EXTREME PHENOMENA IN THE COSMOS

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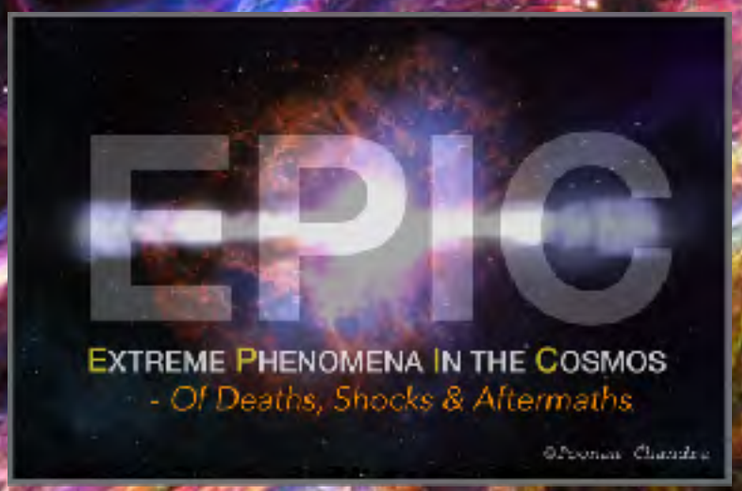
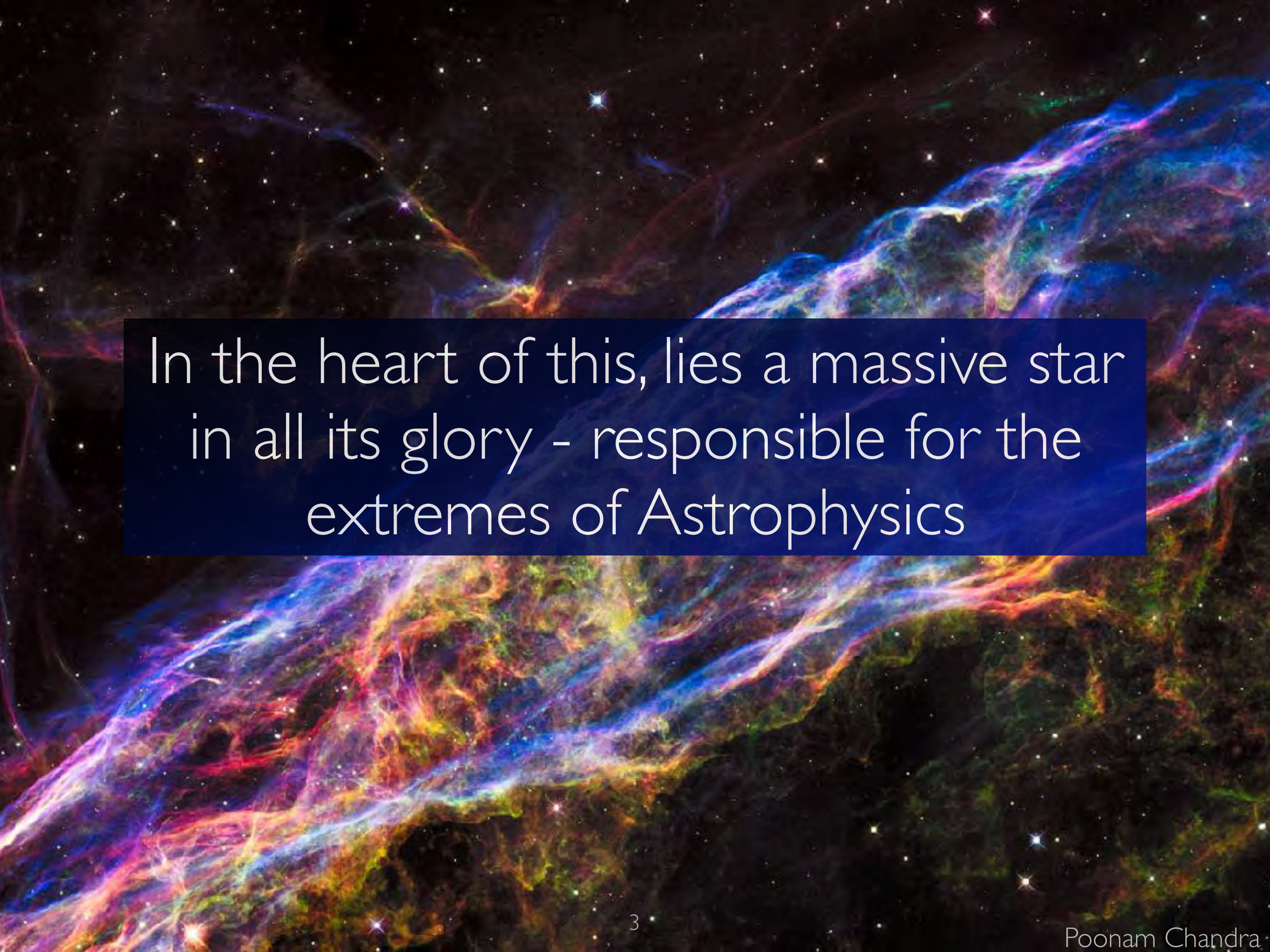
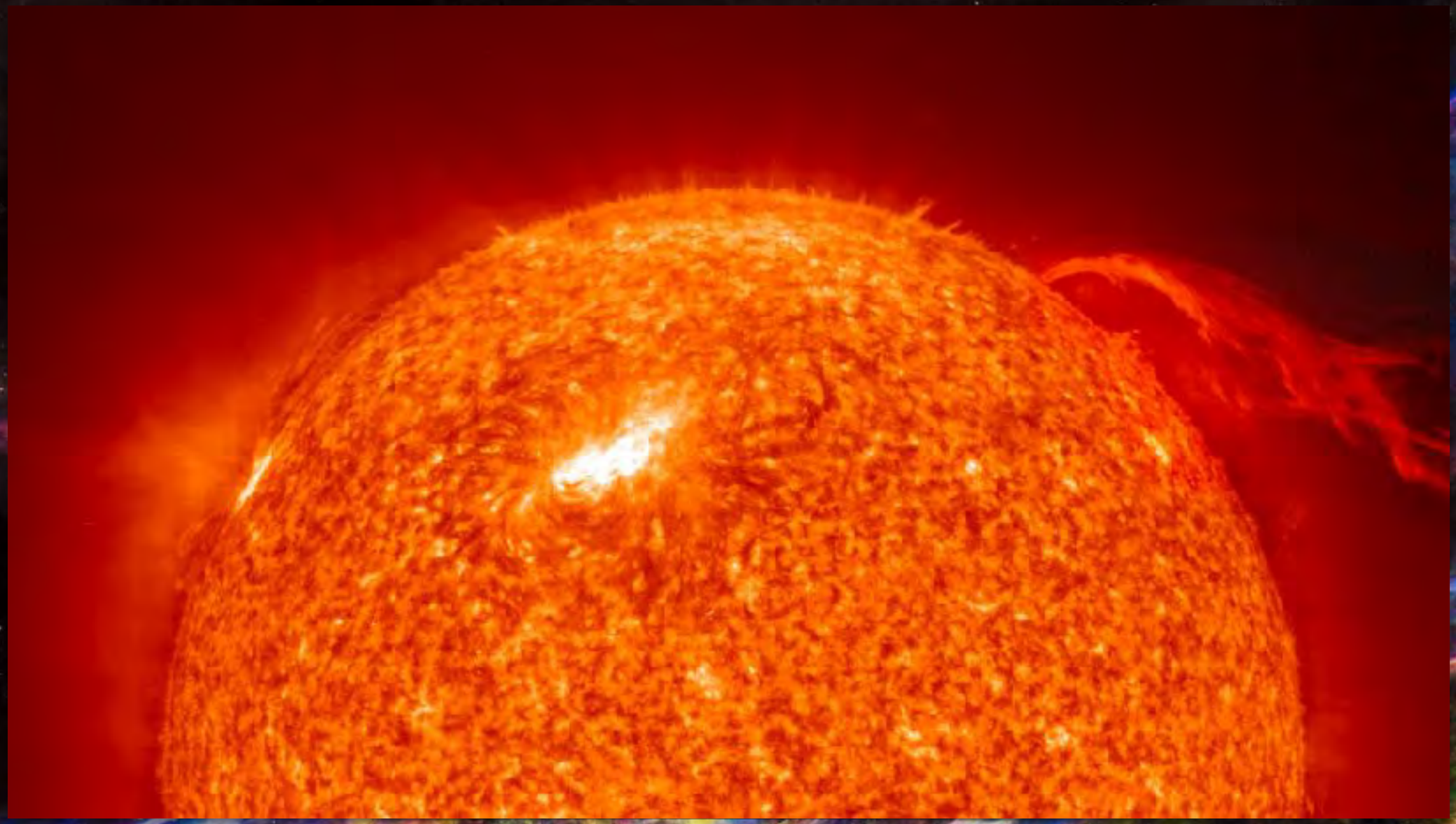


EXTREMES OF ASTROPHYSICS

- Extreme energies
- msec to few minutes variability
- Relativistic velocities
- Ultra high magnetic fields
- A 0.511 MeV electron reaching to TeV energies

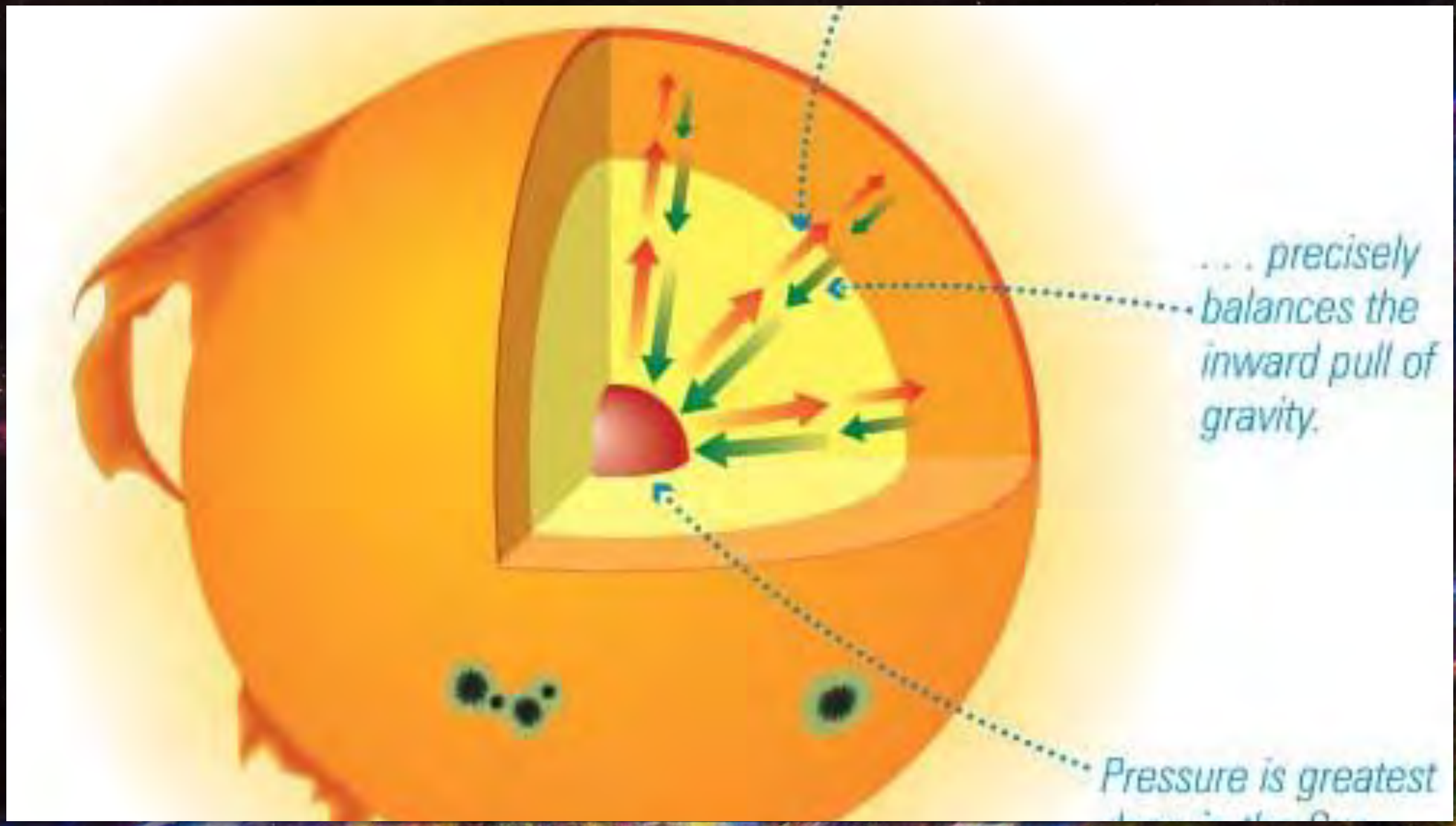


In the heart of this, lies a massive star in all its glory - responsible for the extremes of Astrophysics



THE SUN

Source of energy



THE SUN

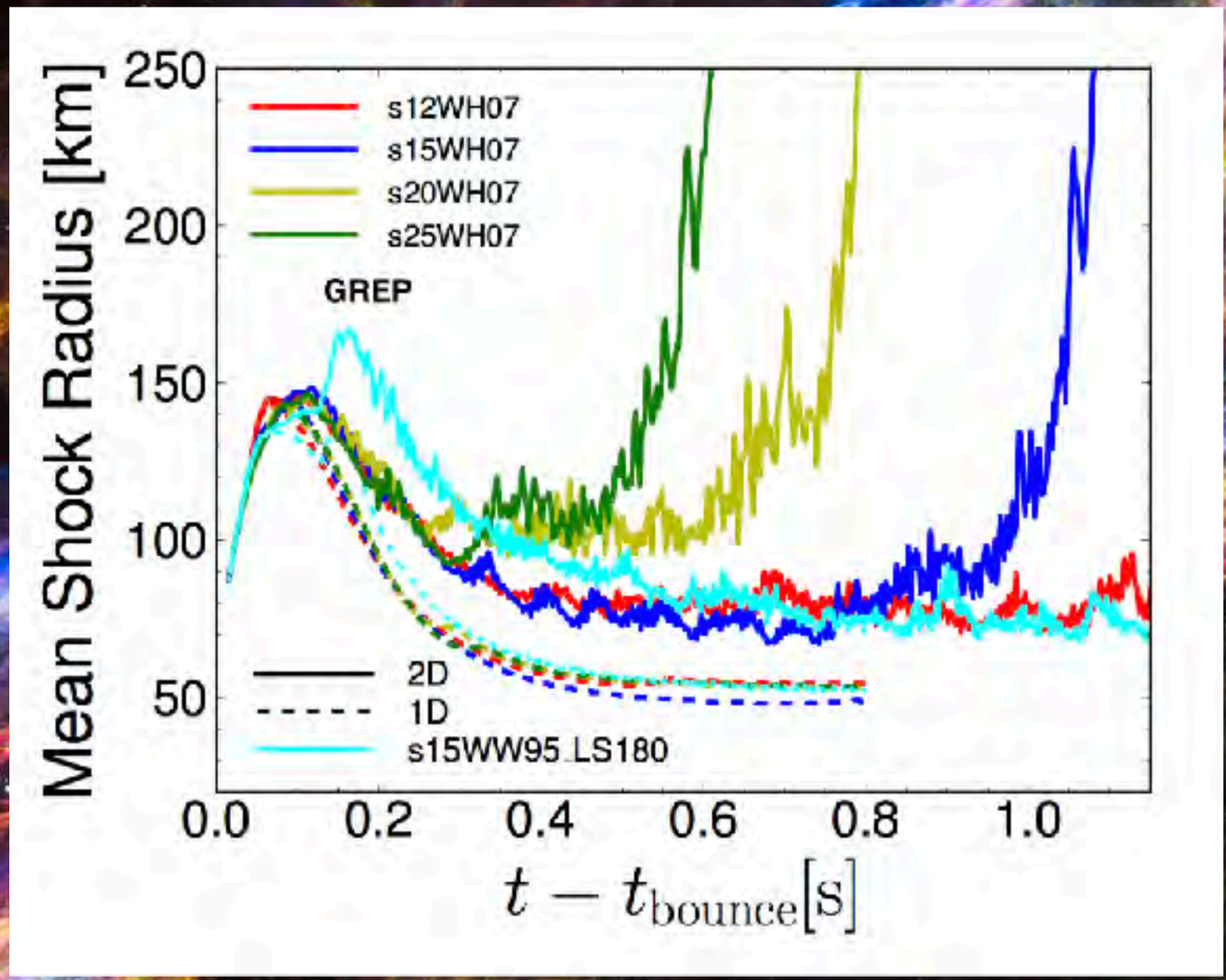
Nuclear fusion

How does a stellar evolution ends so violently

Answer:

I don't know

HOW A STELLAR EVOLUTION ENDS SO VIOLENTLY



Evan O'Connor

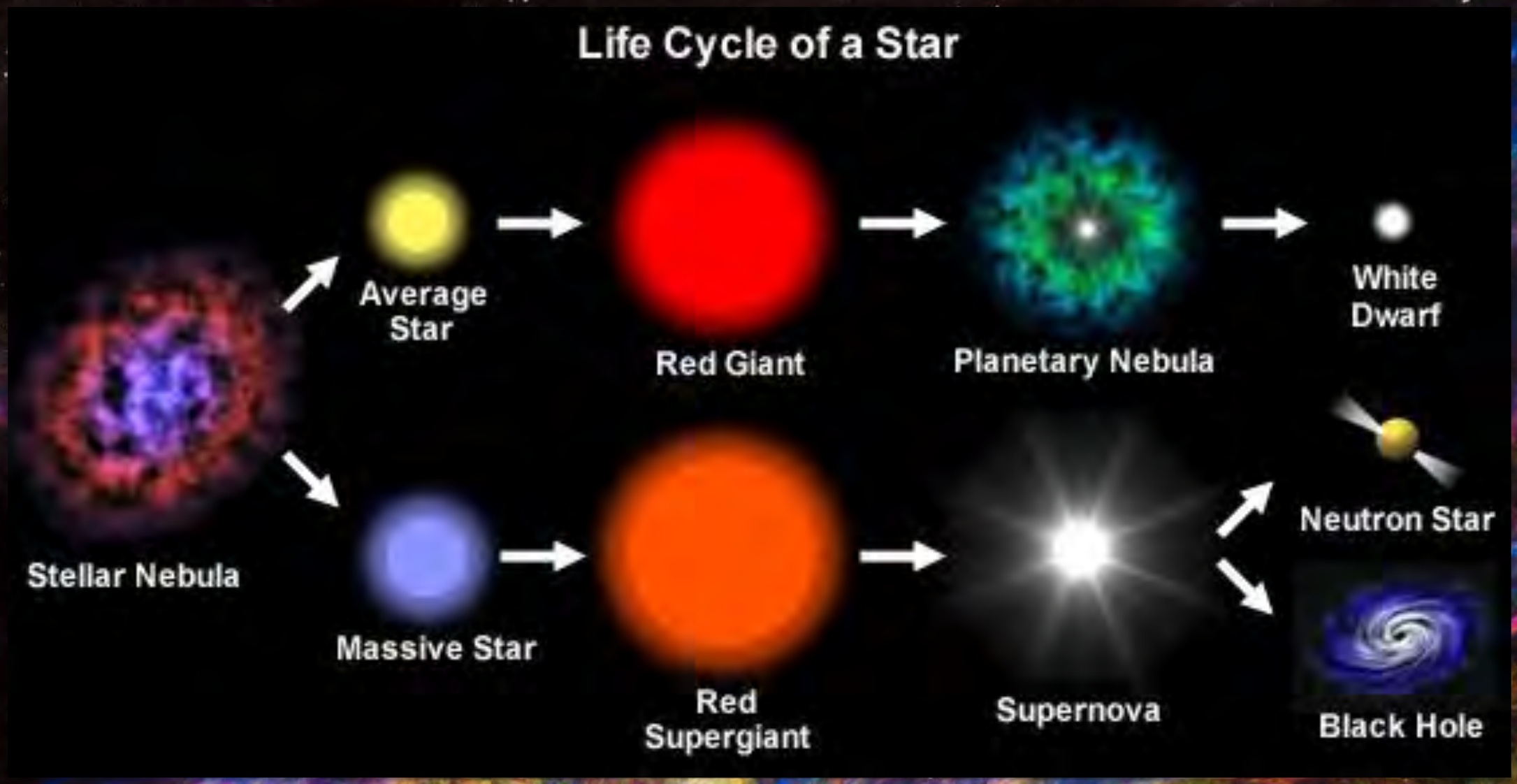
Poonam Chandra

DIFFERENCE BETWEEN NON-EXPLOSION TO EXPLOSION

- Neutrino Physics
- Magnetic fields
- Rotation
- 2D versus 3D
- Standing accretion shock instability!

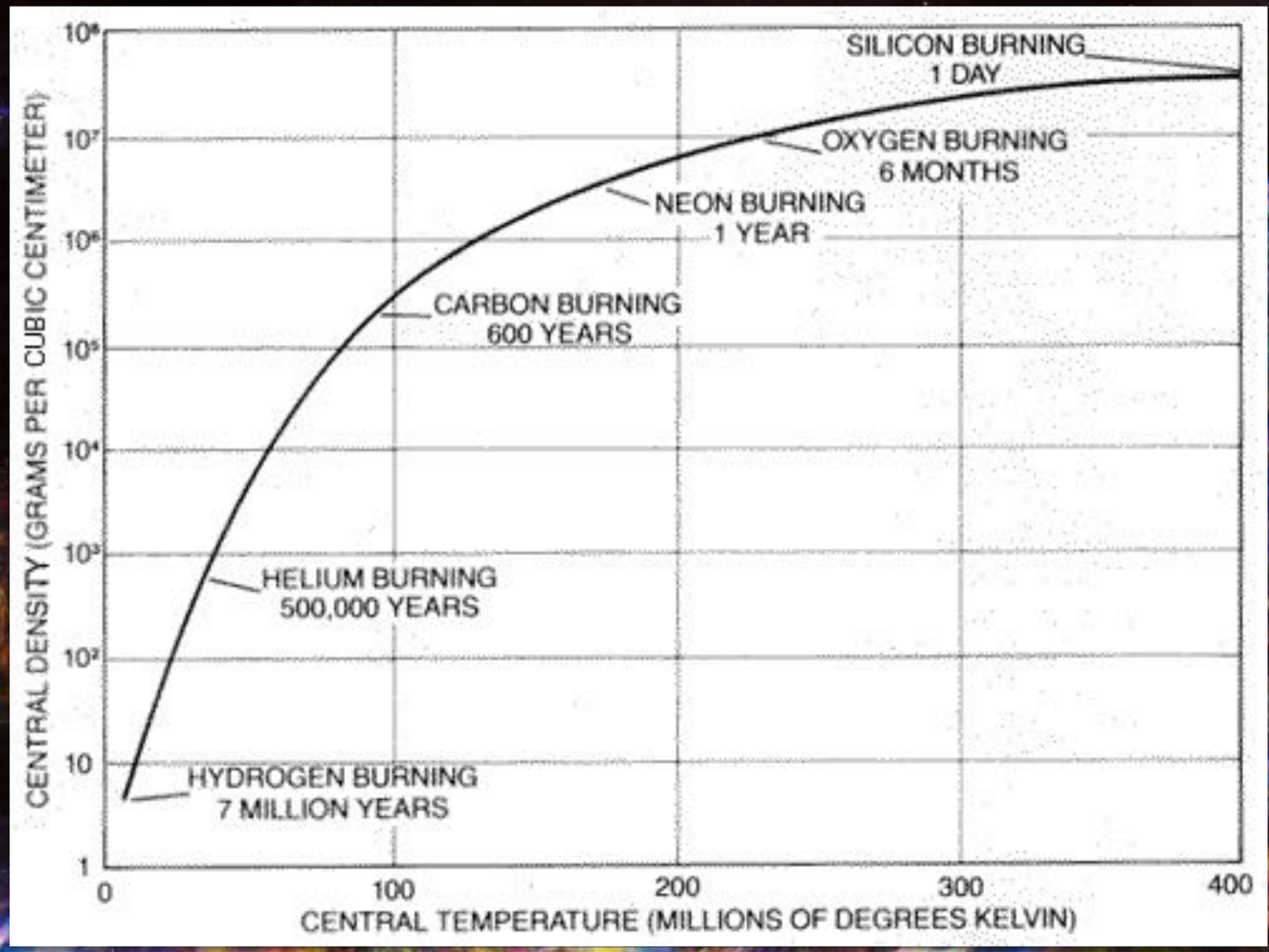
A JOURNEY FROM THE SUN TO A MASSIVE STAR

- Nuclear Fusion
- Formation of Iron core
- Implosion of Iron core
- Formation of Neutron star/black hole
- Explosion - 10^{51} ergs energy



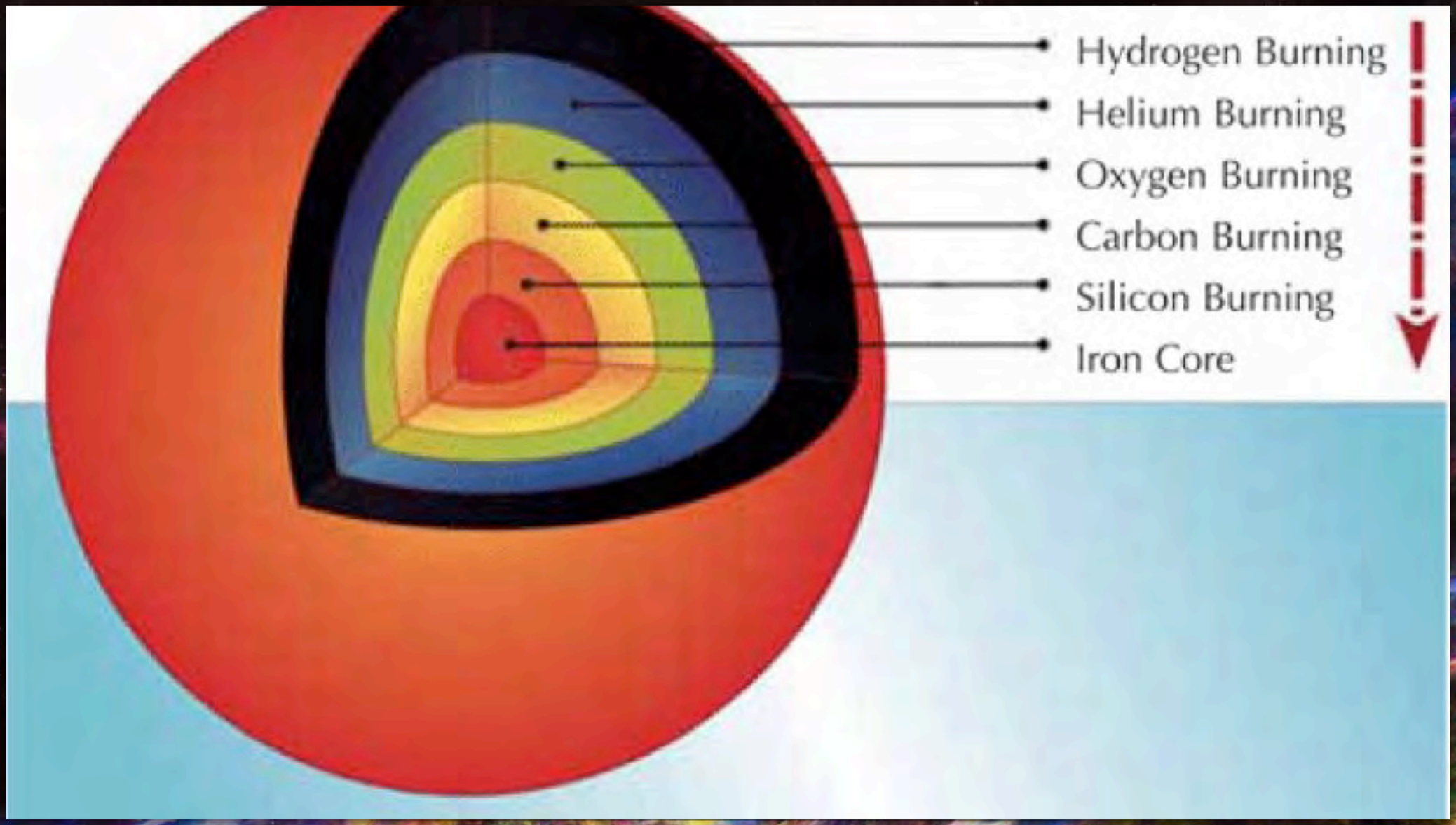
MASSIVE STARS

Life cycle



STELLAR EVOLUTION

Core properties



MASSIVE STARS

Nuclear Fusion

THERMONUCLEAR SUPERNOVAE

- Progenitor 4-8 $M_\odot$ star

- Life cycle of this star with make white dwarf, but heavier than Sun.

- Binary companion

CORE-COLLAPSE SUPERNOVAE

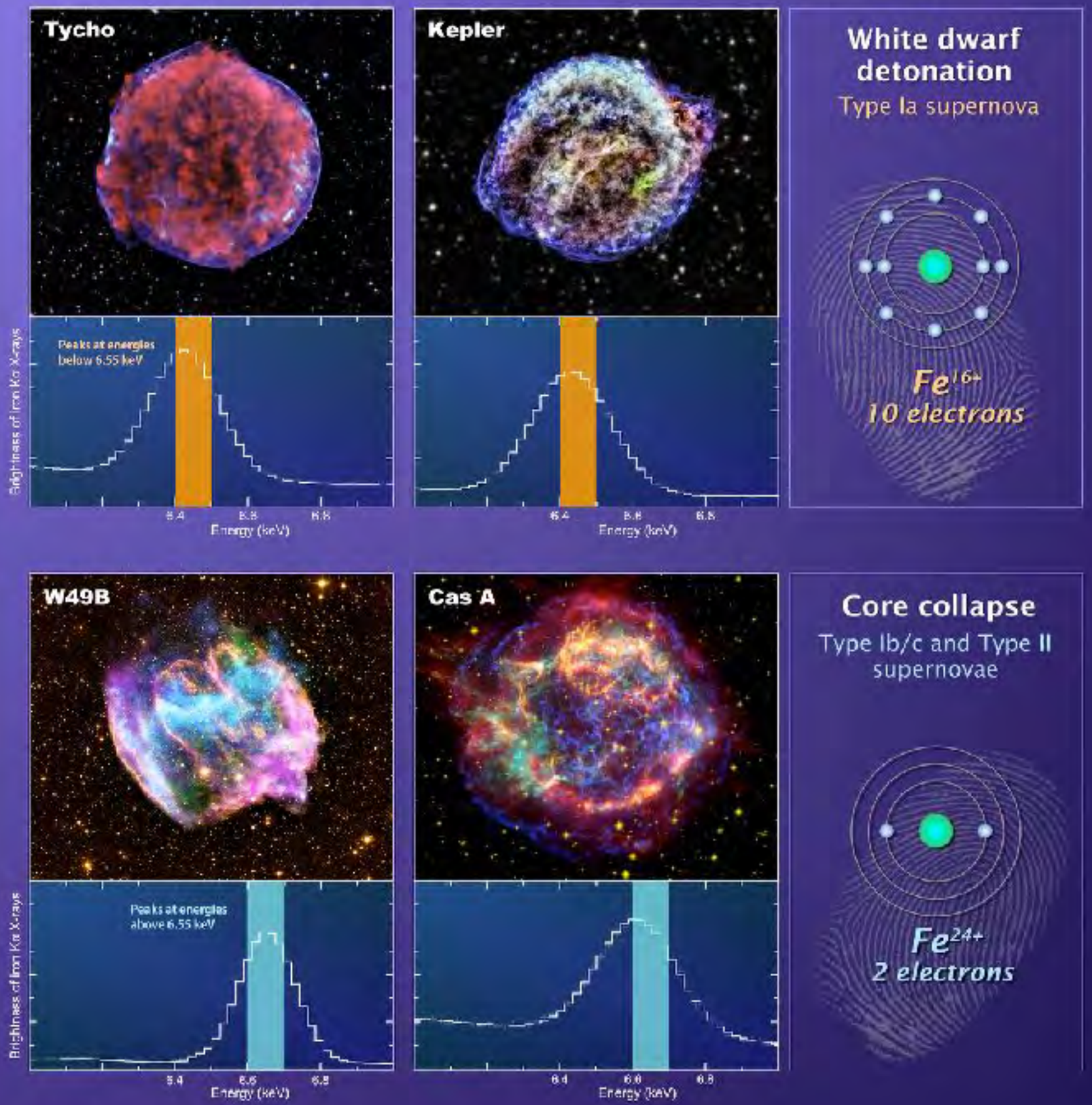
- All supernovae other than thermonuclear explosions are core collapse supernovae

- Progenitor >8 $M_\odot$ star

- Nuclear fusion reaches Si —> Fe state

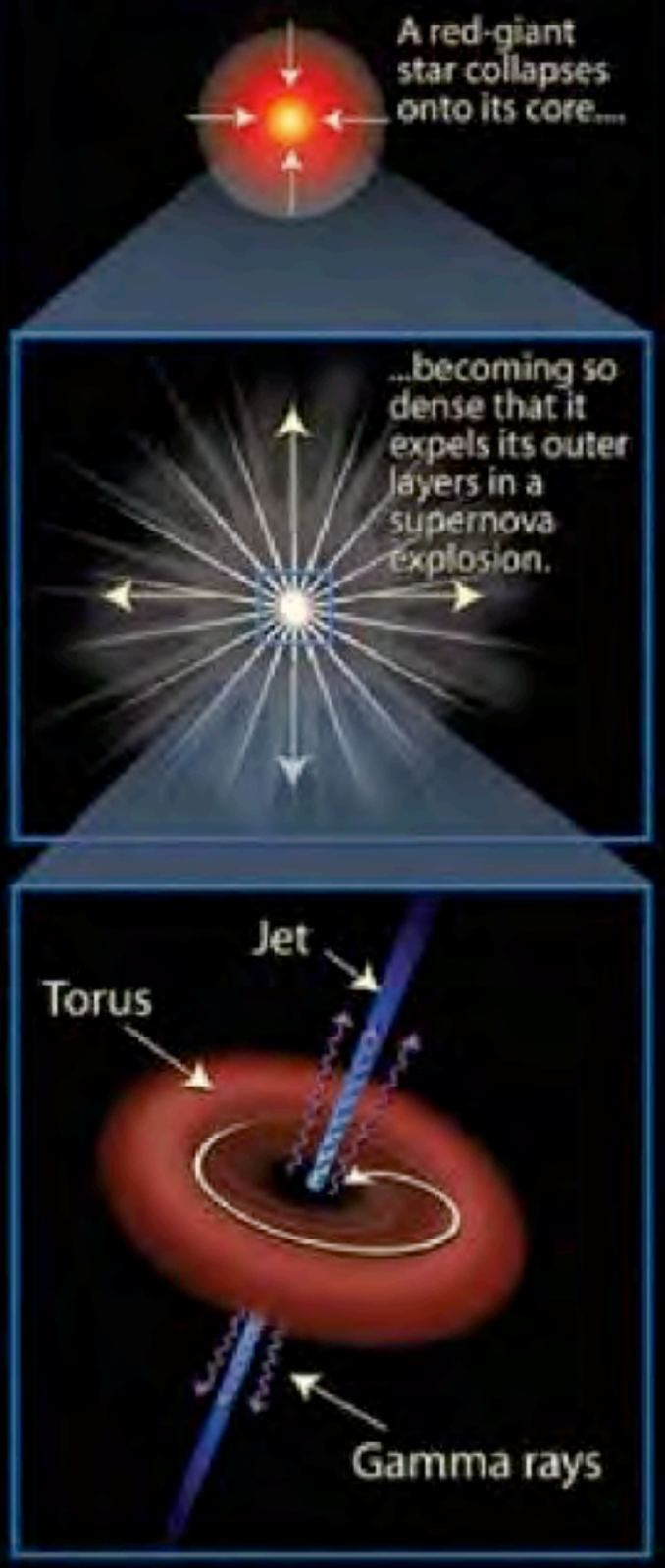
- Implosion converted into explosion

X-ray Fingerprints of Supernova Remnants



Gamma-Ray Bursts (GRBs): The Long and Short of It

Long gamma-ray burst
(>2 seconds' duration)

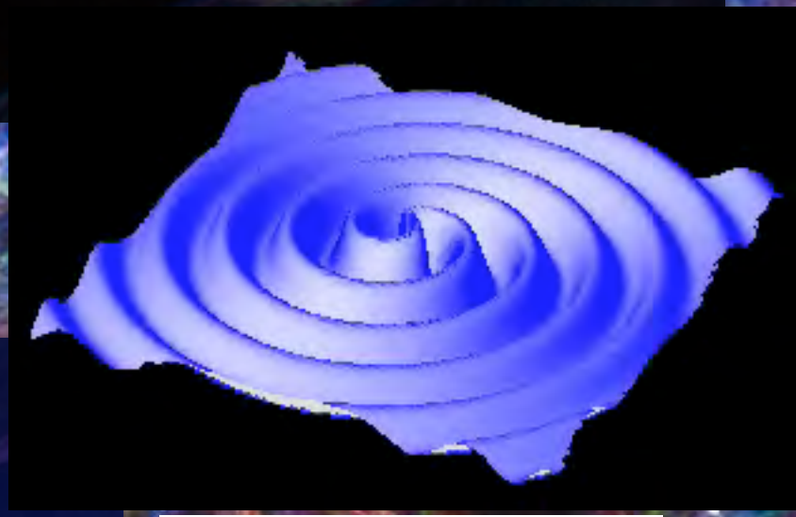


Short gamma-ray burst
(<2 seconds' duration)

Poonam Chandra

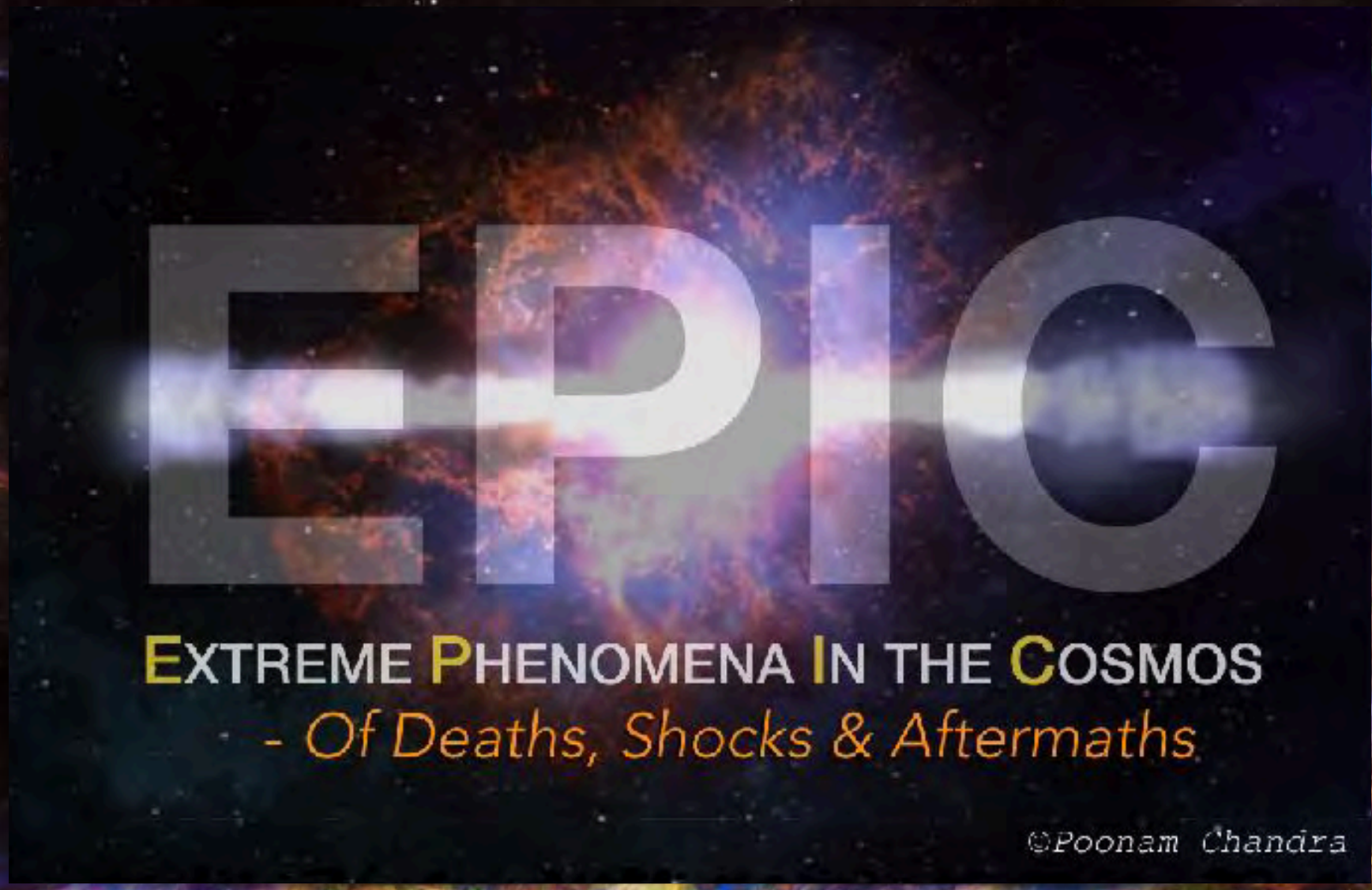
GRAVITATIONAL WAVES

$$h = \frac{2Gd^2Q}{rc^4dt^2}$$



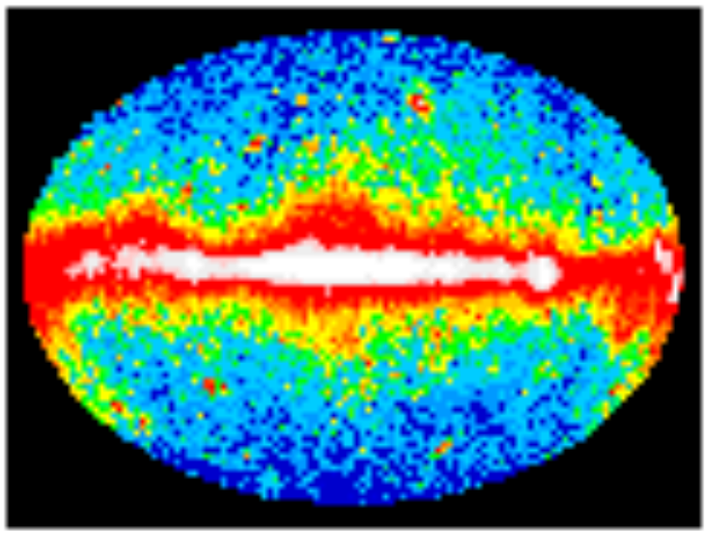
- Ripples in the curvature of space-time. How mass deforms shape of the speed. Deformation can move with speed of light.

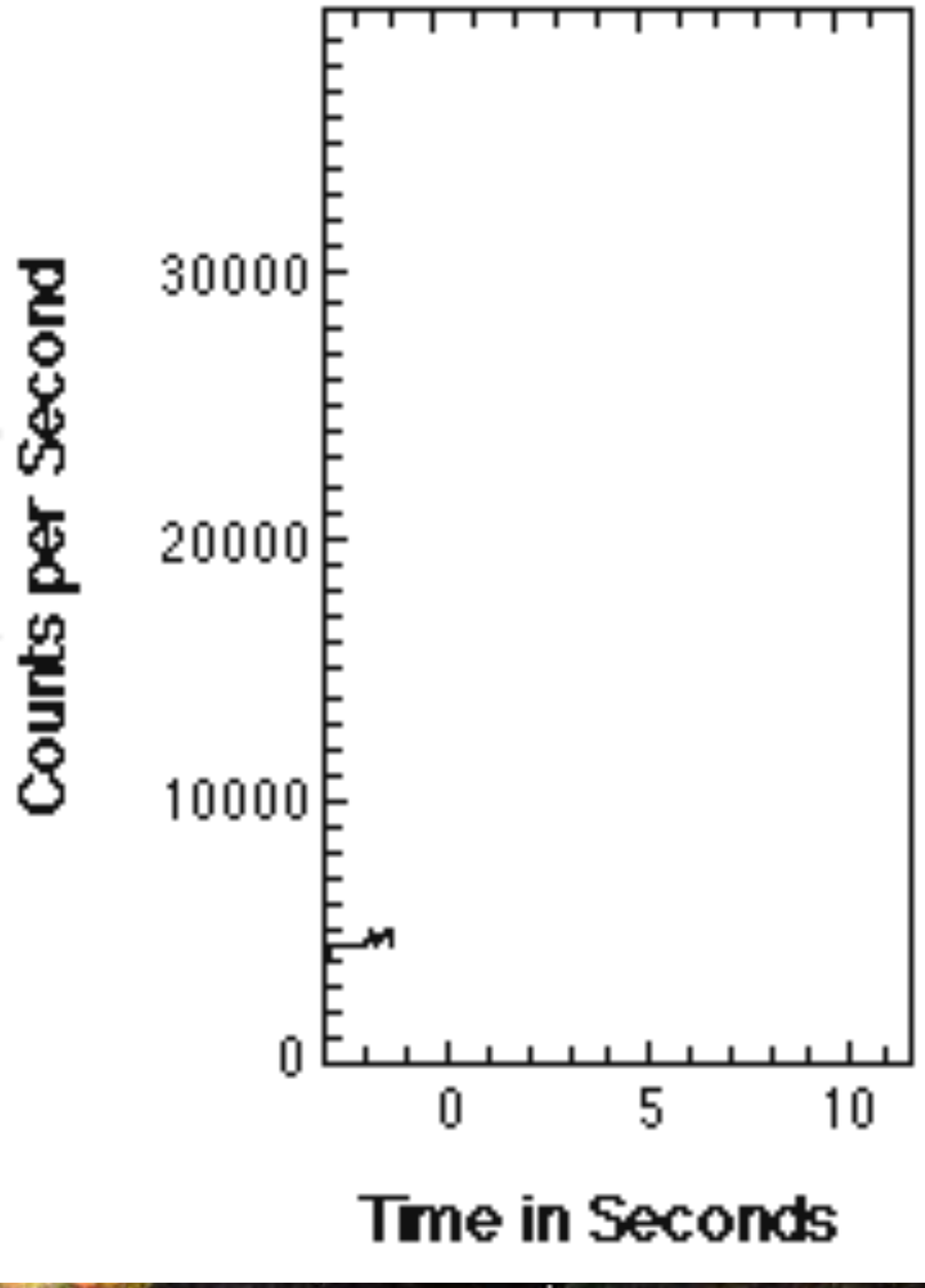
- Anything undergoing violent acceleration can produce gravitational waves.



EXTREME PHENOMENON IN THE COSMOS

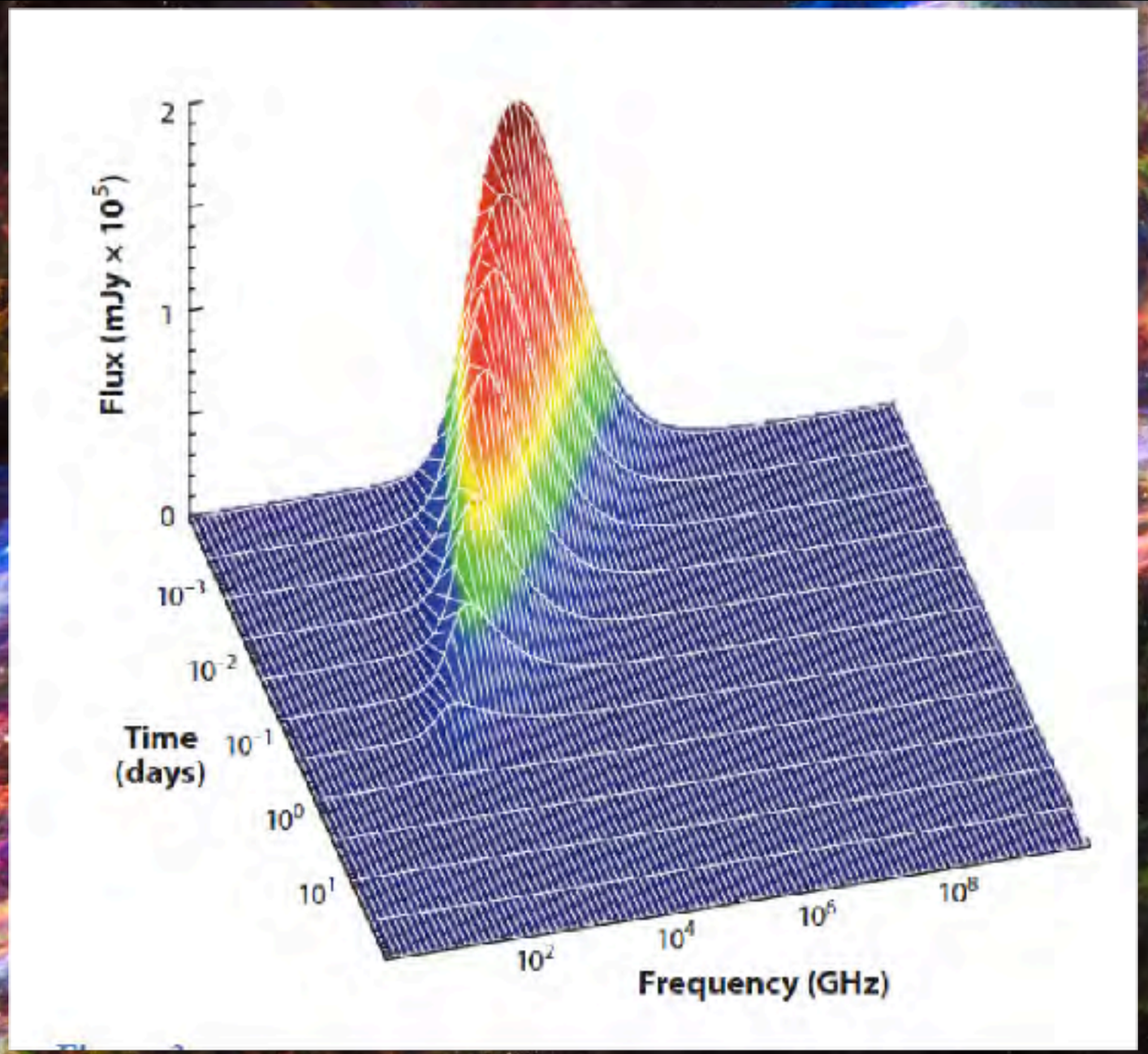
-Of Shocks, Deaths and Aftermaths





EXTREME ENERGIES

SYNCHROTRON EMISSION

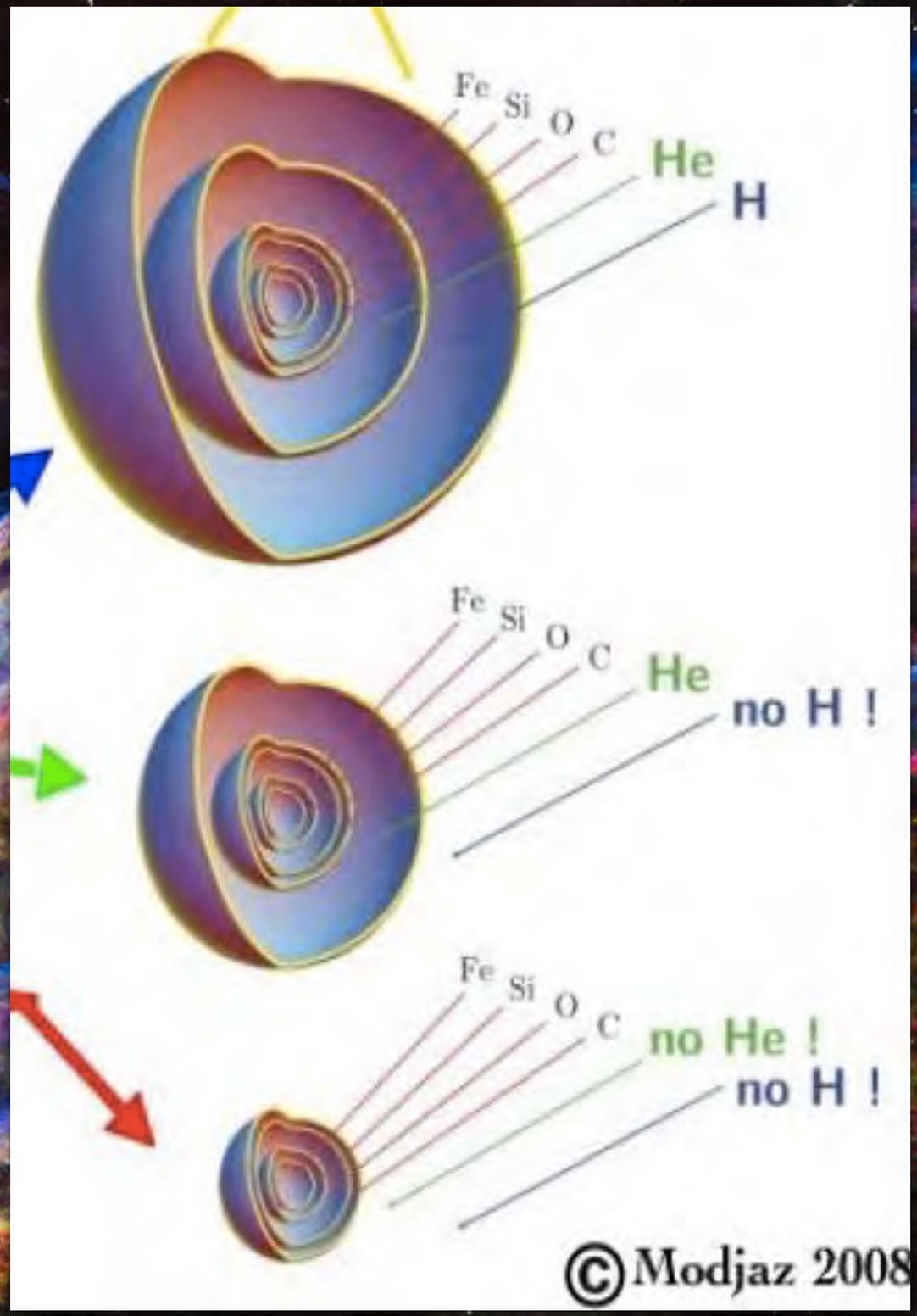


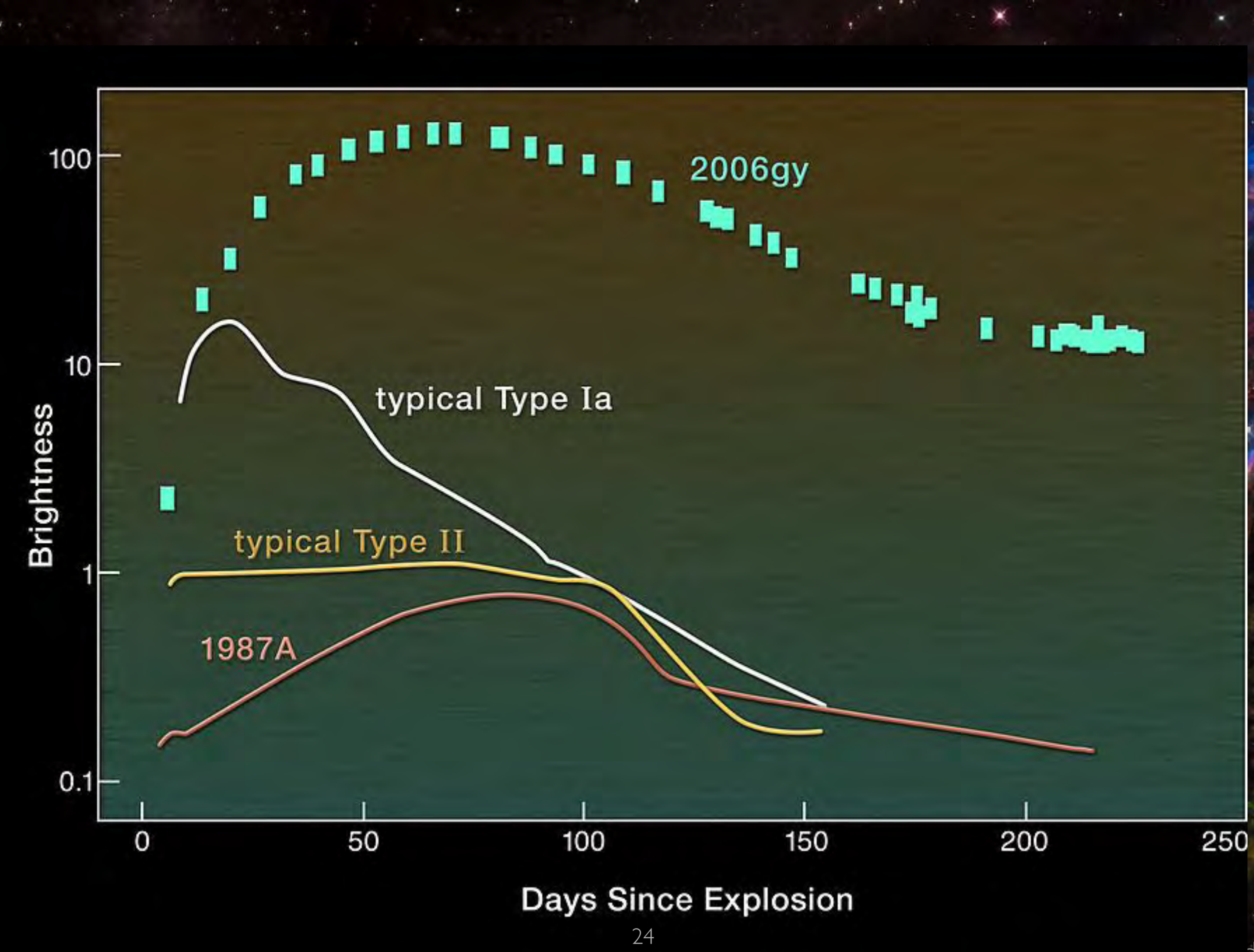
SUPERSONIC SPEEDS

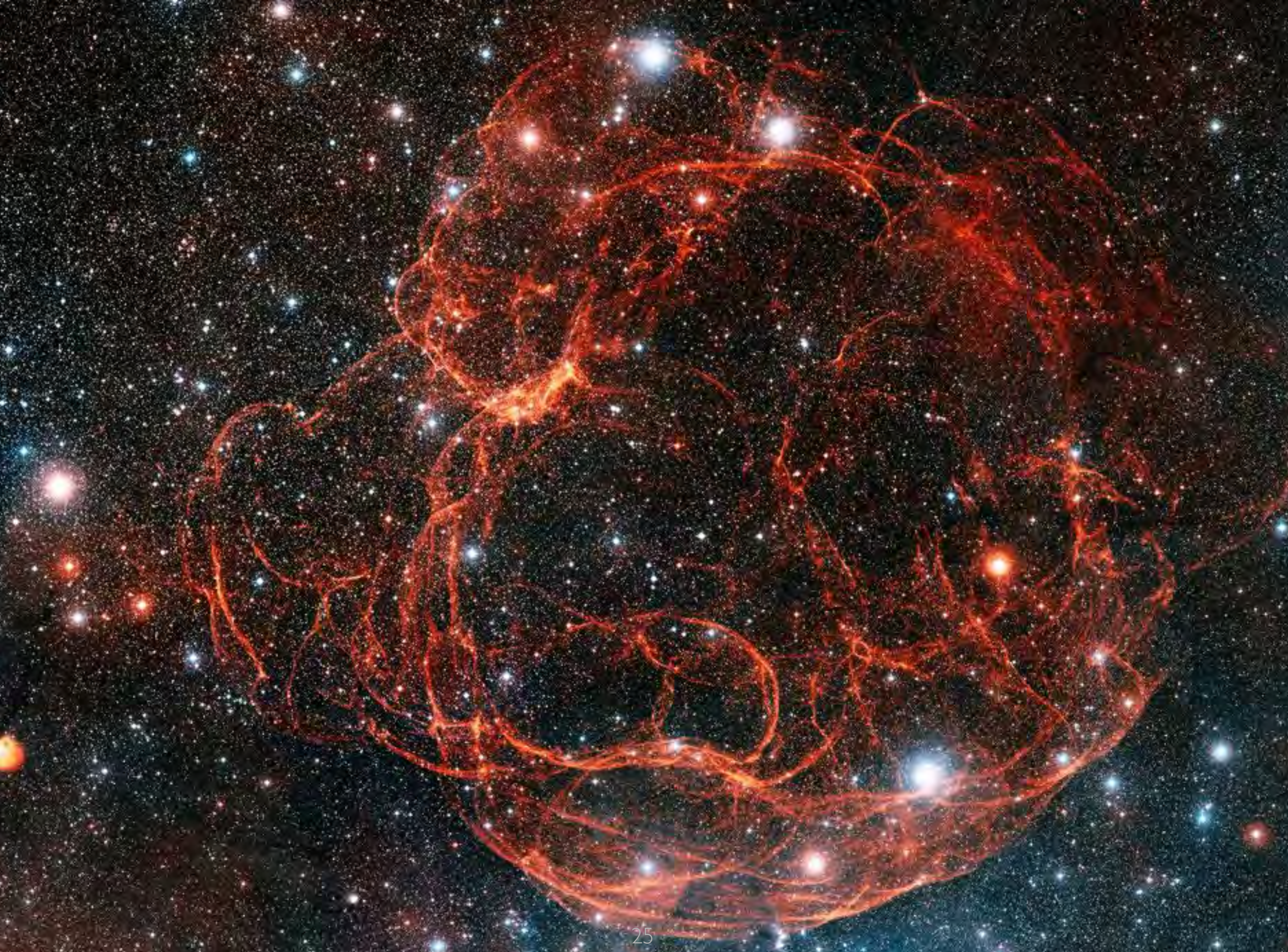
CORE-COLLAPSE SUPERNOVAE

Various subtypes, but fixed energy of 1E51 ergs.

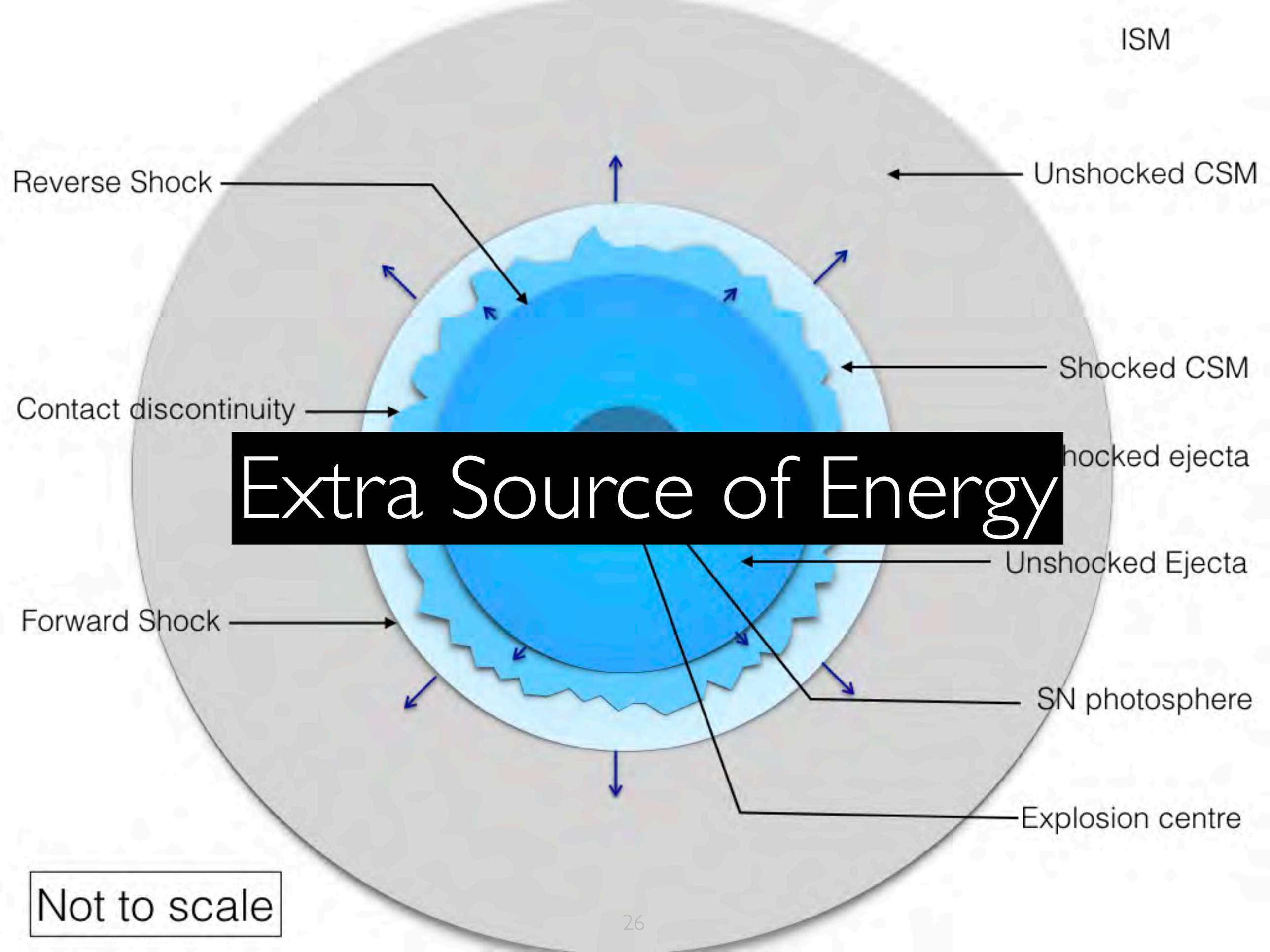
However…….

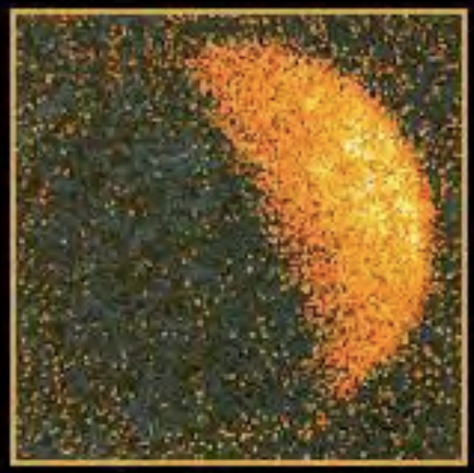



100
10
1
0.1
Brightness
2006gy
typical Type Ia
typical Type II
1987A
0
50
100
150
200
250
Days Since Explosion



Extra Source of Energy



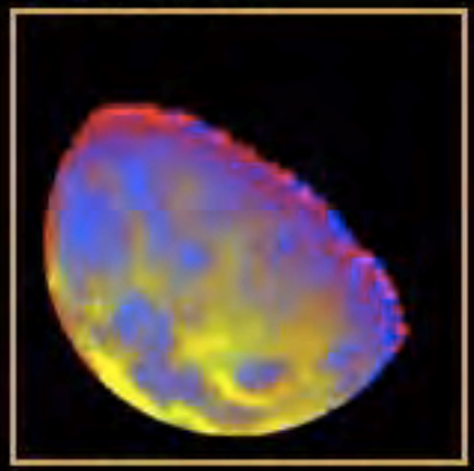


X-Ray: ROSAT

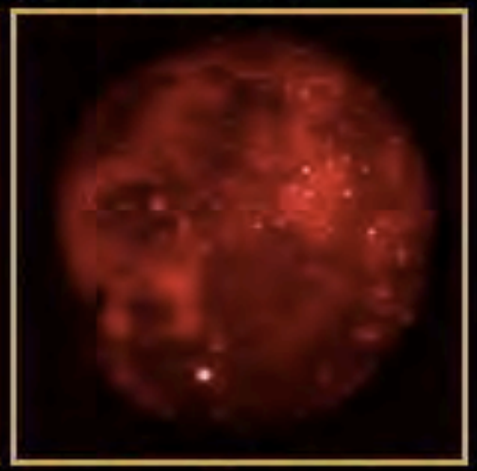
UV ASTRO-2 UIT

Visible: TIE - Colleen Gino

Visible Color: Galileo

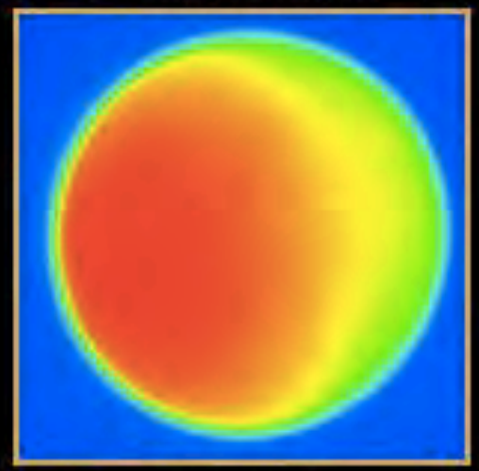


Near Infrared: Galileo



Mid Infrared: MSX

Far-Infrared Image
Not Available

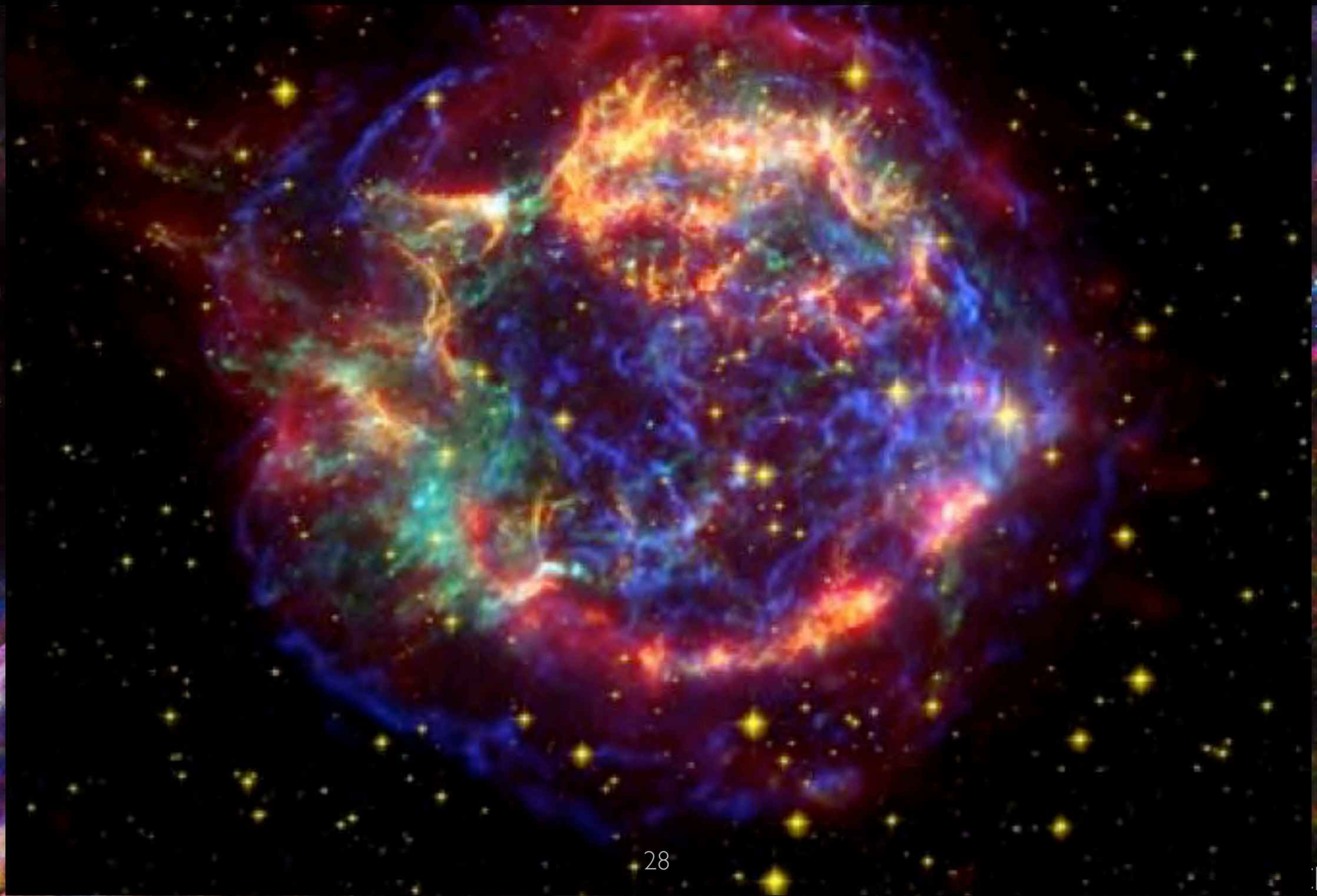


Radio: NRAO VLA

MULTIWAVEBAND ASTRONOMY

Complimentary Information

KEPLER SUPERNOVA REMNANT



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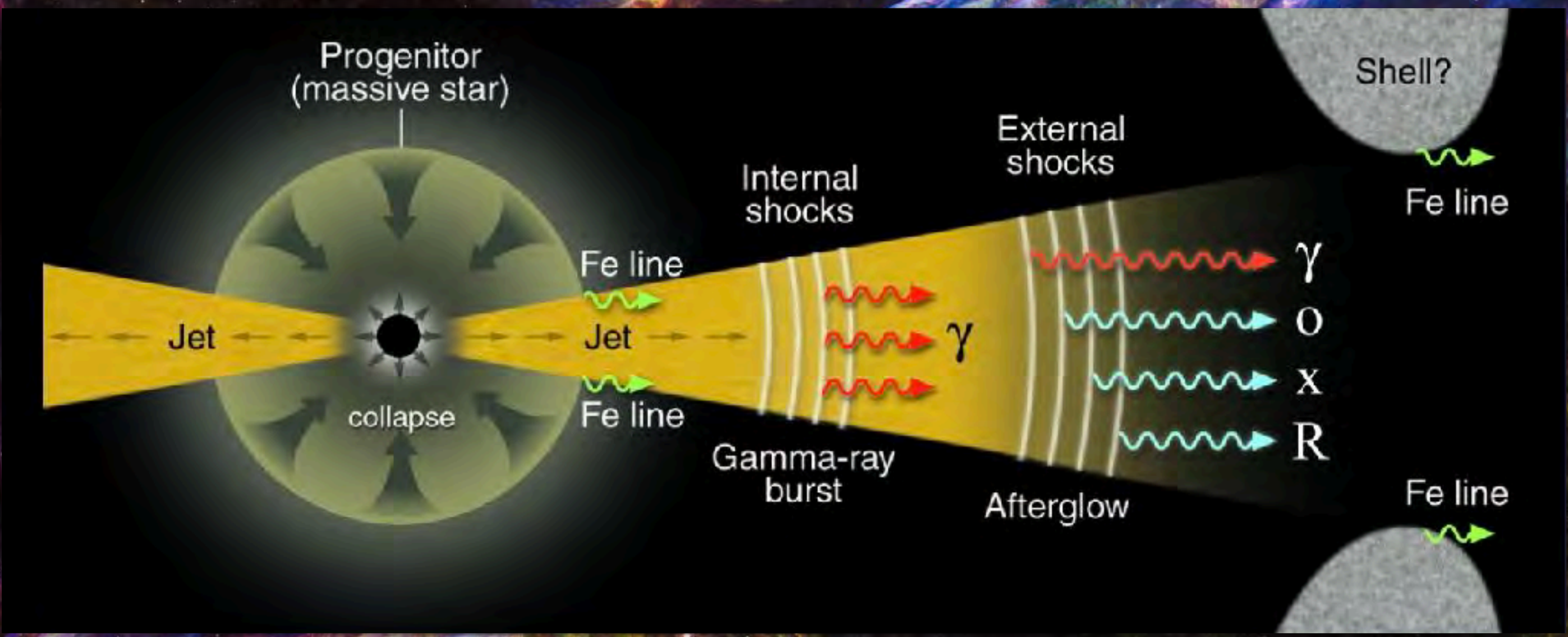
GAMMA RAY BURSTS



SUPERNOVAE AND GRB SEARCHES

- Robotic Surveys - iPTF, ASAS-SN, Amateur Astronomers
- Future Missions like LSST
- For GRBs - Swift has changed the GRB Physics