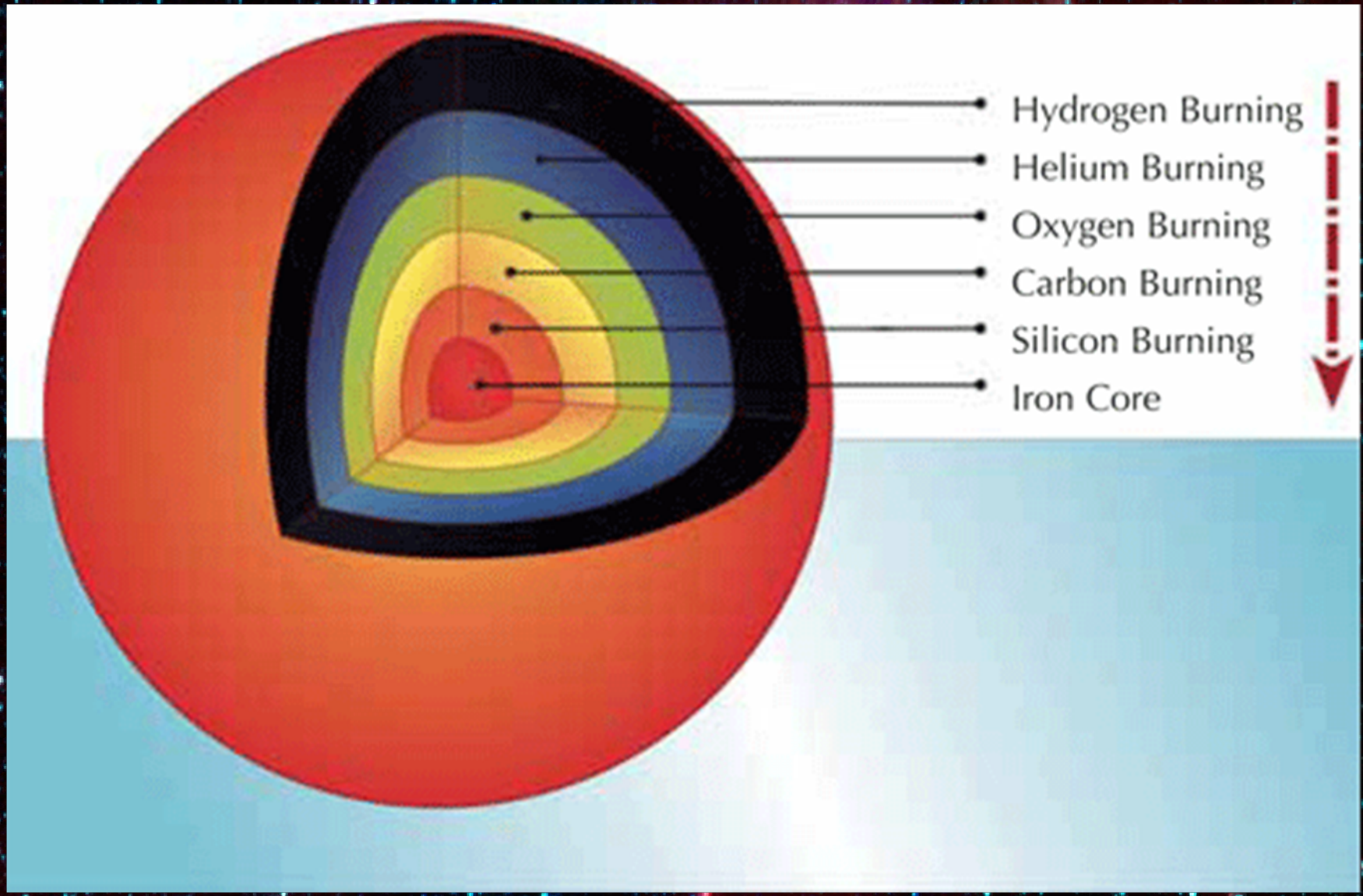


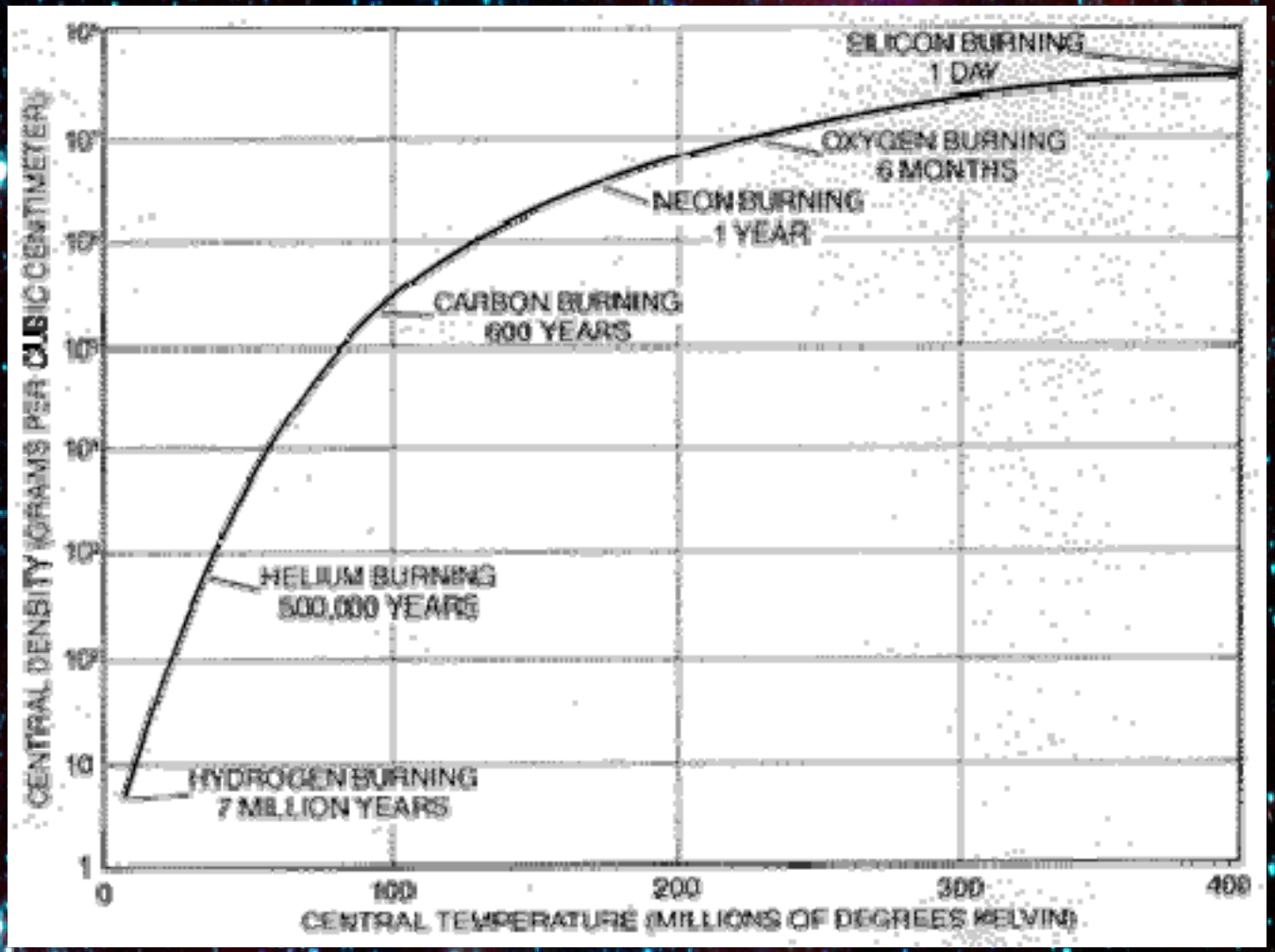
Luminosity=3.846×10^{26} W


Main Form of Proton-Proton (pp) Chain in Sun
Nuclear fusion reactions
$^1p + {}^1p + {}^1p + {}^1p = {}^4He$
Key
proton
neutron
positron
ν neutrino
γ photon


Chemical reactions inside every star
More chemical reactions in heavy stars (10-50 Msun)

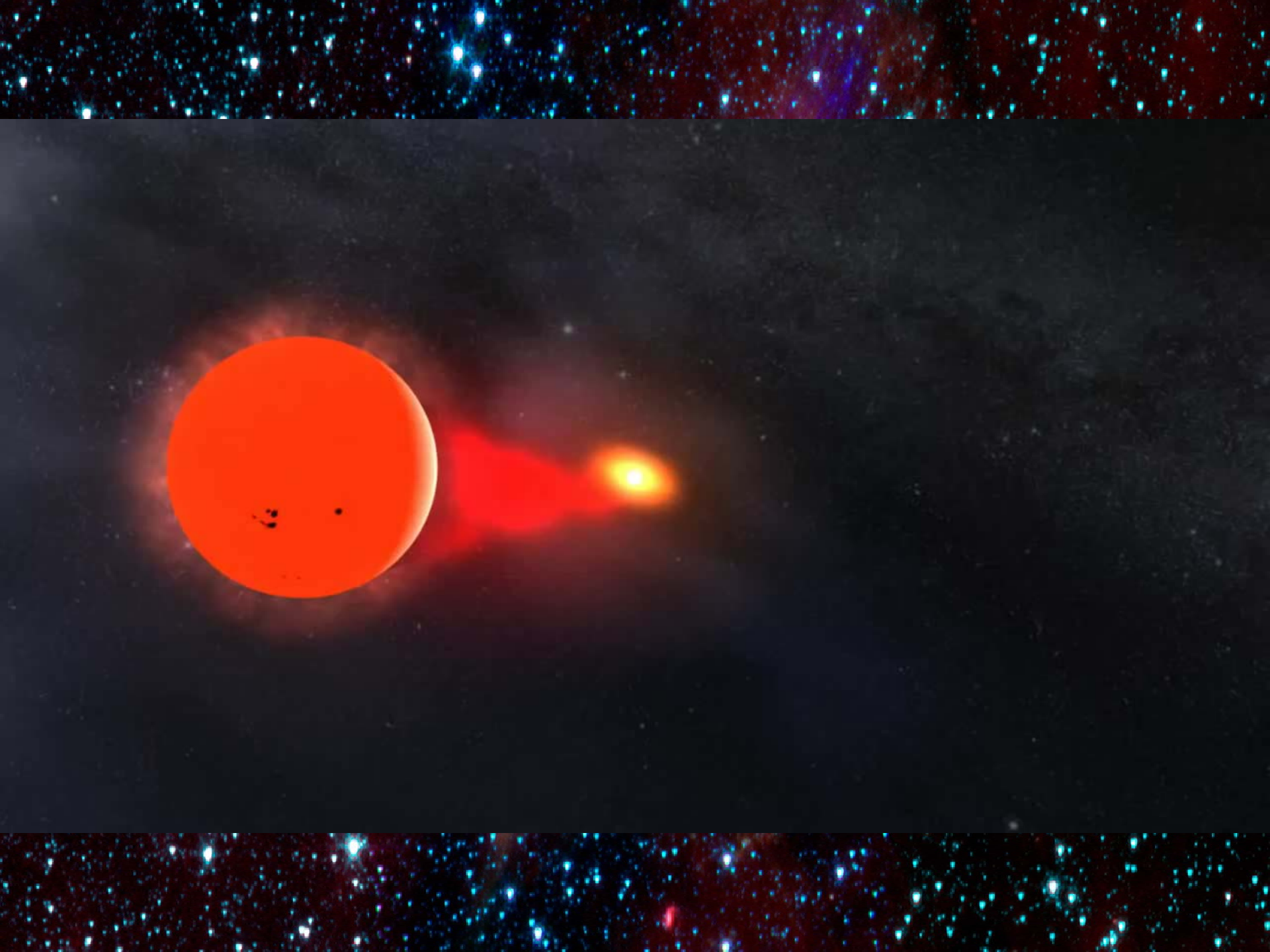
Nuclear reactions inside a heavy star




SILICON BURNING
1 DAY
OXYGEN BURNING
6 MONTHS
NEON BURNING
1 YEAR
CARBON BURNING
600 YEARS
HELIUM BURNING
500,000 YEARS
HYDROGEN BURNING
7 MILLION YEARS
CENTRAL DENSITY (GRAMS PER CUBIC CENTIMETER)
CENTRAL TEMPERATURE (MILLIONS OF DEGREES KELVIN)
0
100
200
300
400

Gravitational Collapse

Supernovae



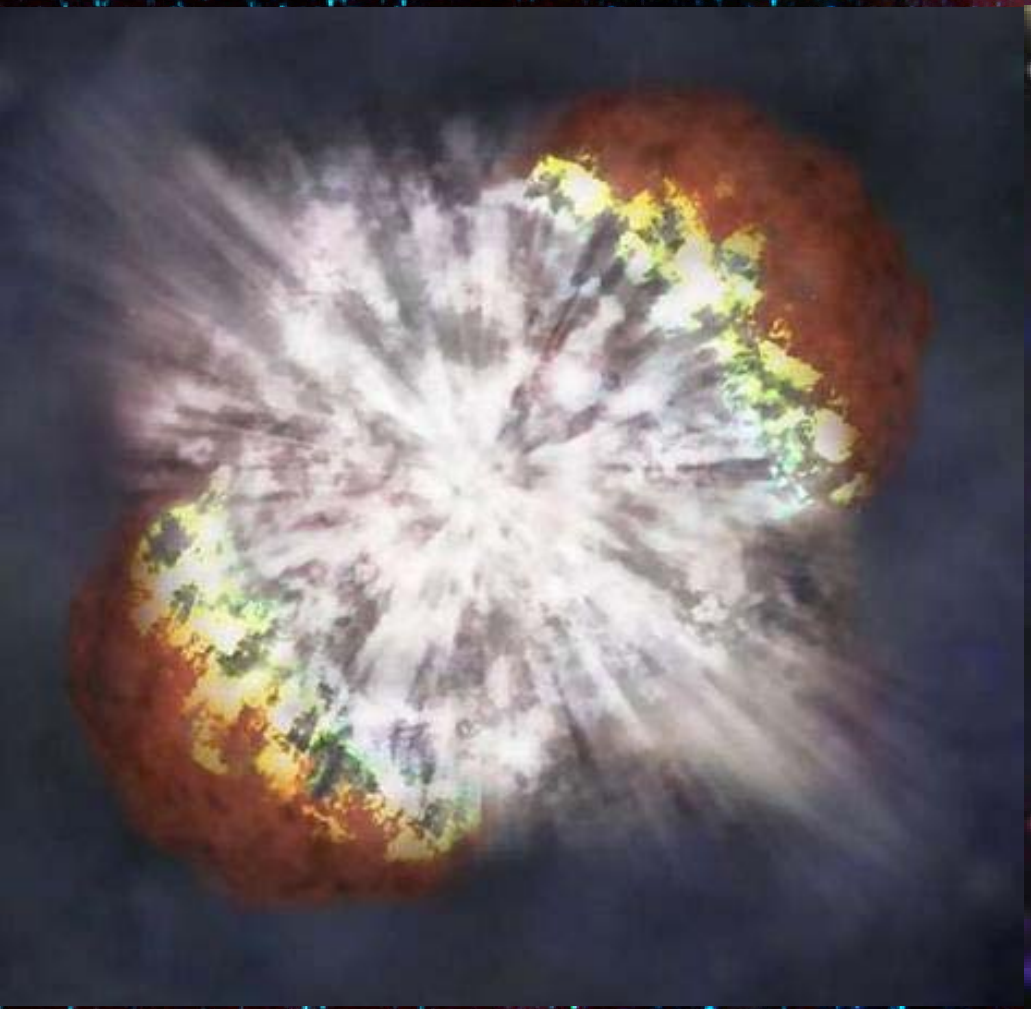
Thermonuclear Supernovae

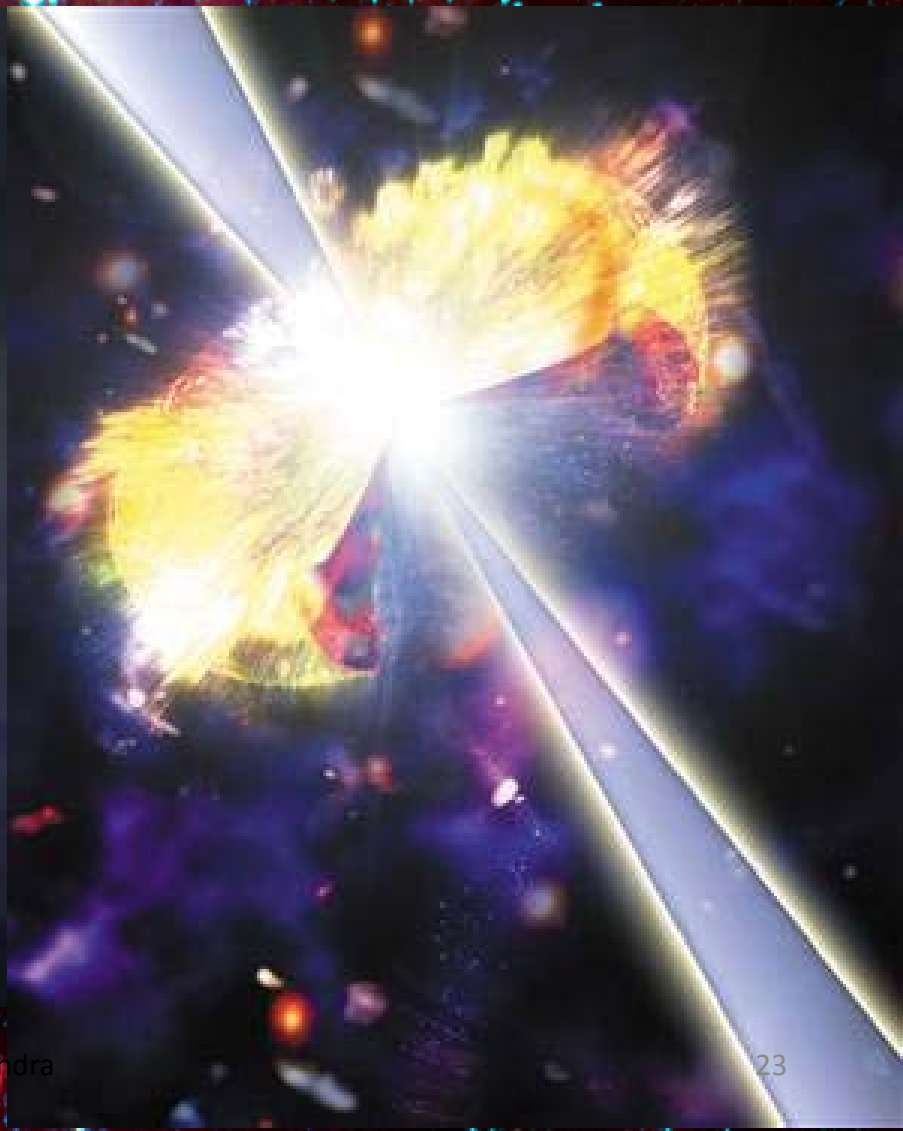
$8M_\odot \leq M \leq 30M_\odot$

Supernova

$M \geq 30M_\odot$

Gamma Ray Burst

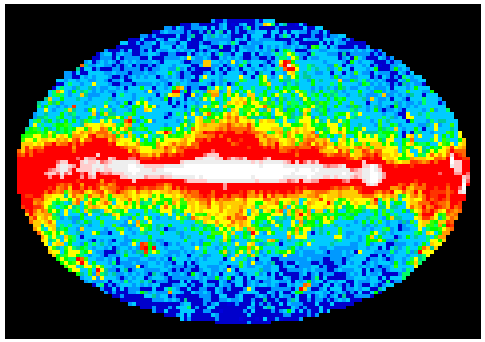


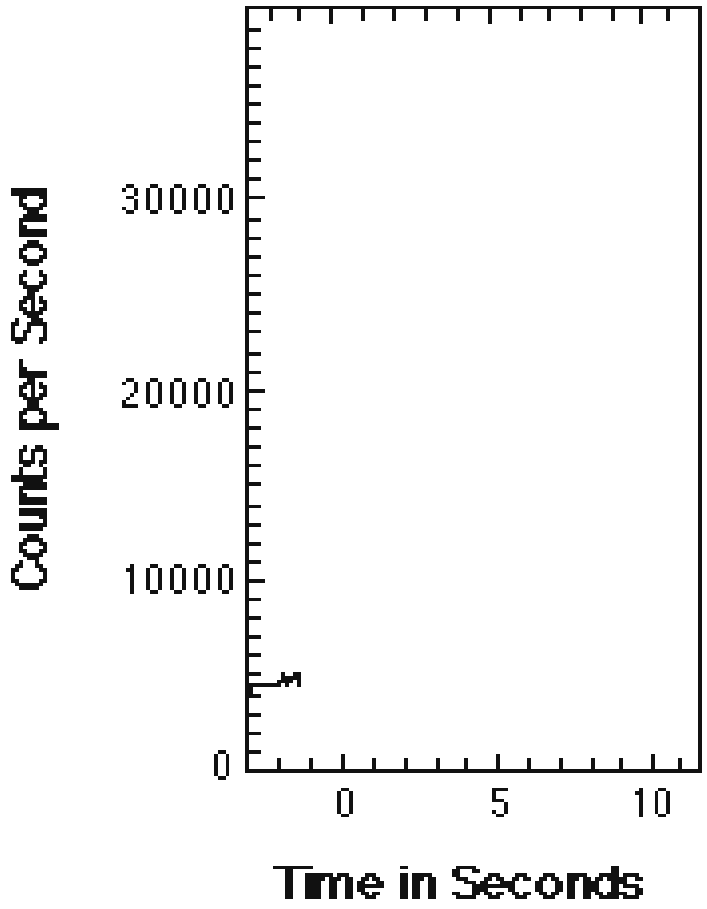


Gamma Ray Burst

What are Gamma Ray bursts (GRBs)?

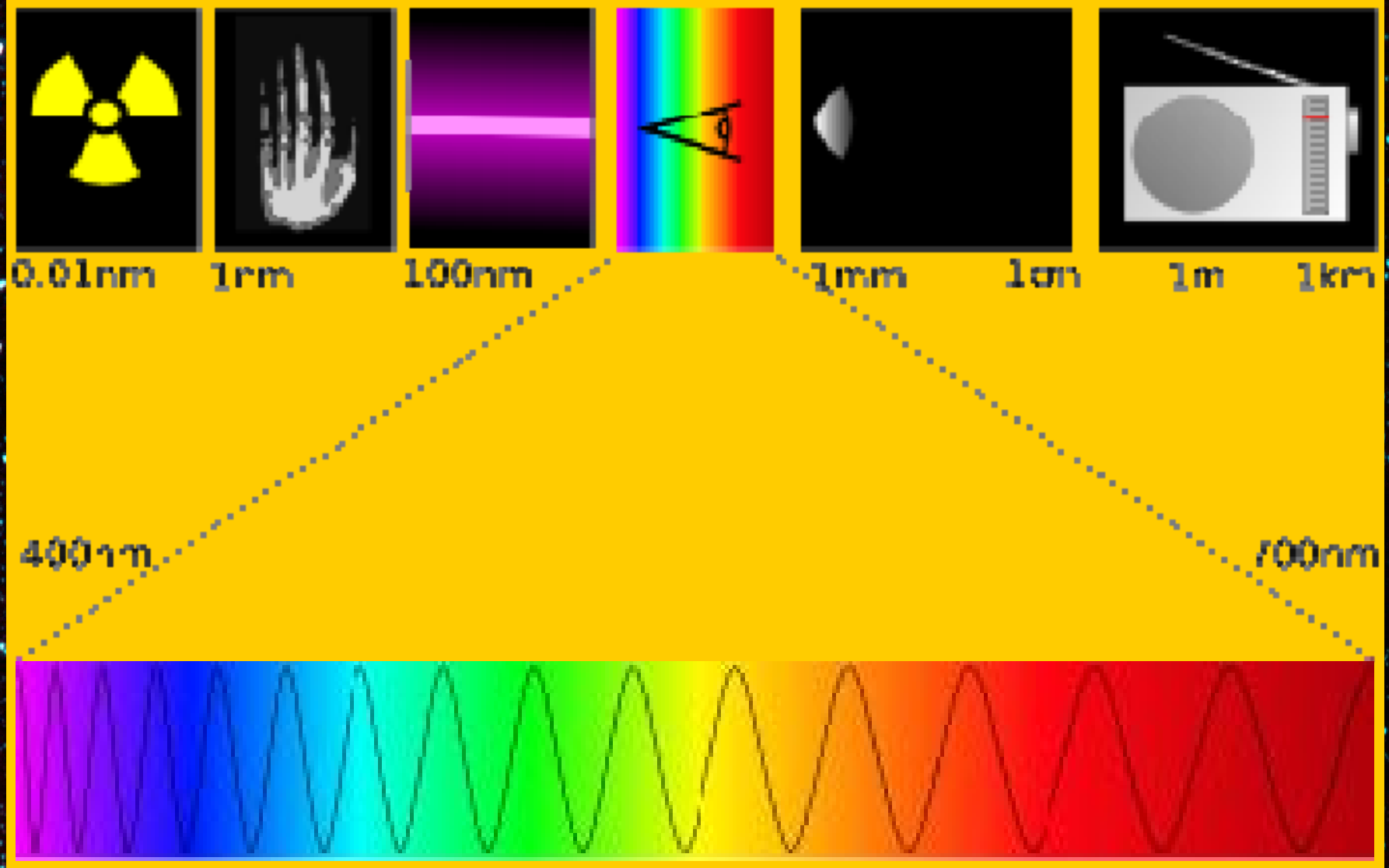
Most energetic events in the universe

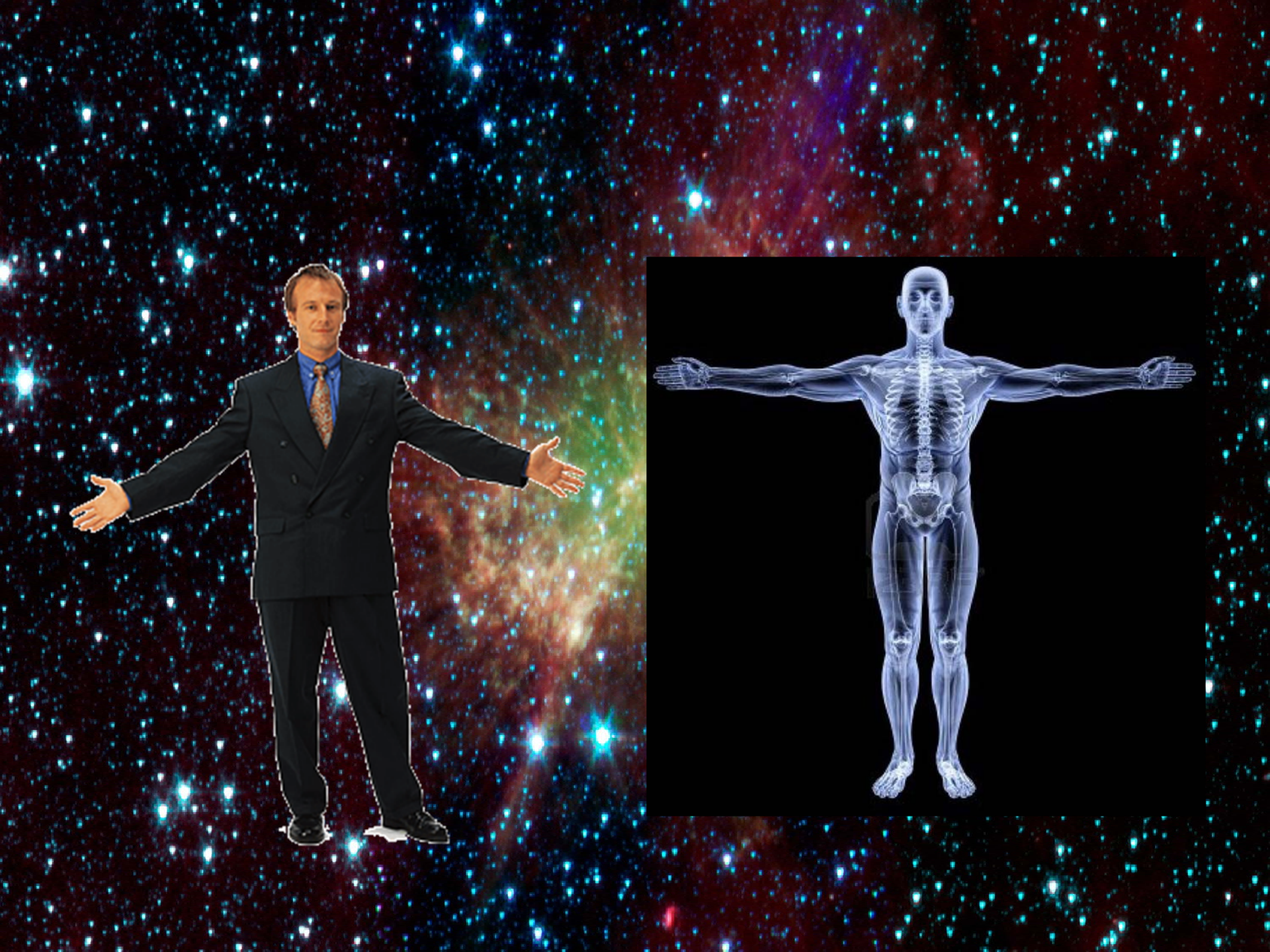


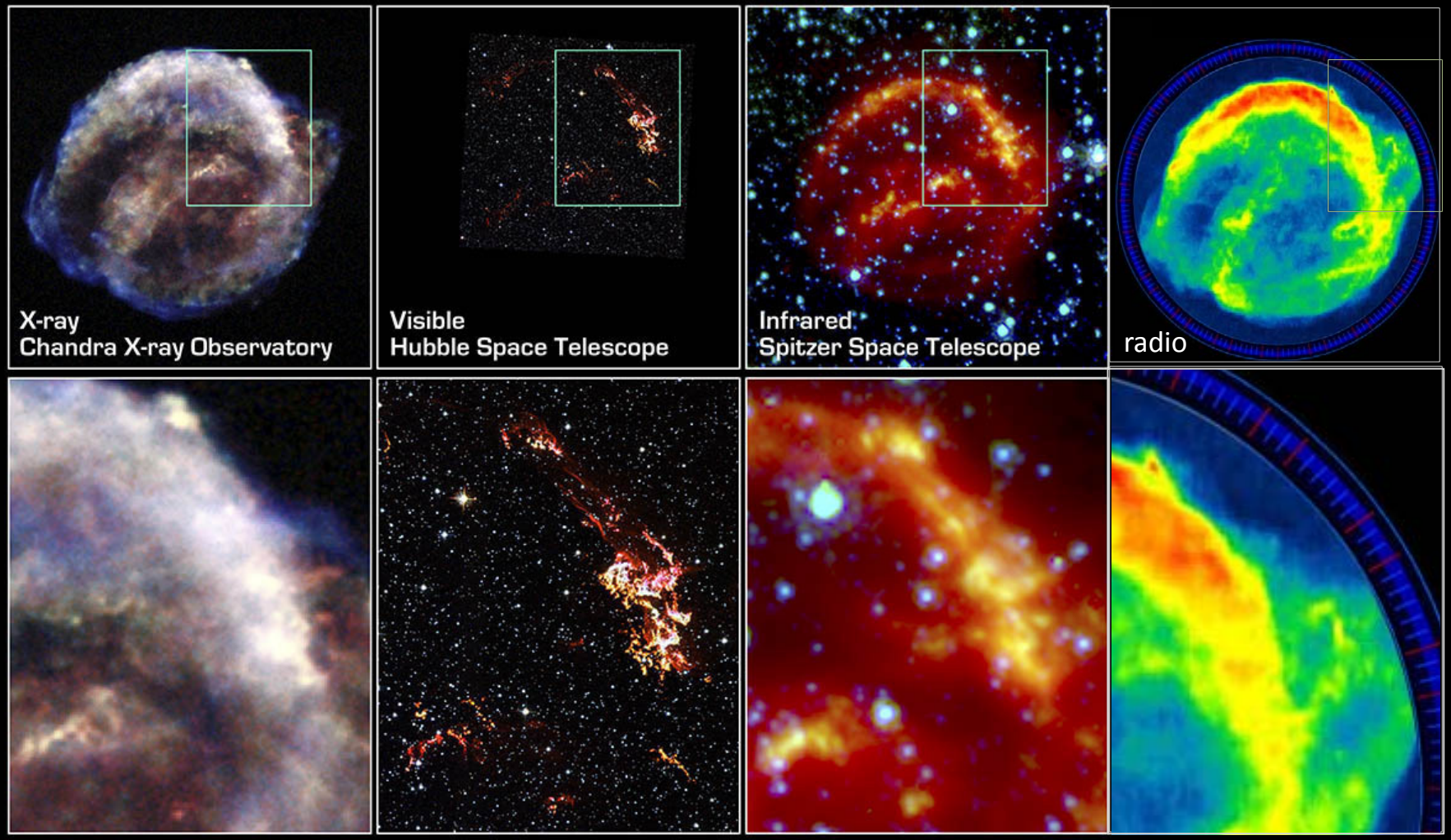



We detect roughly one
GRB per day.

How We study them?





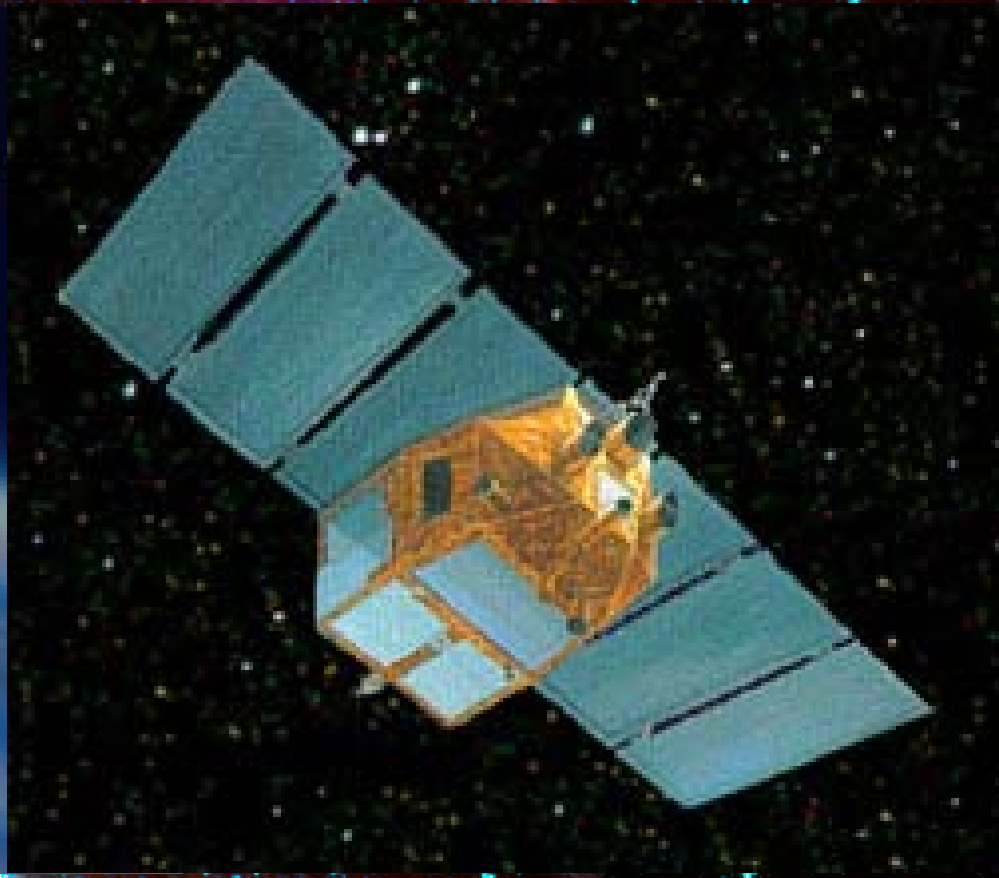


Kepler's Supernova Remnant • SN 1604

ssc2004-15b

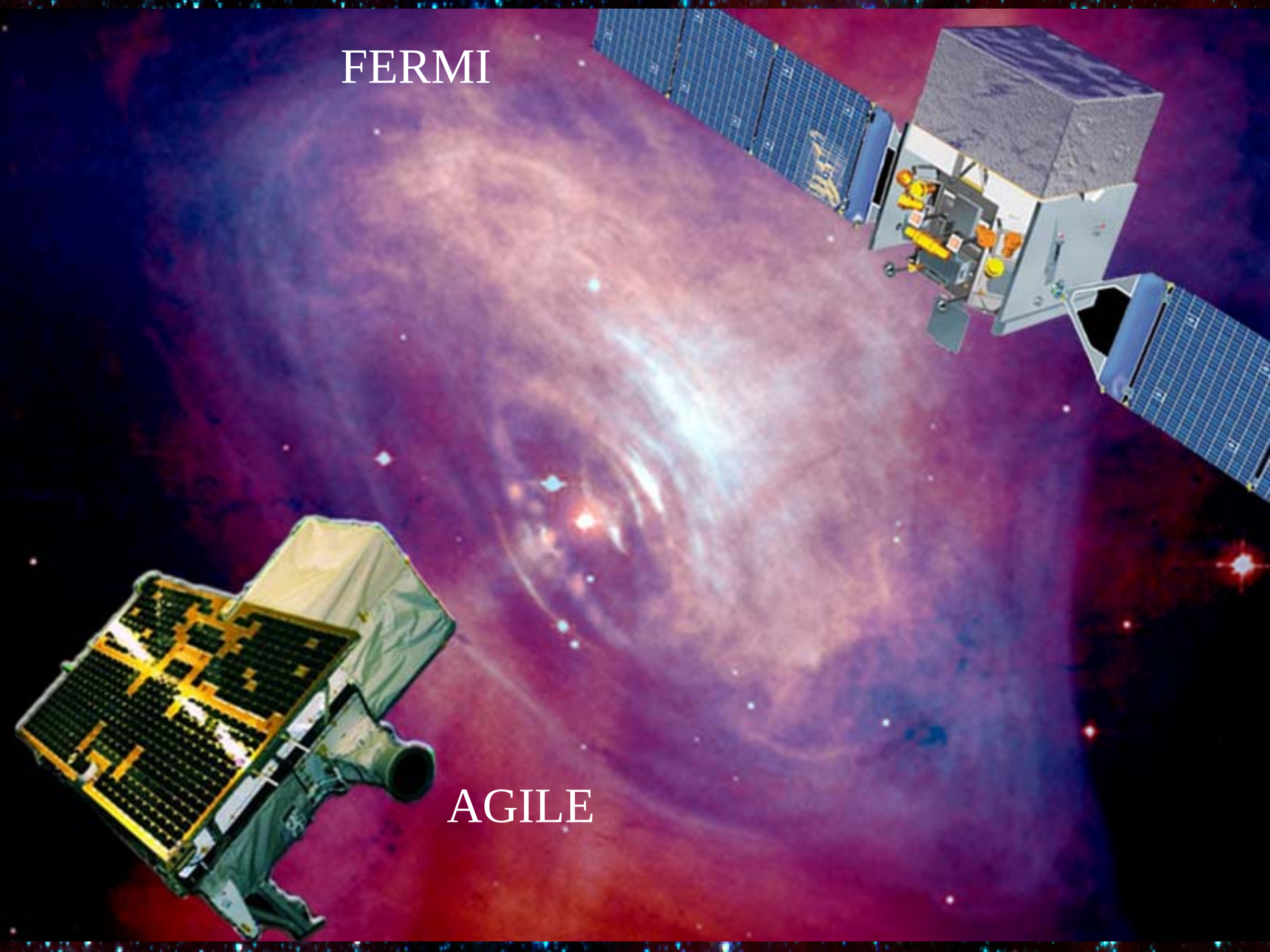
NASA, ESA / JPL-Caltech / R. Sankrit & W. Blair (Johns Hopkins University)

GRB Missions

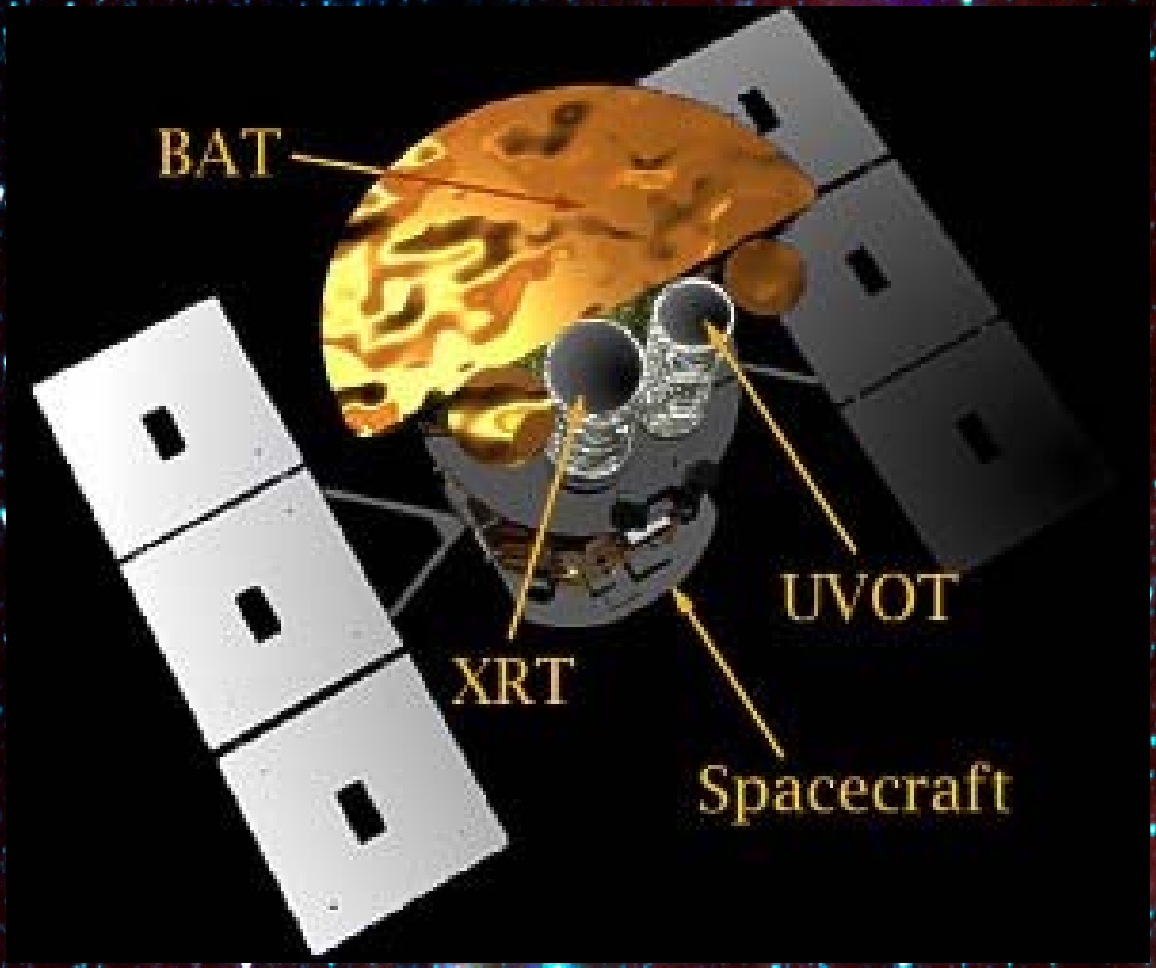


BATSE

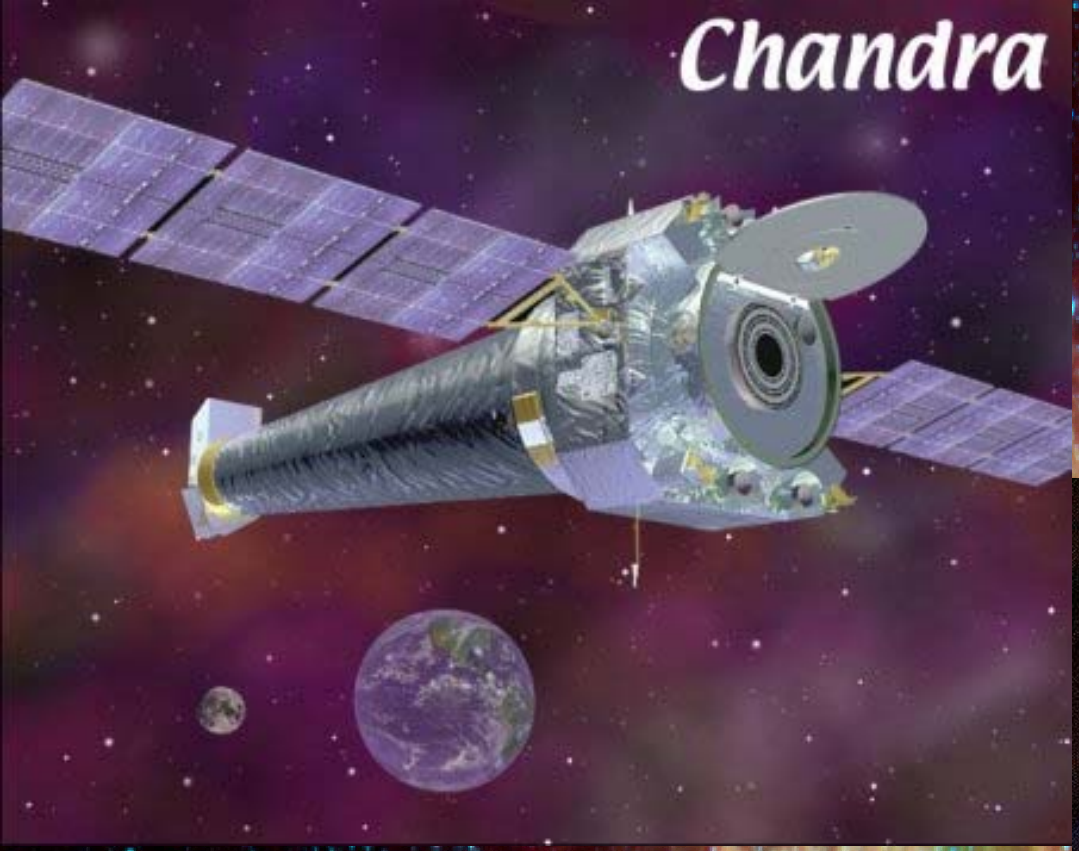
BeppoSAX

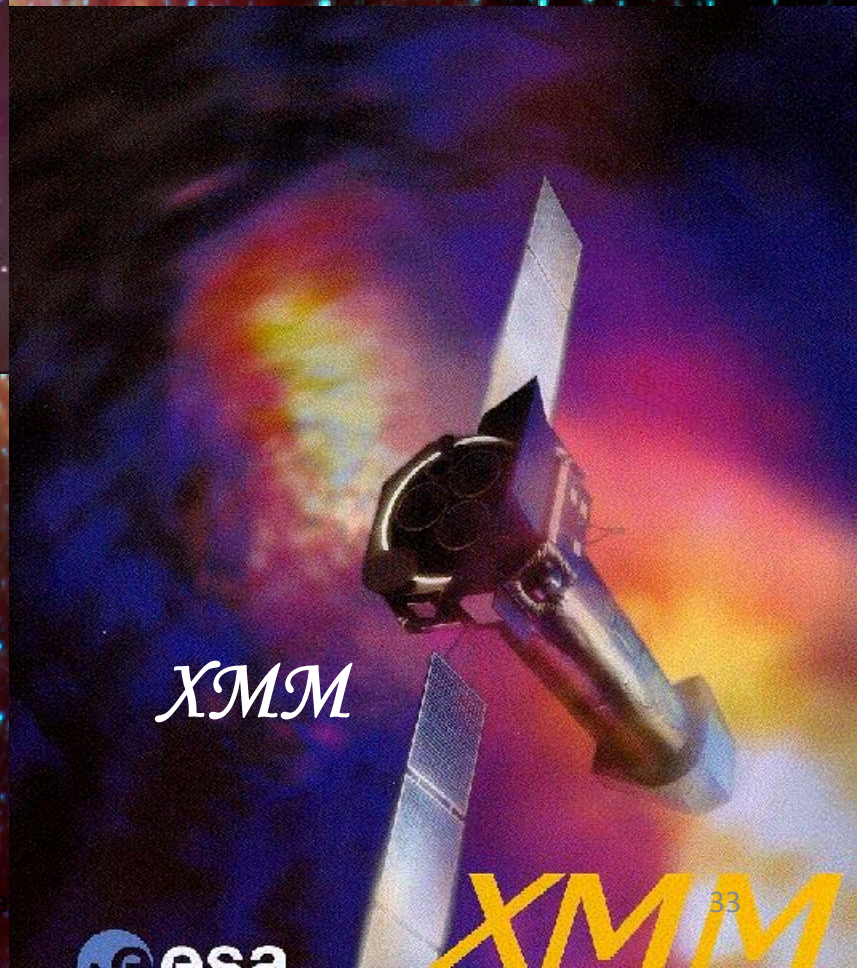

FERMI
AGILE

SWIFT



X-ray telescopes





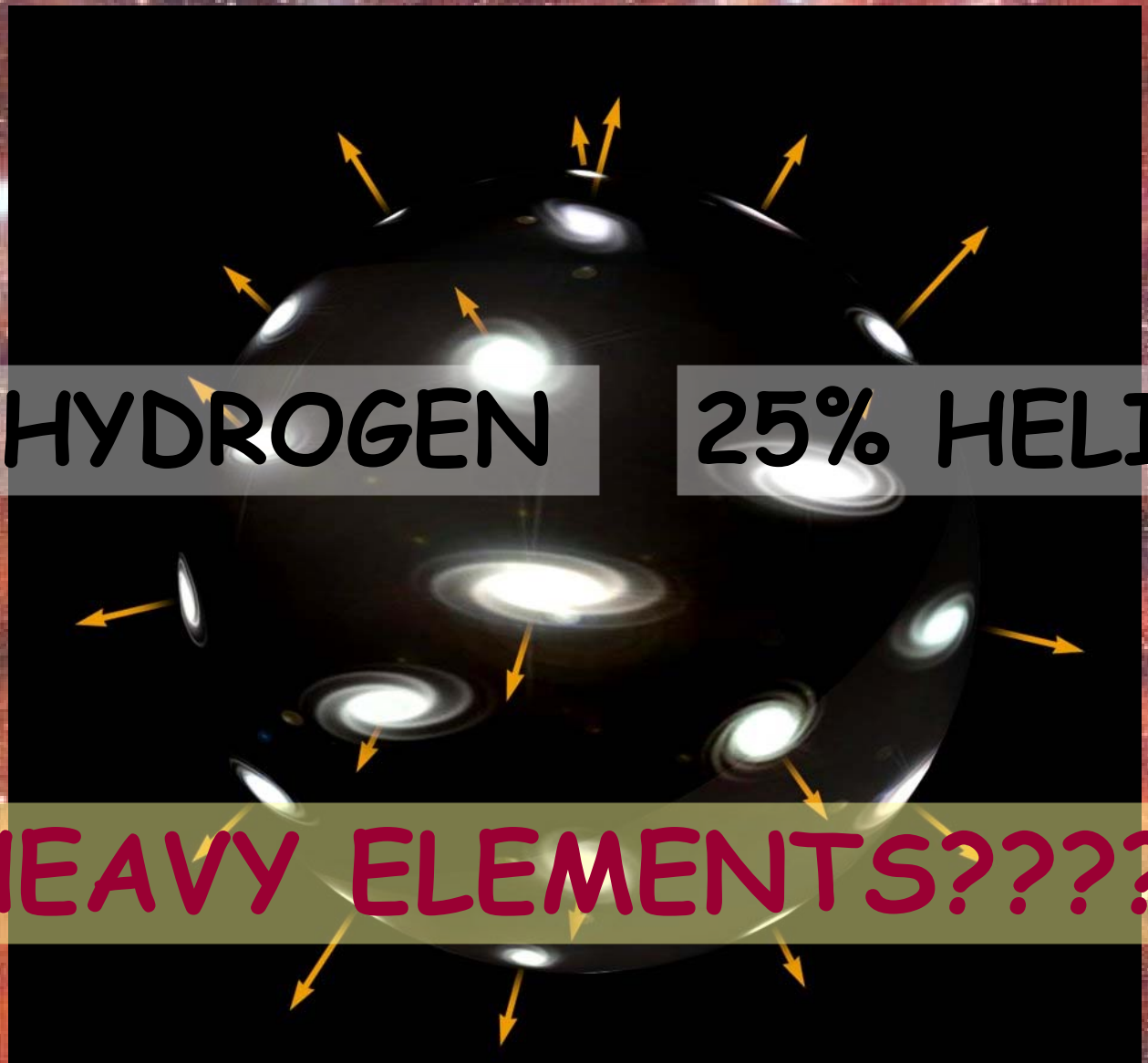
Atacama Large Millimeter Array

RADIO TELESCOPES

Why we study them?

Supernovae: the seeds of life

BIG BANG

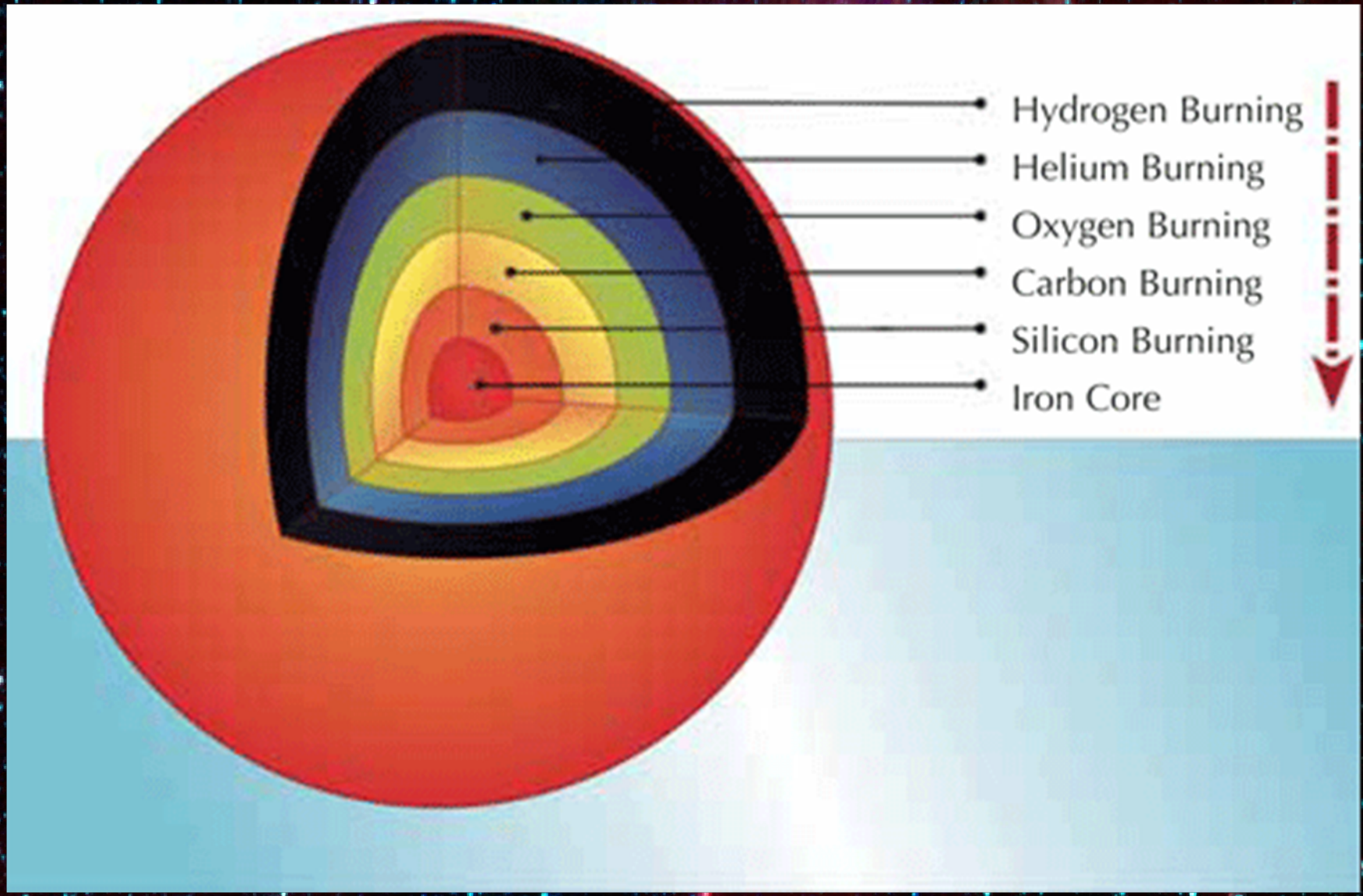


75% HYDROGEN

25% HELIUM

HEAVY ELEMENTS????

Nuclear reactions inside a heavy star



Supernovae: seeds of life

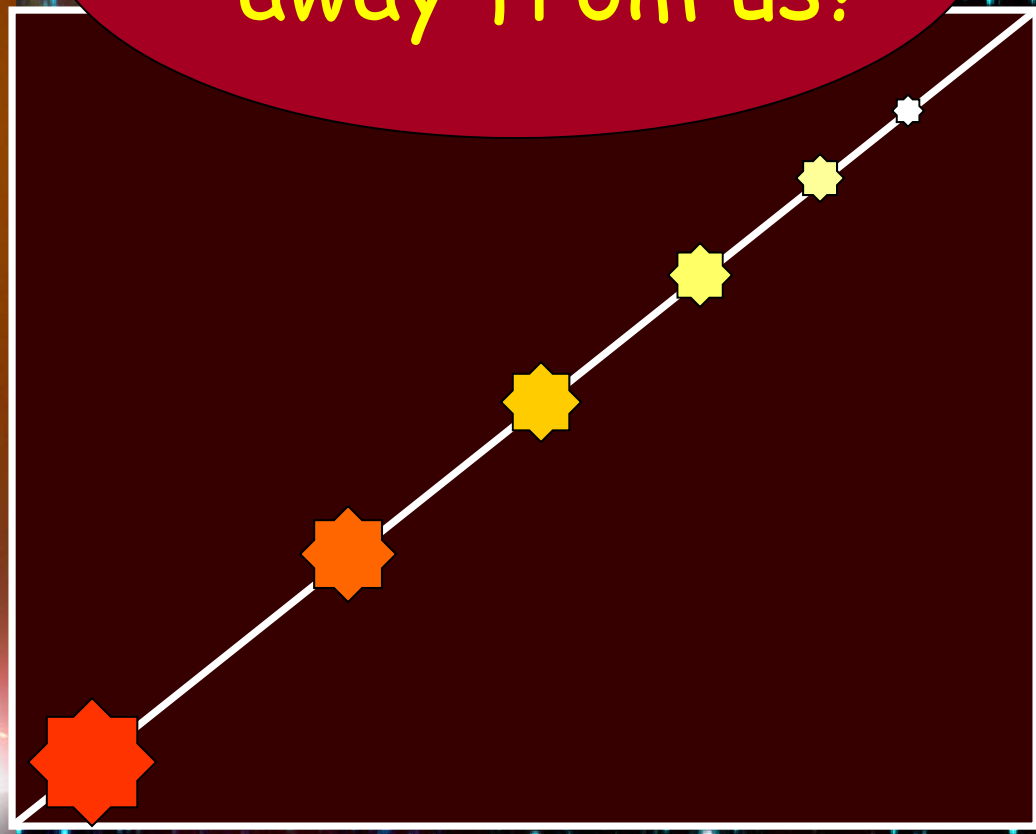
Calcium in our bones

Oxygen we breath

Iron, Aluminium
Our cars

Supernova and our Universe

Everything going away from us?



What about us?

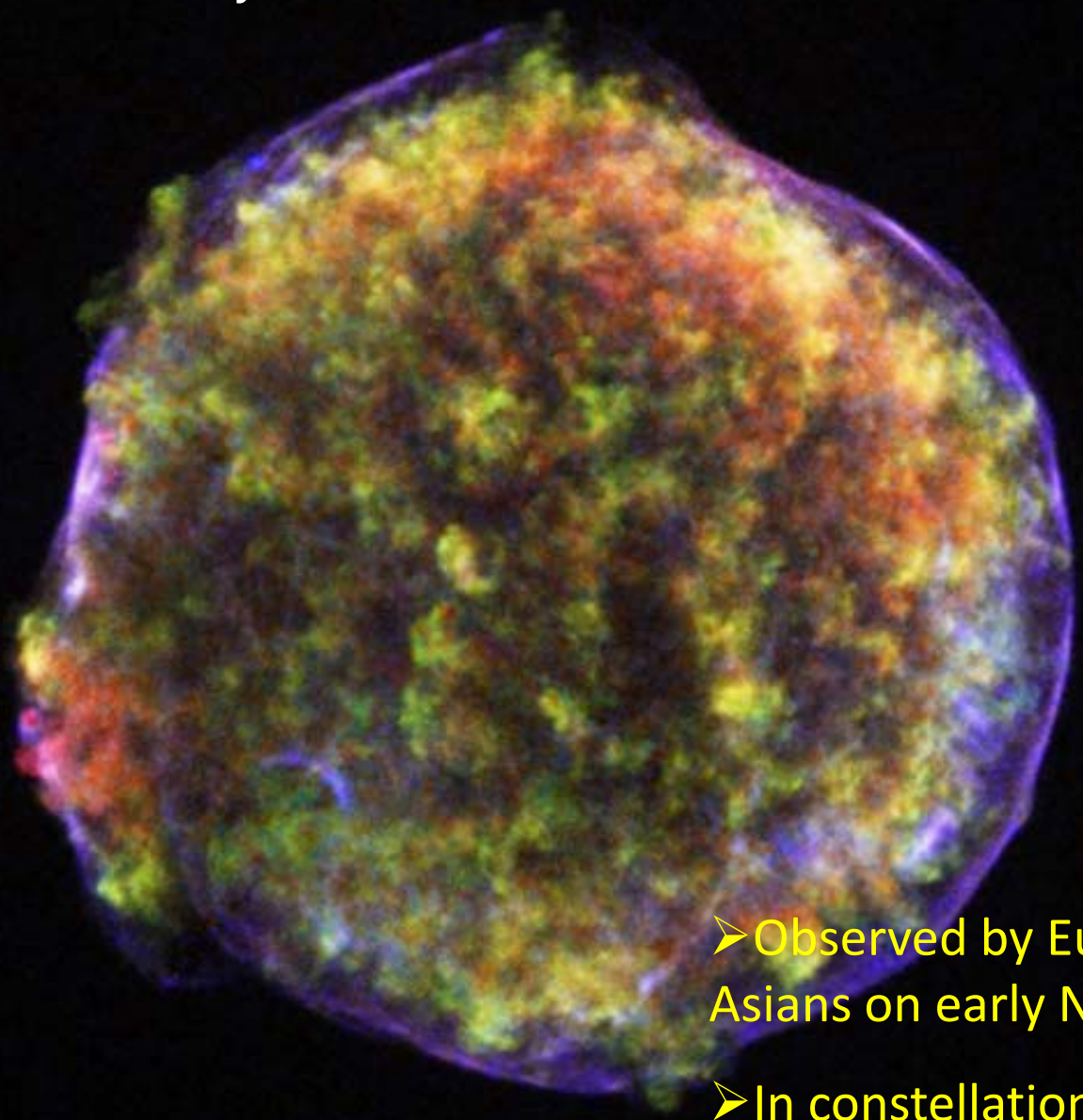
- We?
- Our Earth?
- Our Solar System?
- Our Galaxy?

SN 1006

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

- Observed by chinese on May 1, 1054.
- Bright enough to cast shadow on earth.
- Brighter than ¼ moon.
- In Taurus Constellation.

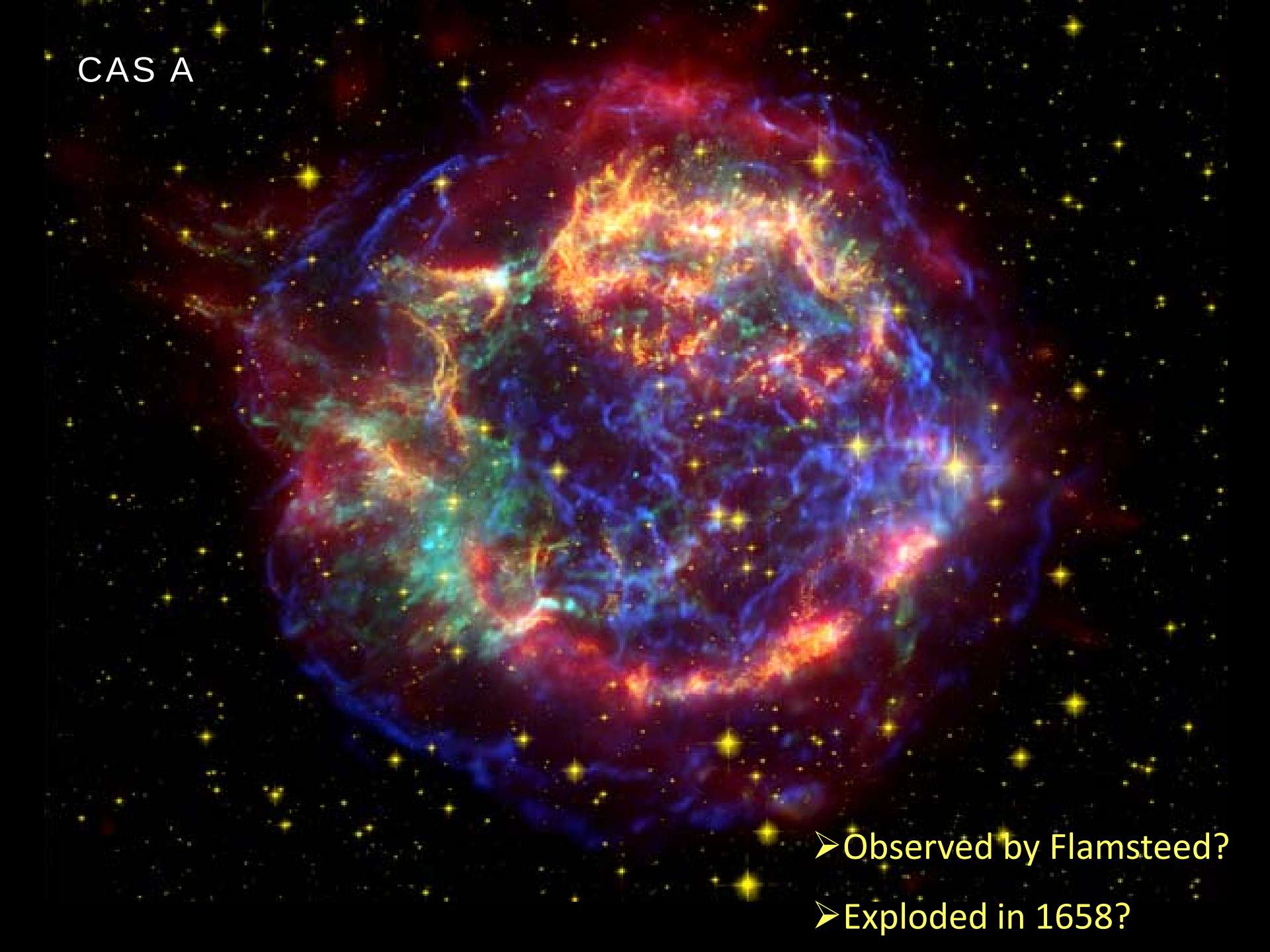
Tycho



- 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.

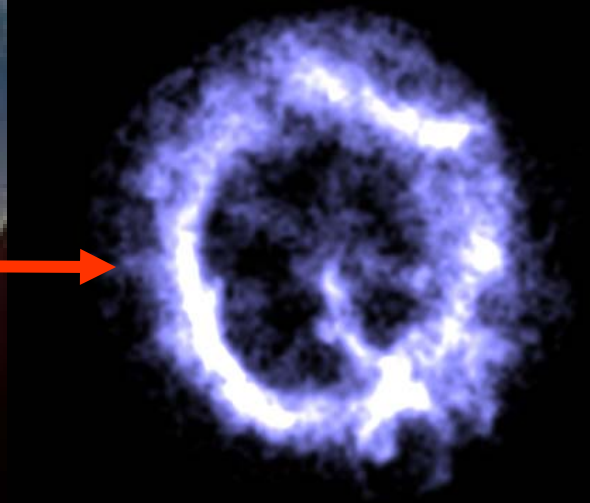

CAS A
Observed by Flamsteed?
Exploded in 1658?

Ill Effects?

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

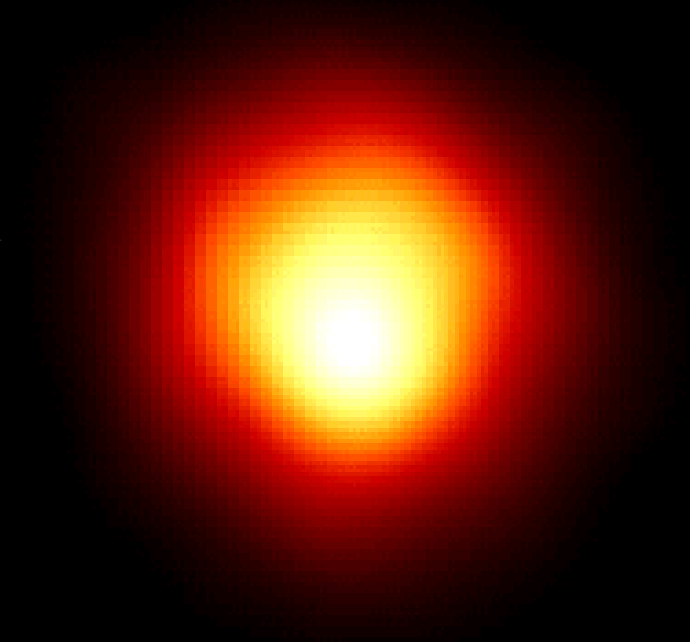
How Close is Too Close?

30 light years



Nearest star is 4 light years

Nearest Supernova Candidate



BETELGEUSE

500 light years away

Our Earth is Safe…

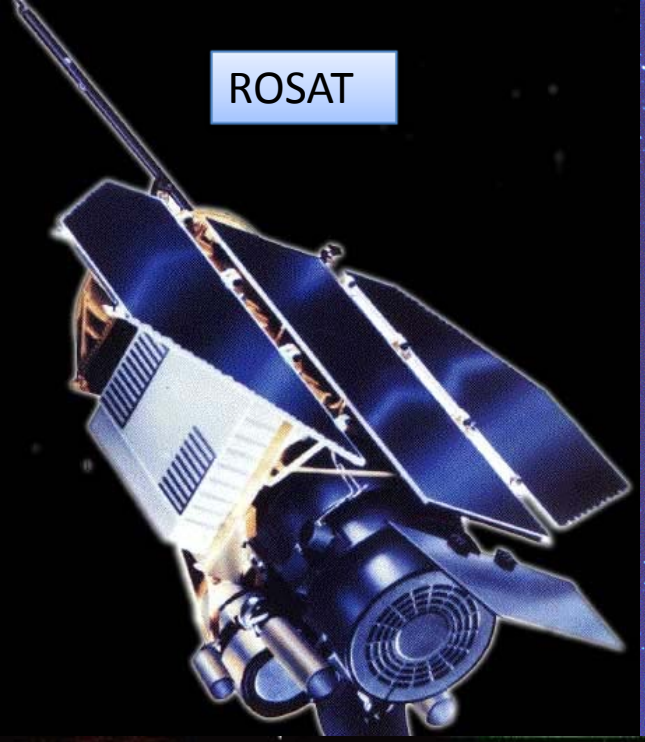

THANKS

NASA

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

Energy scales in various explosions

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

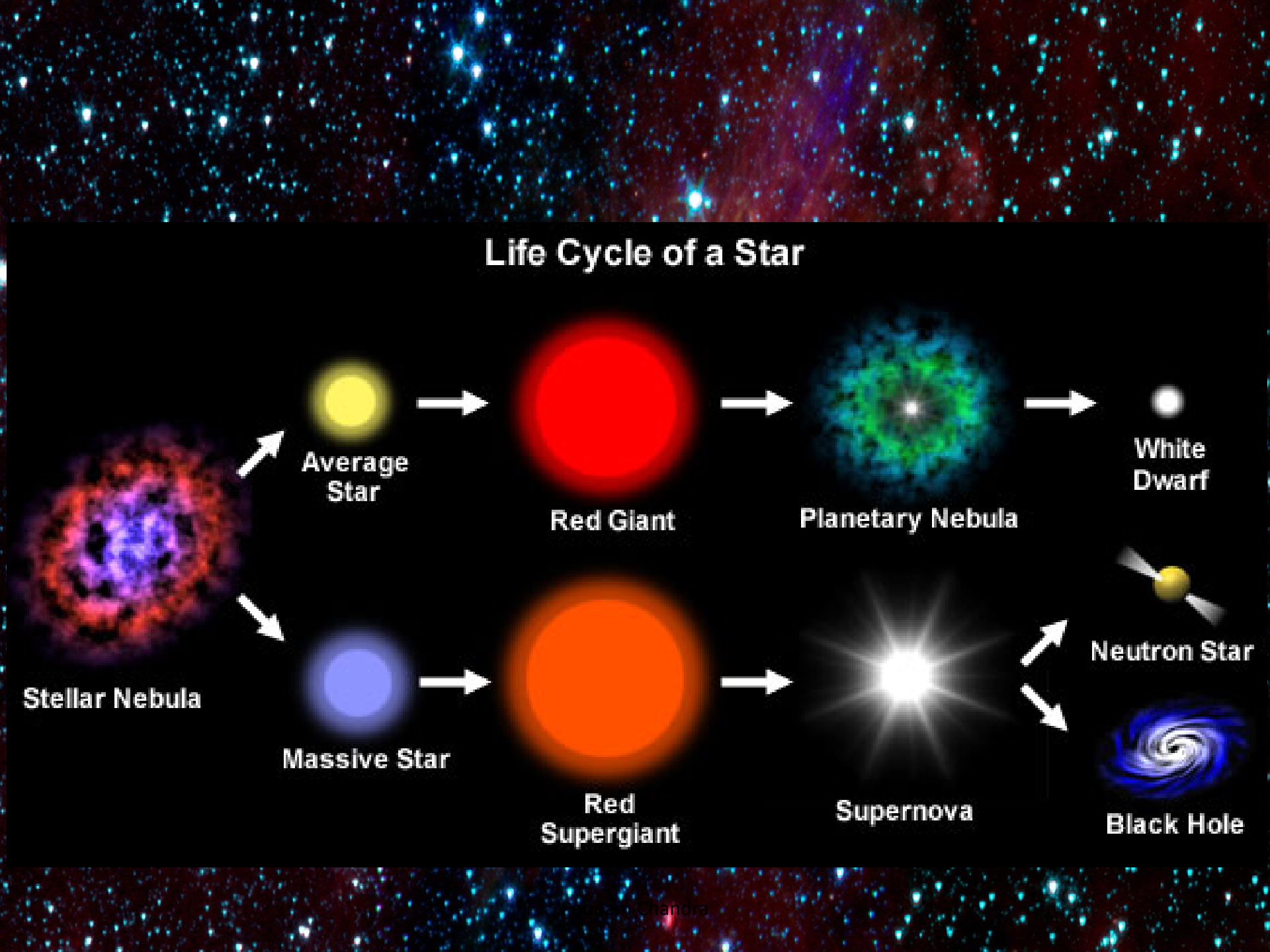

ROSAT


ASCA


Swift


XMM


Chandra


Life Cycle of a Star
Average Star
Red Giant
Planetary Nebula
White Dwarf
Stellar Nebula
Massive Star
Red Supergiant
Supernova
Neutron Star
Black Hole