

Supernovae and Neutron Stars

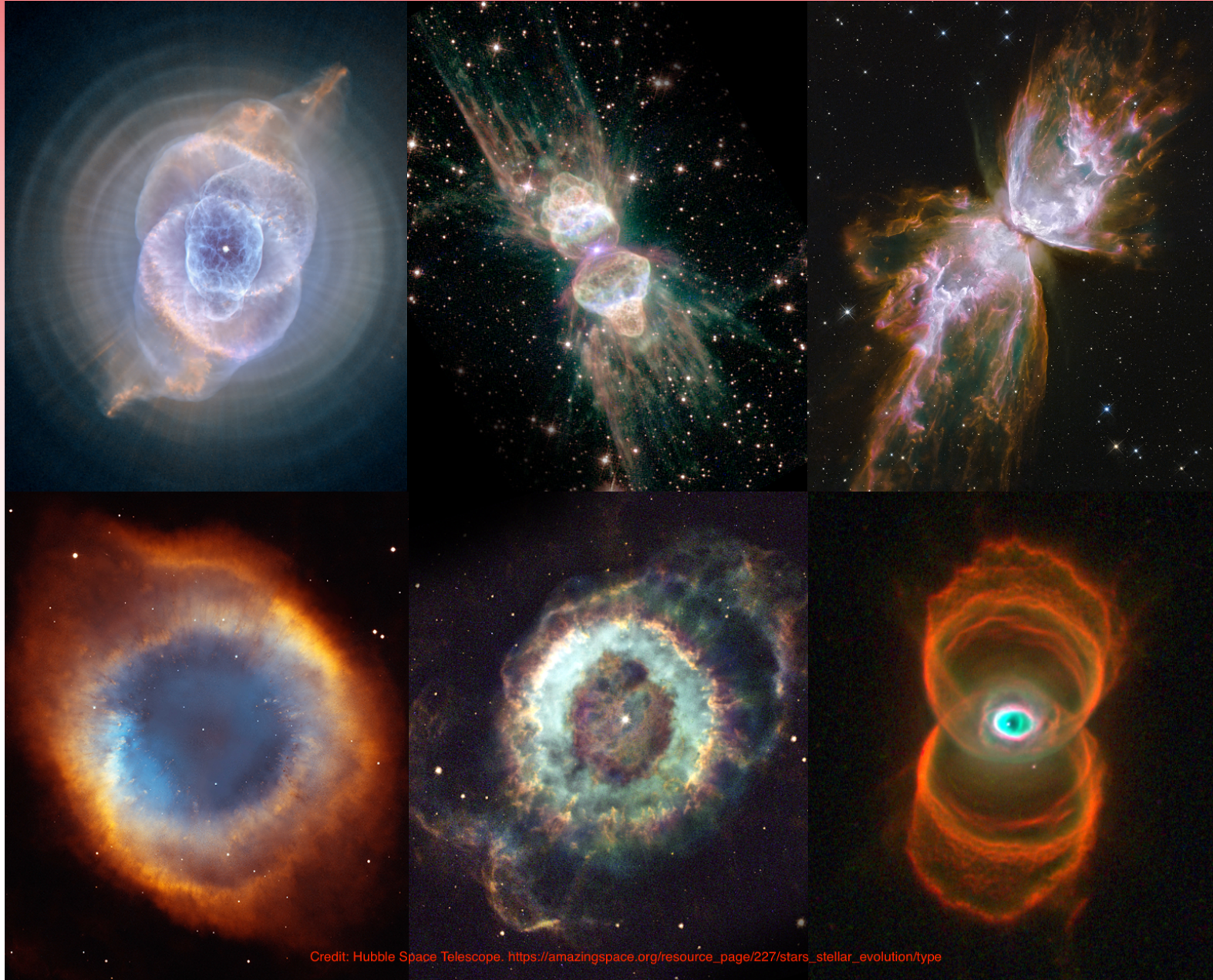
Physics 090

2020-04-29

Endgames of Stars—By Size

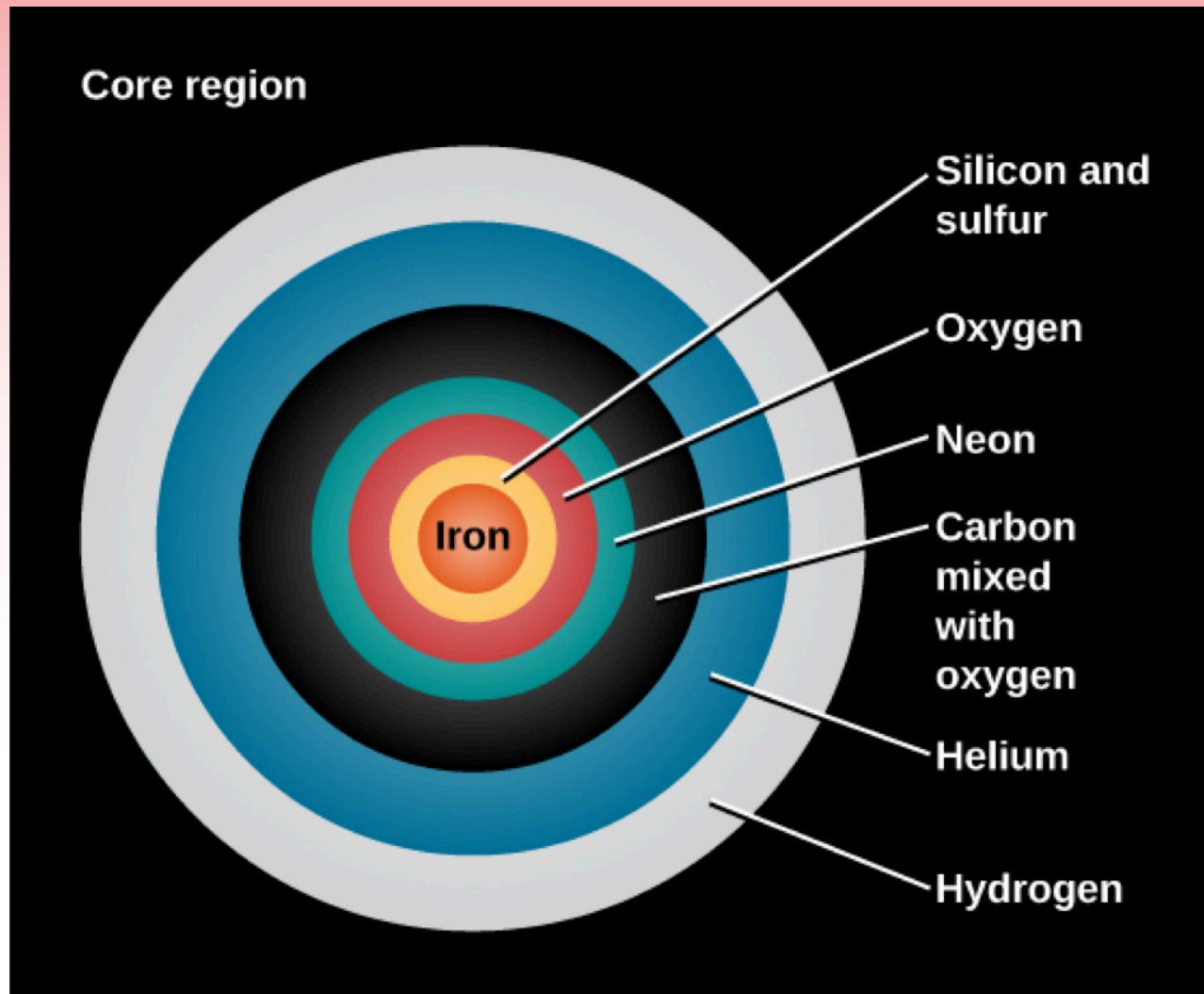
Initial Mass (Mass of Sun = 1) ^[1]	Final State at the End of Its Life
< 0.01	Planet
0.01 to 0.08	Brown dwarf
0.08 to 0.25	White dwarf made mostly of helium
0.25 to 8	White dwarf made mostly of carbon and oxygen
8 to 10	White dwarf made of oxygen, neon, and magnesium
10 to 40	Supernova explosion that leaves a neutron star
> 40	Supernova explosion that leaves a black hole

"Planetary" Nebulae in Our Galaxy



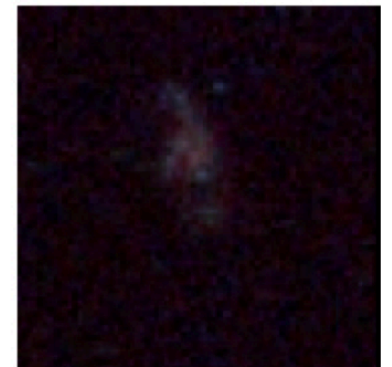
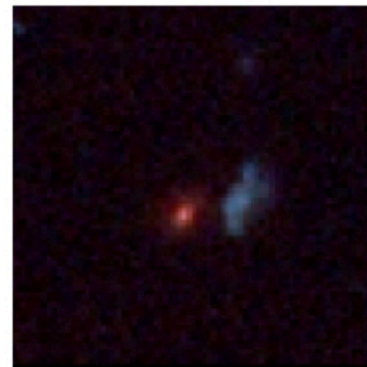
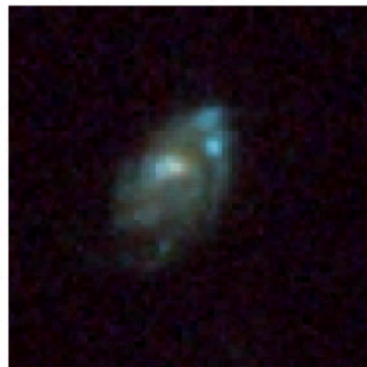
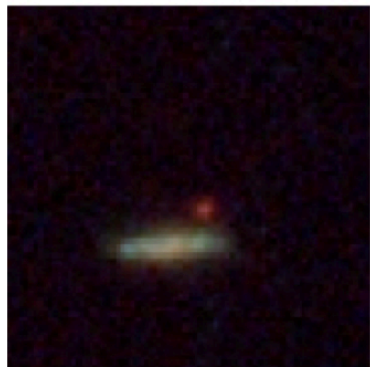
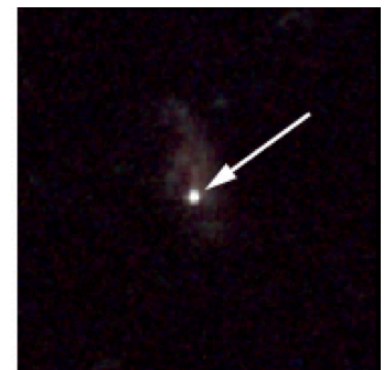
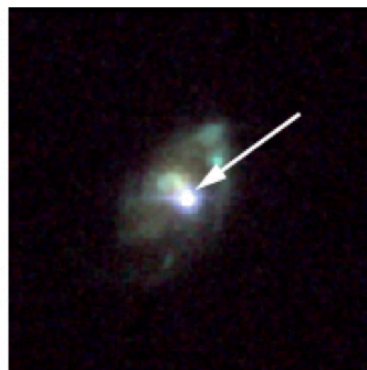
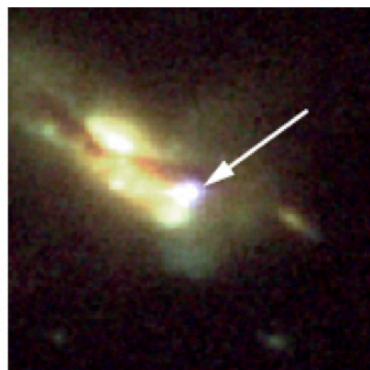
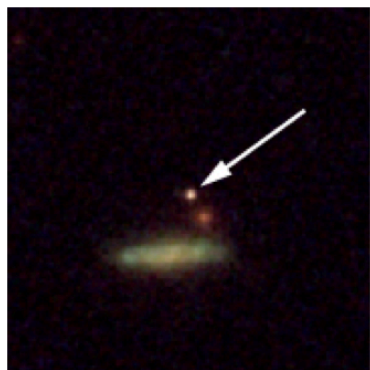
Credit: Hubble Space Telescope. https://amazingspace.org/resource_page/227/stars_stellar_evolution/type

End of Fusion — Massive Star $>8x$ Sun



Supernovae Observed in Other Galaxies

(None in our Galaxy in >300 years)



HST04Sas

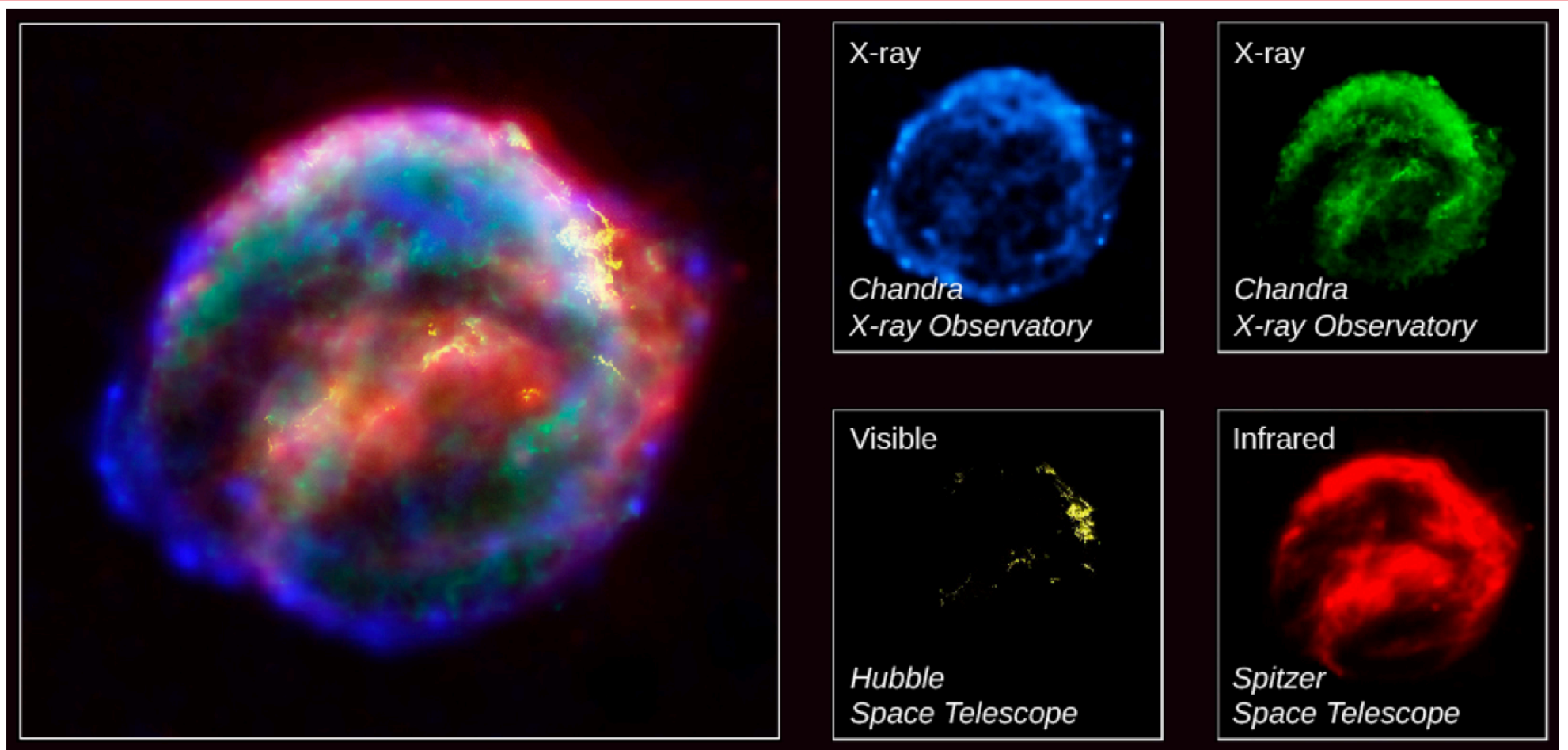
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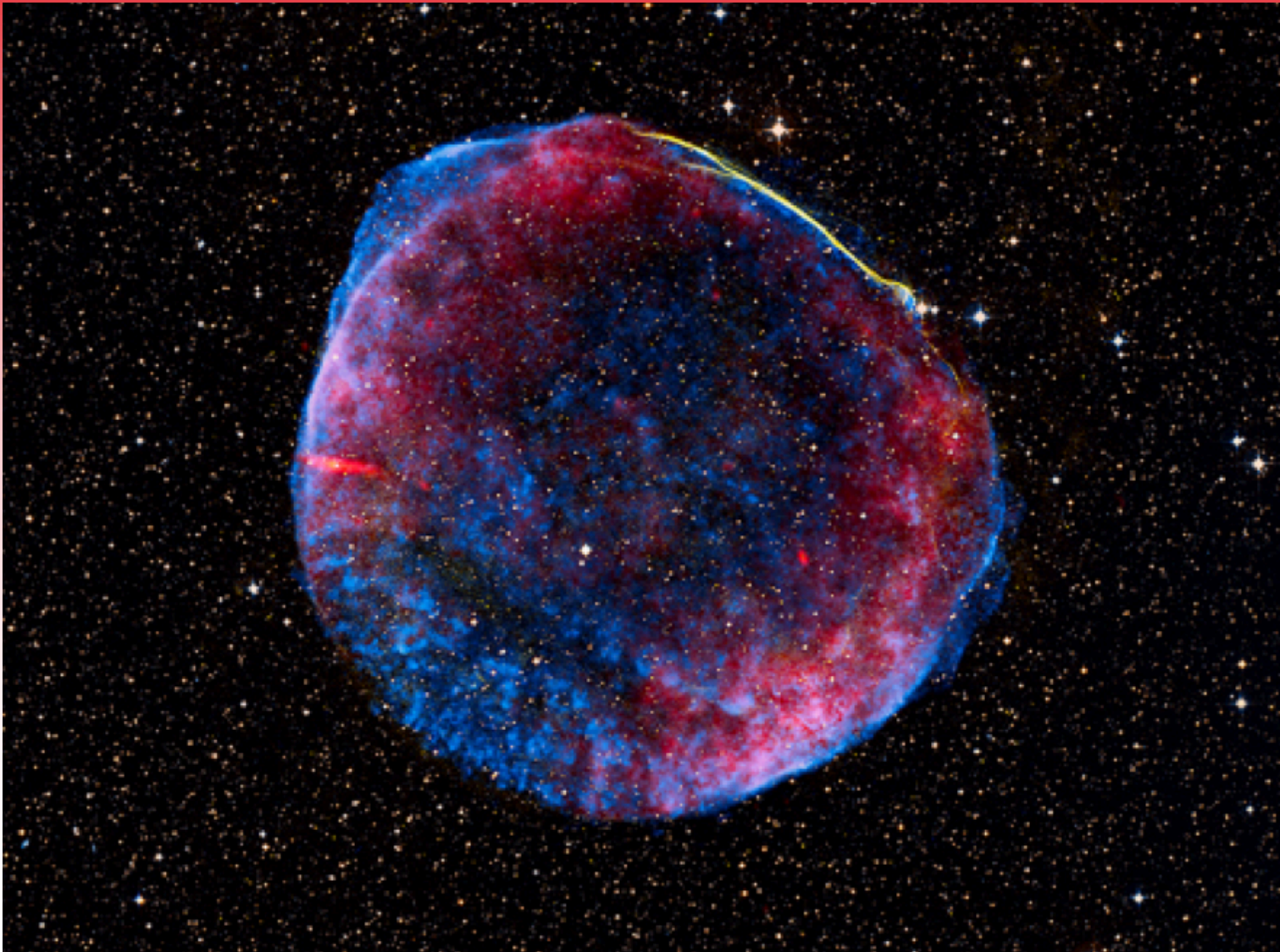
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HST05Lan

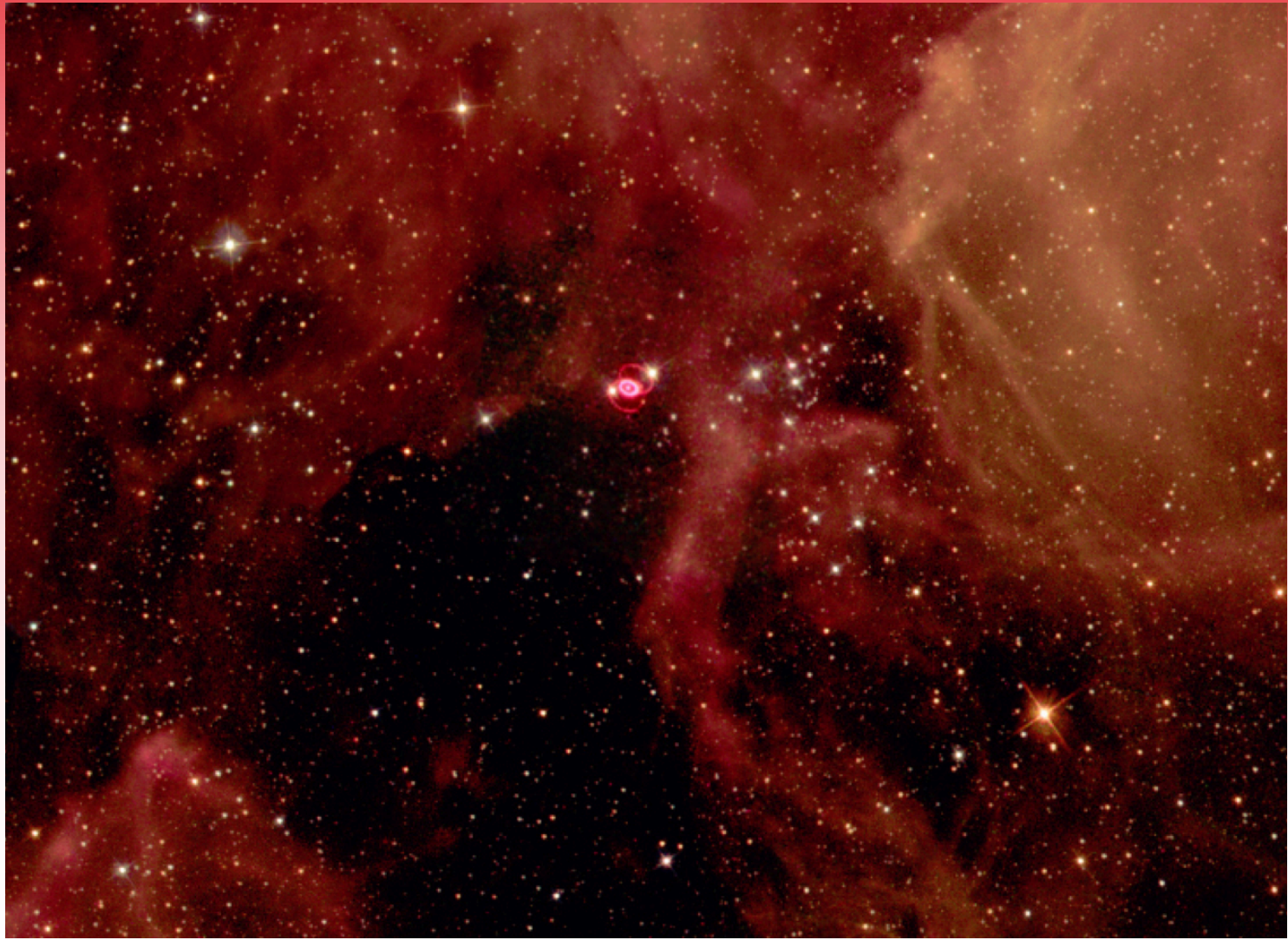
HST05Str

Composite Image Kepler Supernova Today

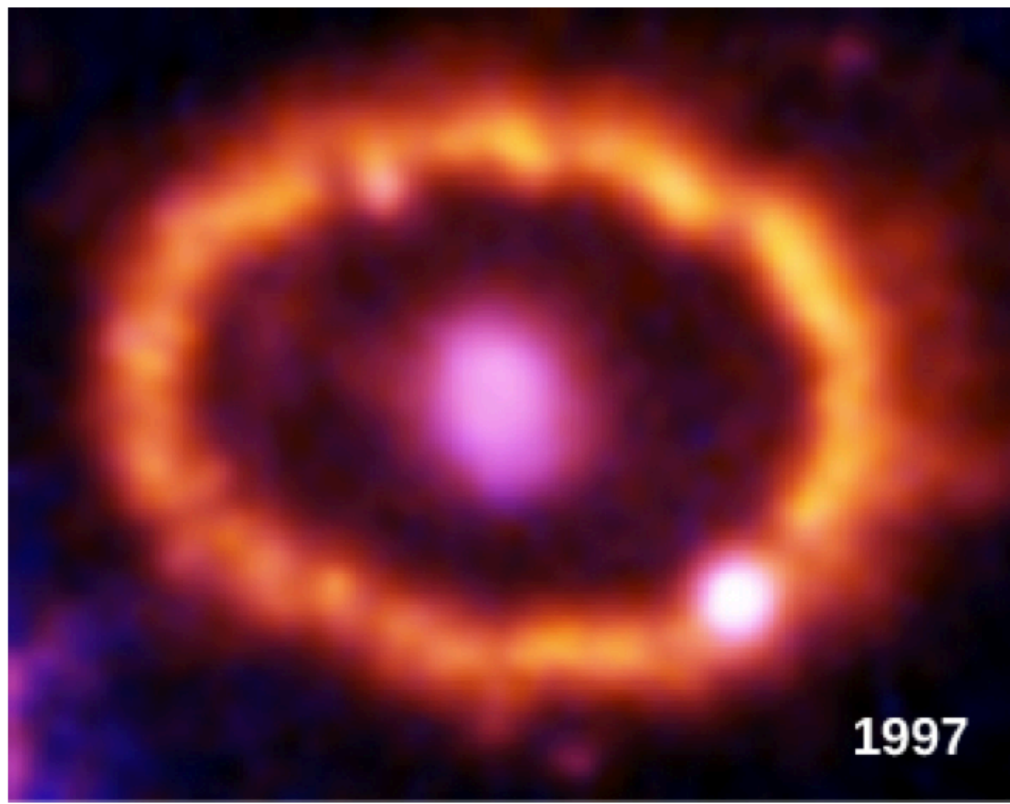




Composite Image
Supernova 1006



Hubble Space Telescope Image
Supernova 1987A



Evolution of
Supernova 1987A

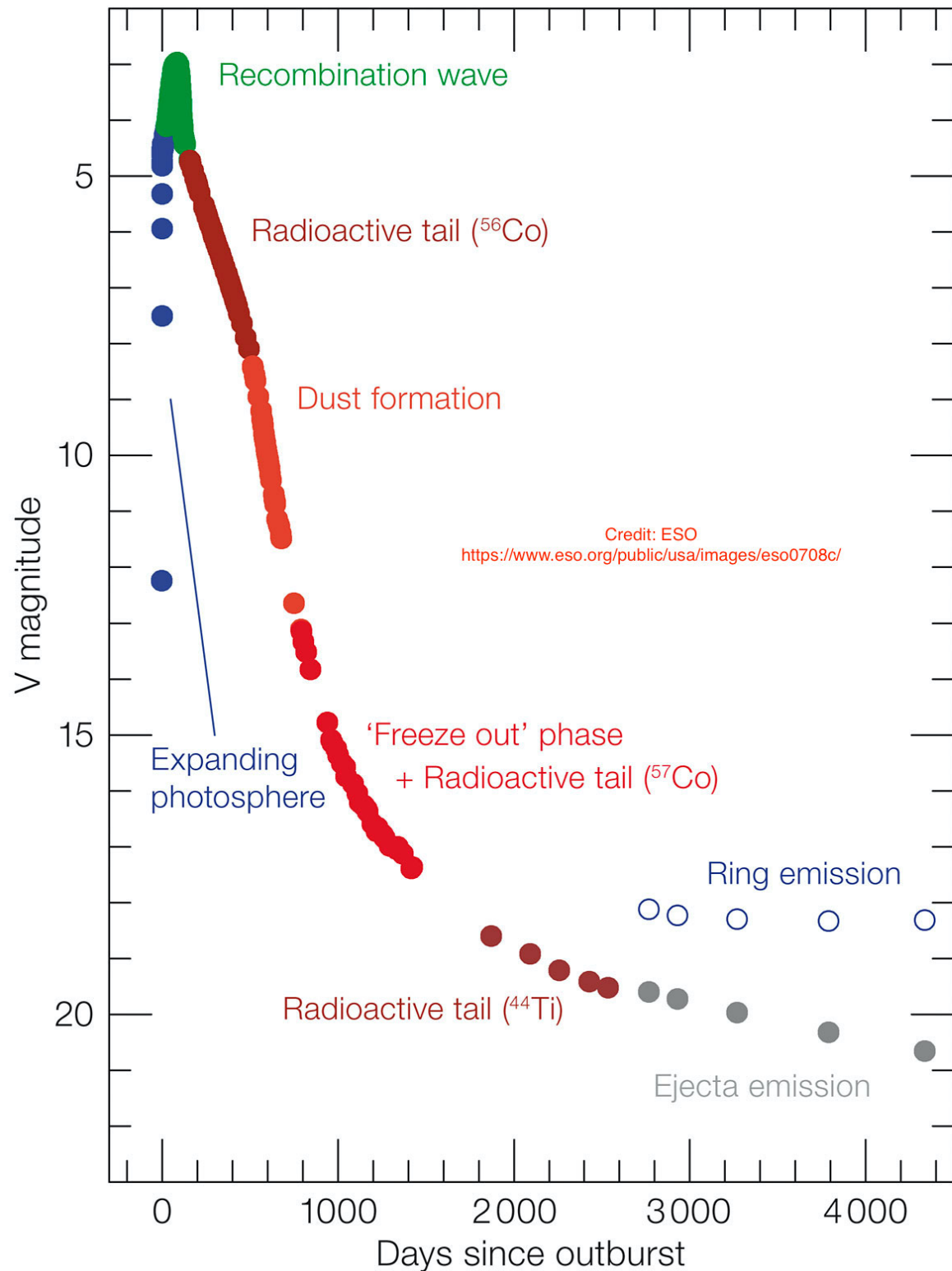
The Life History of the Star Leading to Supernova 1987A

Phase	Central Temperature (K)	Central Density (g/cm ³)	Time Spent in This Phase
Hydrogen fusion	40×10^6	5	8×10^6 years
Helium fusion	190×10^6	970	10^6 years
Carbon fusion	870×10^6	170,000	2000 years
Neon fusion	1.6×10^9	3.0×10^6	6 months
Oxygen fusion	2.0×10^9	5.6×10^6	1 year
Silicon fusion	3.3×10^9	4.3×10^7	Days
Core collapse	200×10^9	2×10^{14}	Tenths of a second

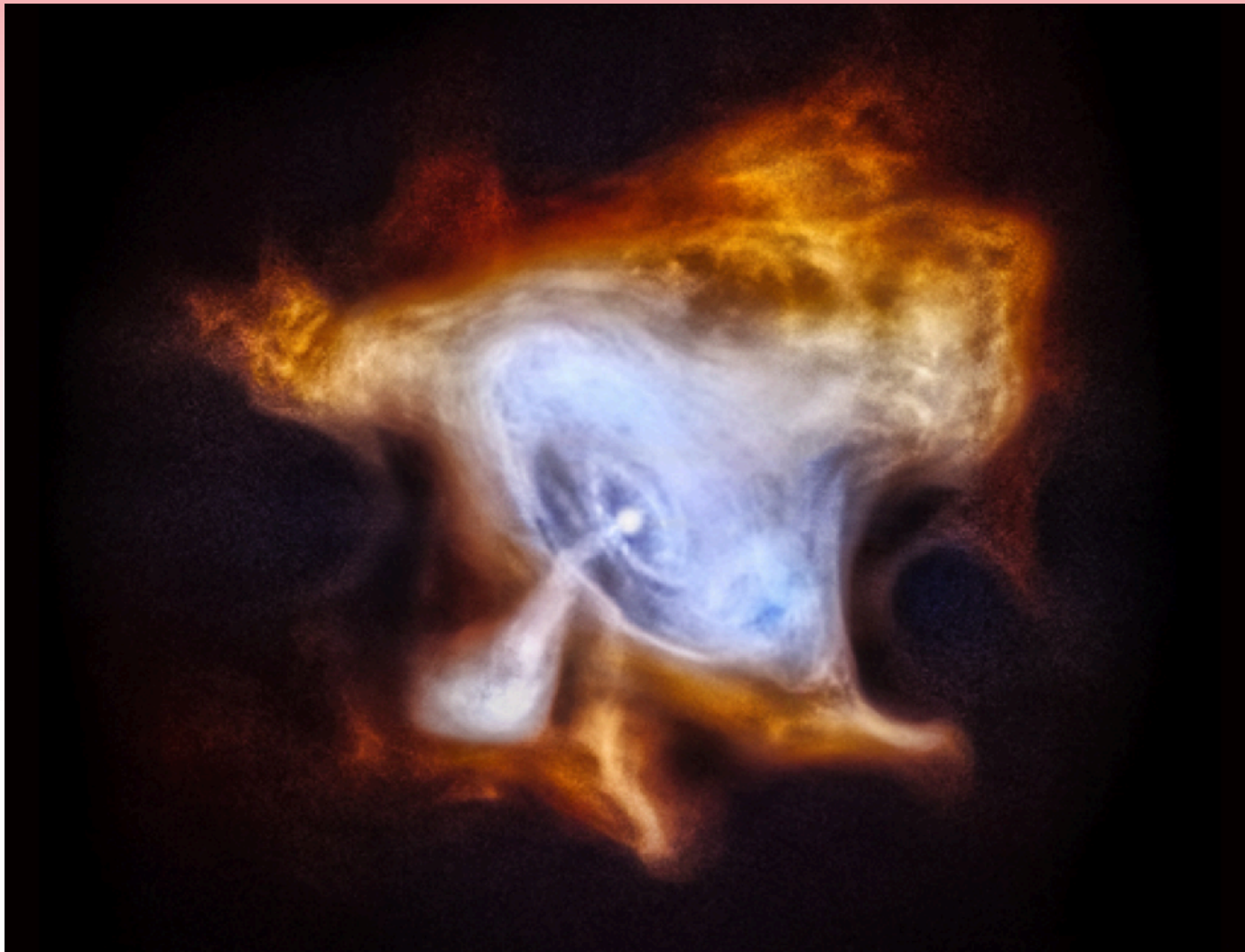
Light Curve

Supernova 1987A

European Southern Observatory



Neutron Star in Crab Nebula (Supernova of 1054)



Pulsars—Spinning Neutron Stars

