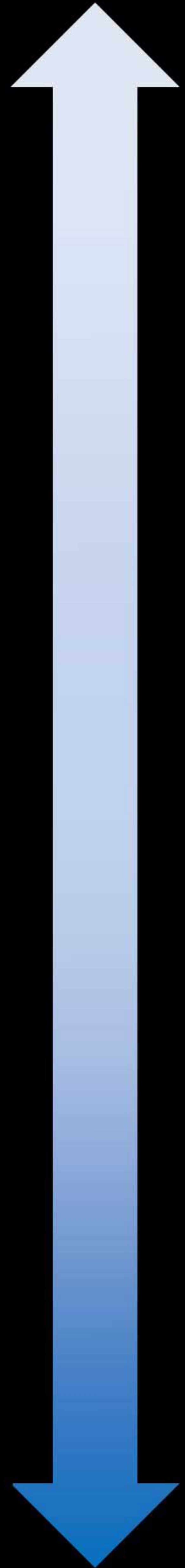


THE LIVES OF STARS

CAROLIN CRAWFORD
GRESHAM PROFESSOR IN
ASTRONOMY

NASA, ESA

Brighter



Dimmer

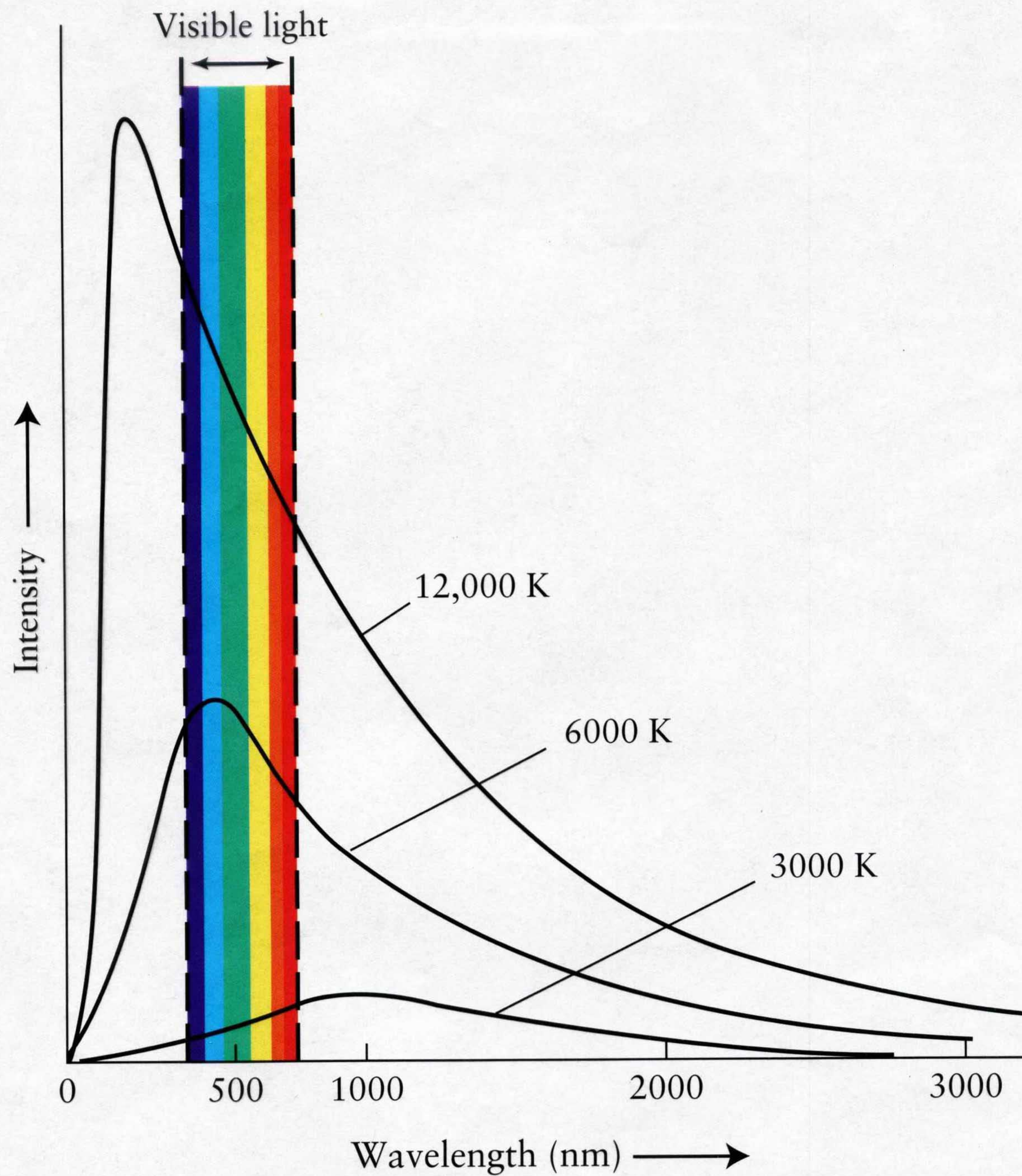
Magnitude
scale

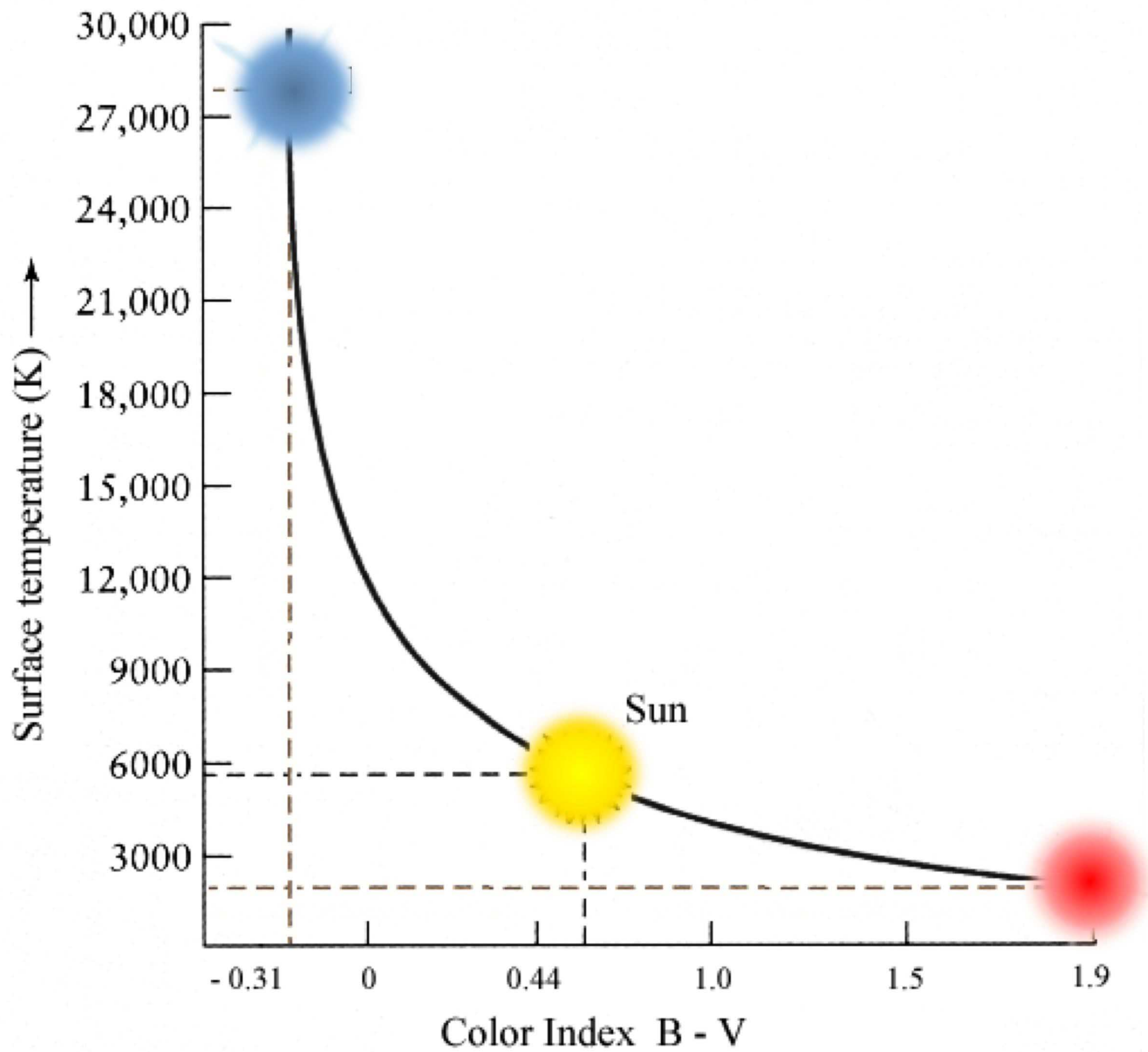
Hipparchus





NASA/ESA/Hubble Heritage





$$L=4\pi R^2\sigma T^4$$

$$L=4\pi R^2\sigma T^4$$

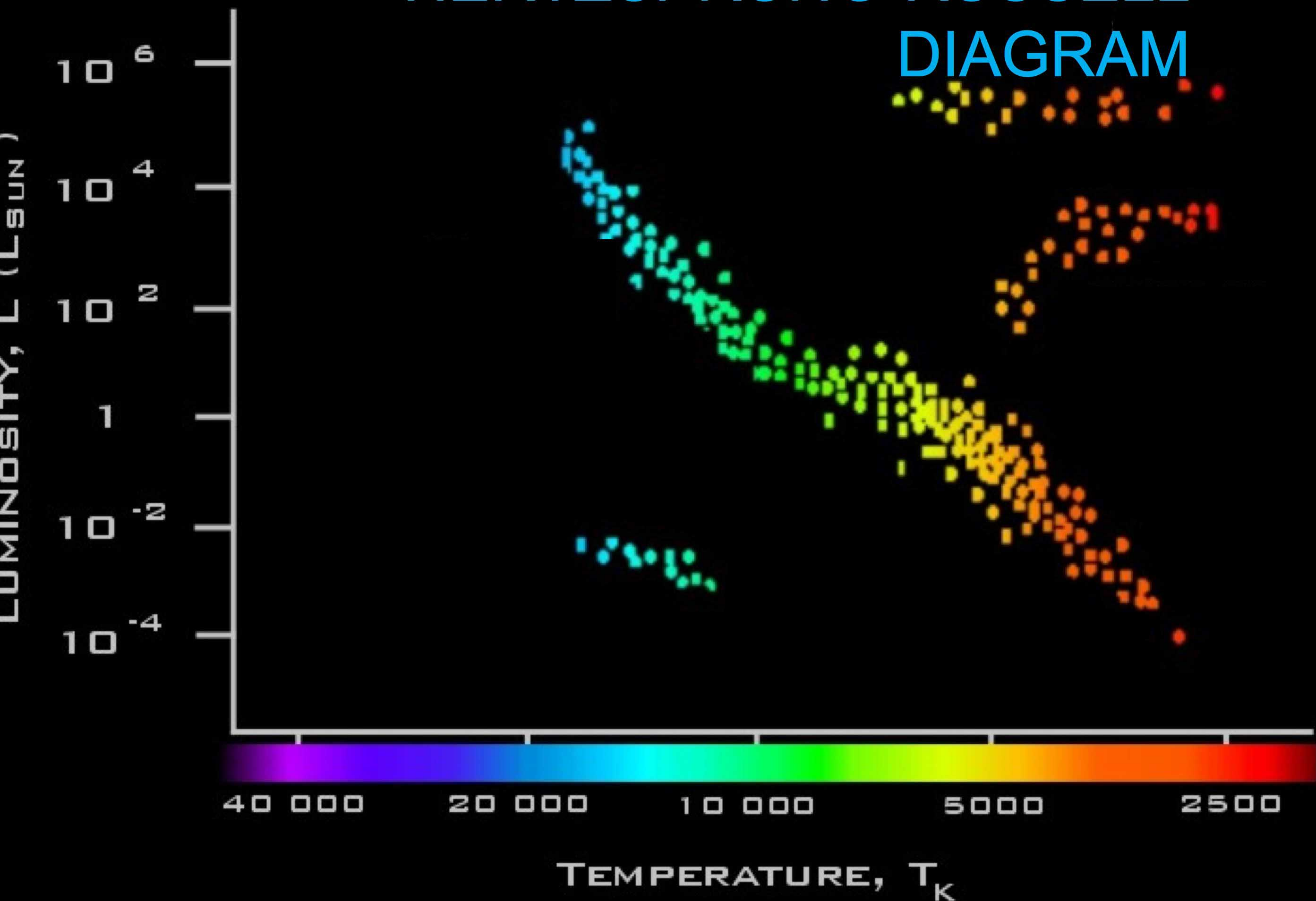
$$L=4\pi R^2\sigma T^4$$

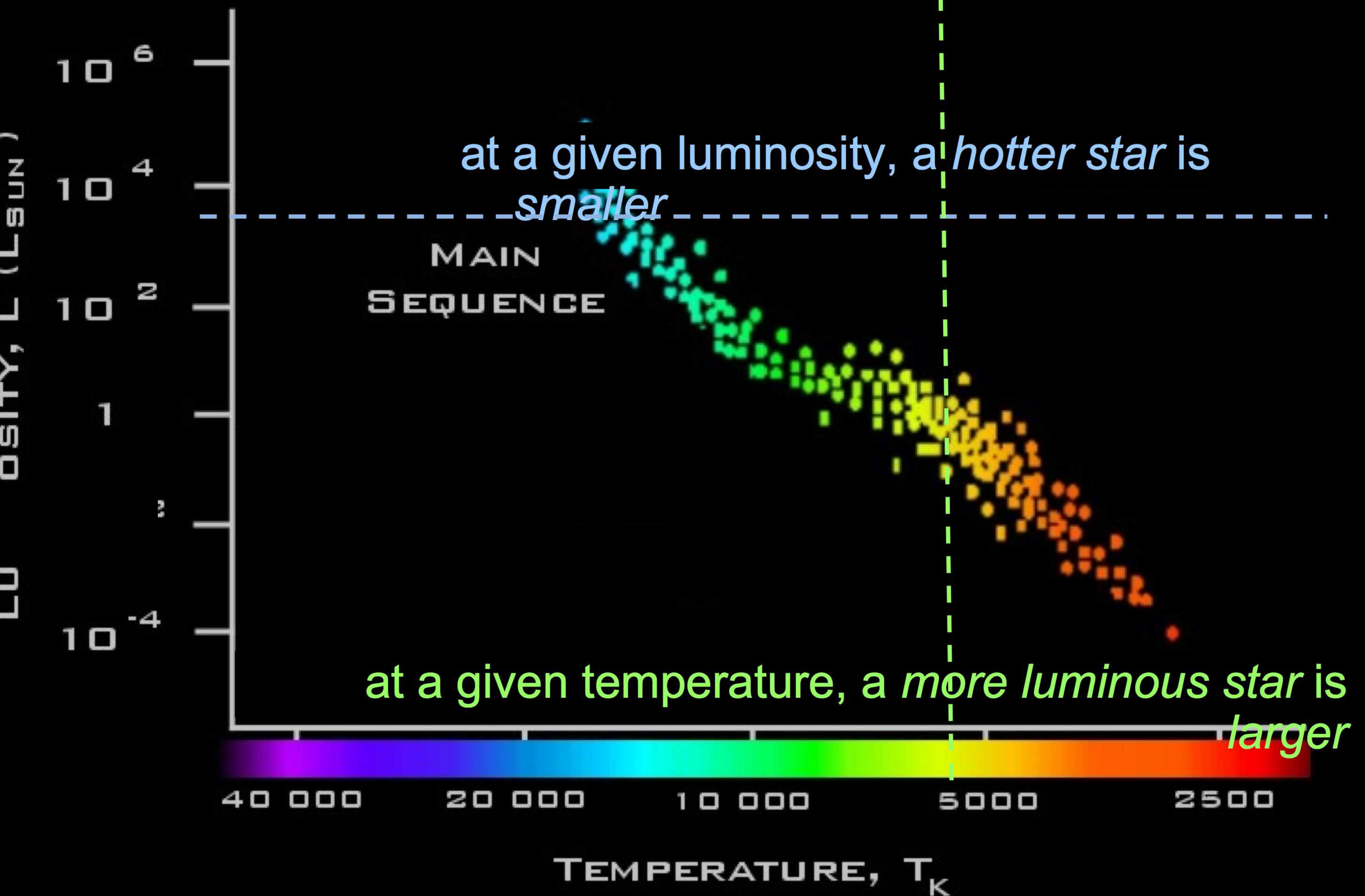
at a given luminosity, a *hotter star* is

smaller

at a given temperature, a *more luminous star* is
larger

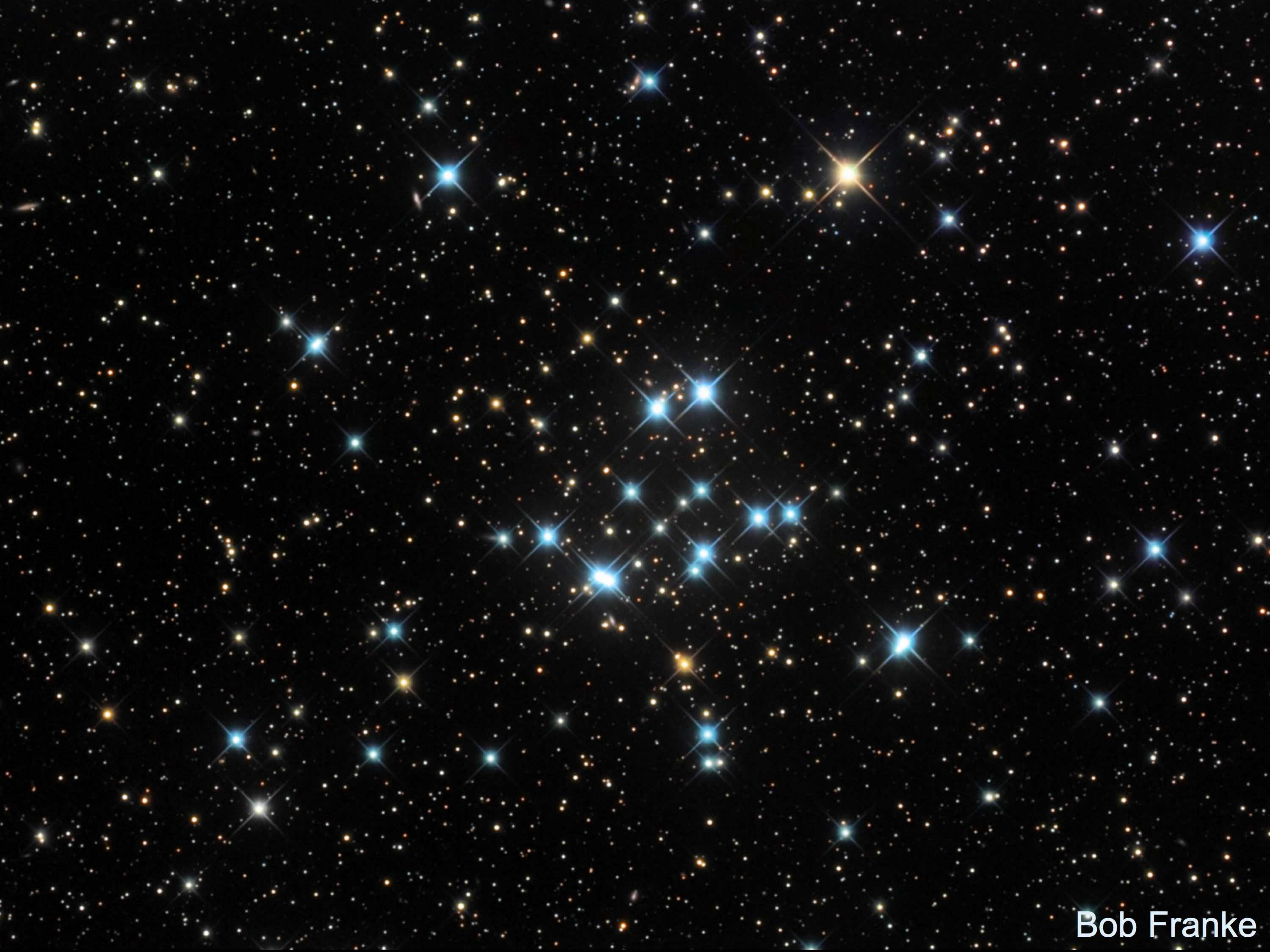
HERTZSPRUNG-RUSSELL DIAGRAM

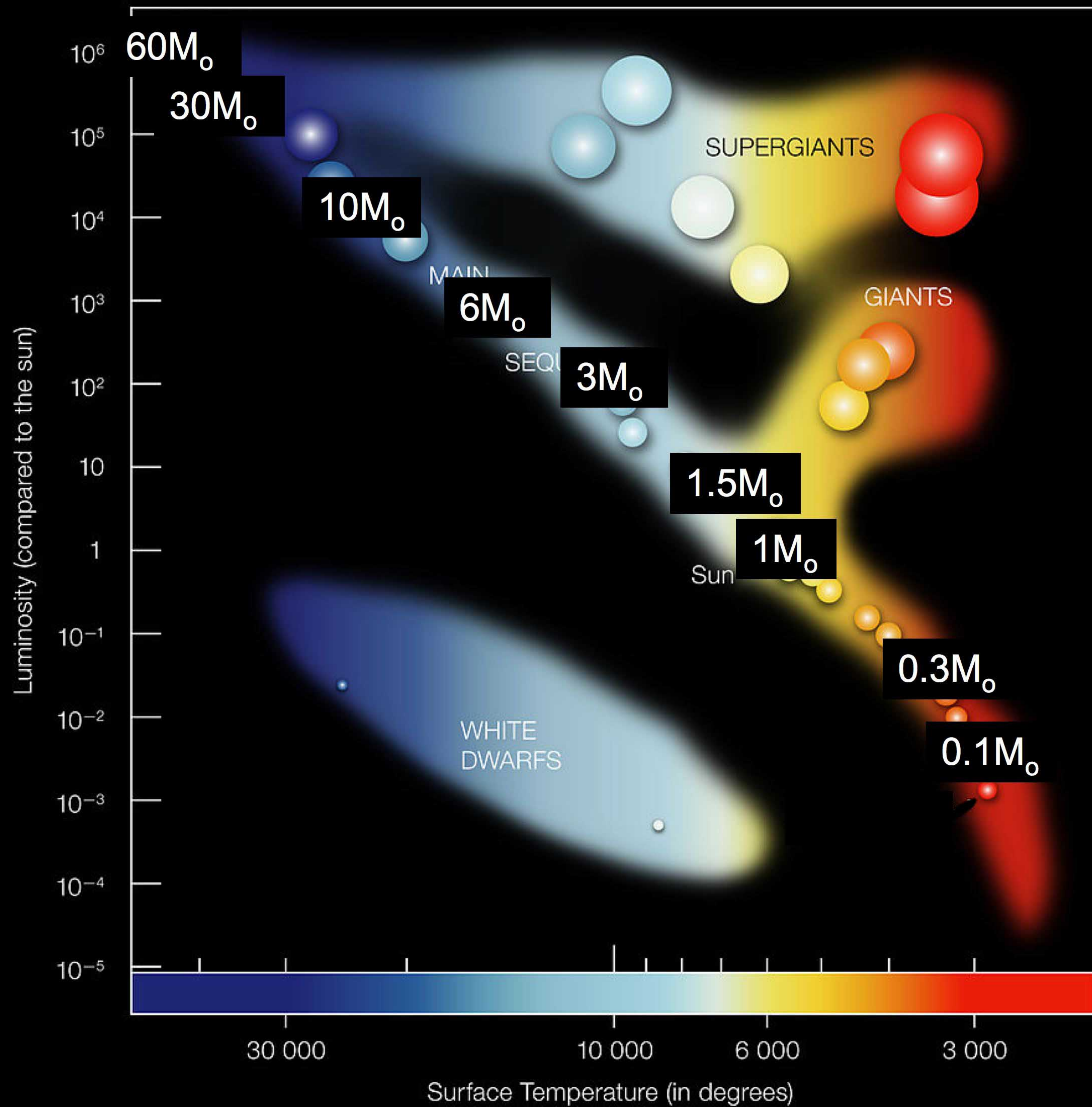


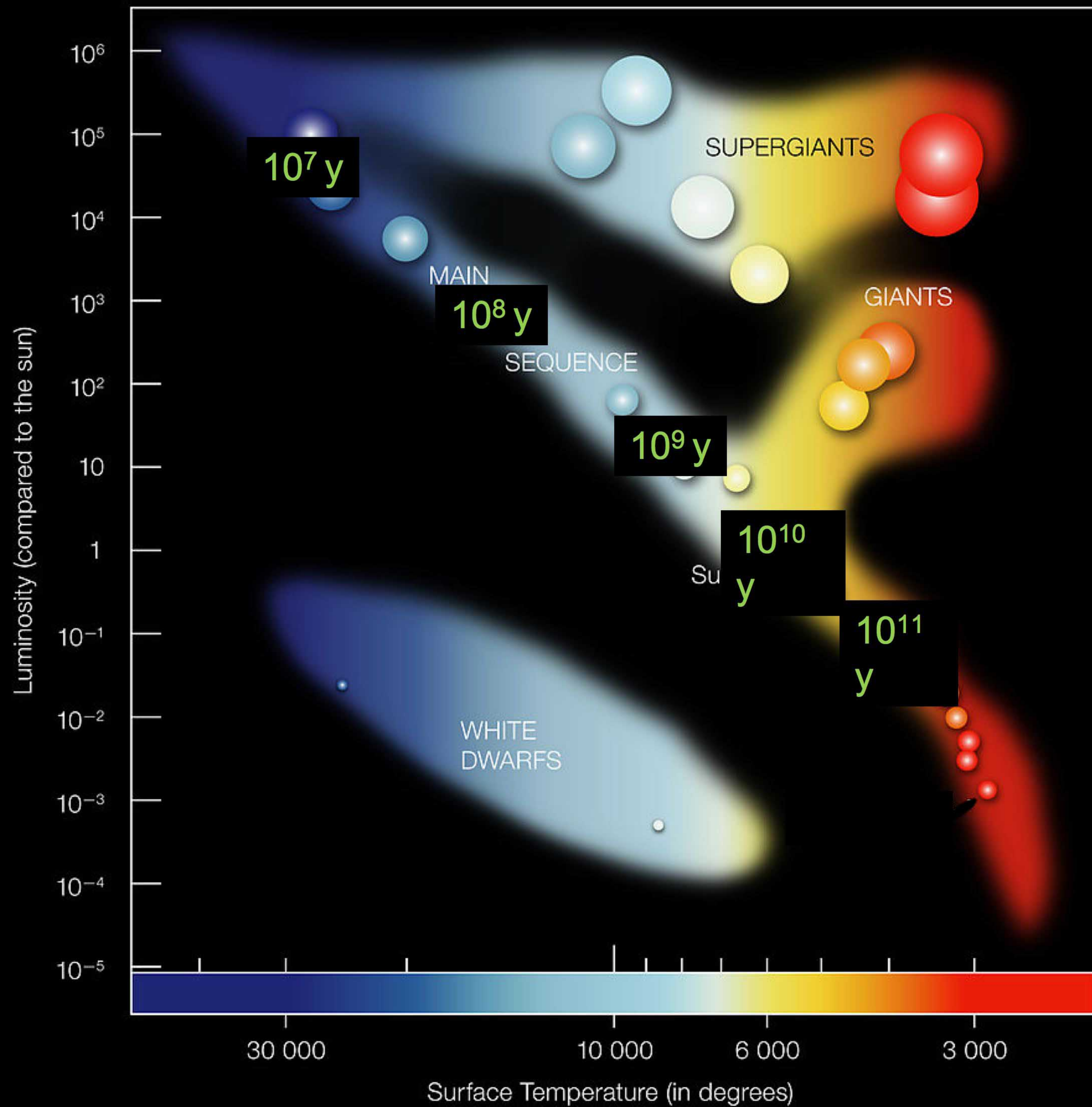




morn1415 (youtube)









NASA/ESA/HST

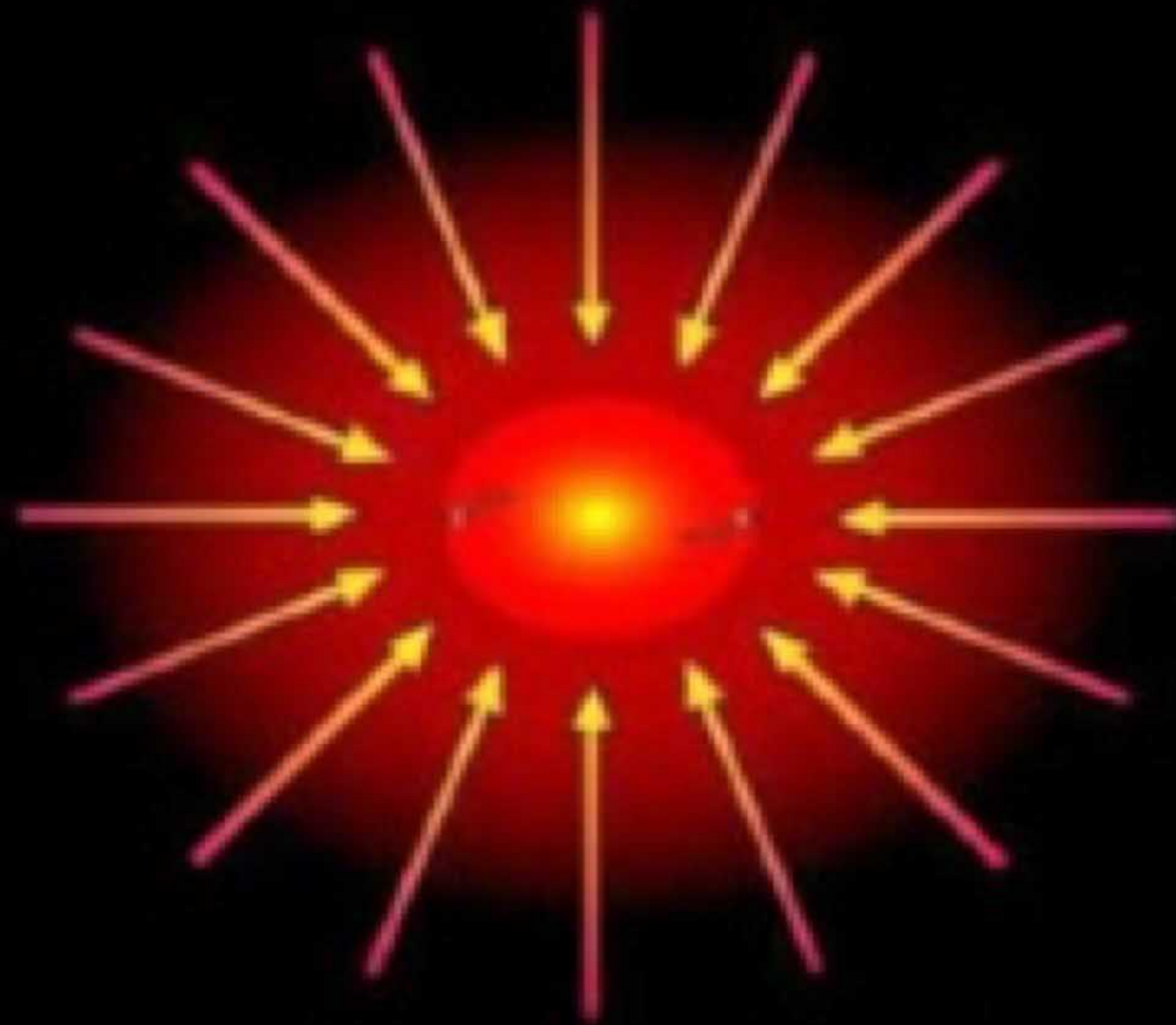




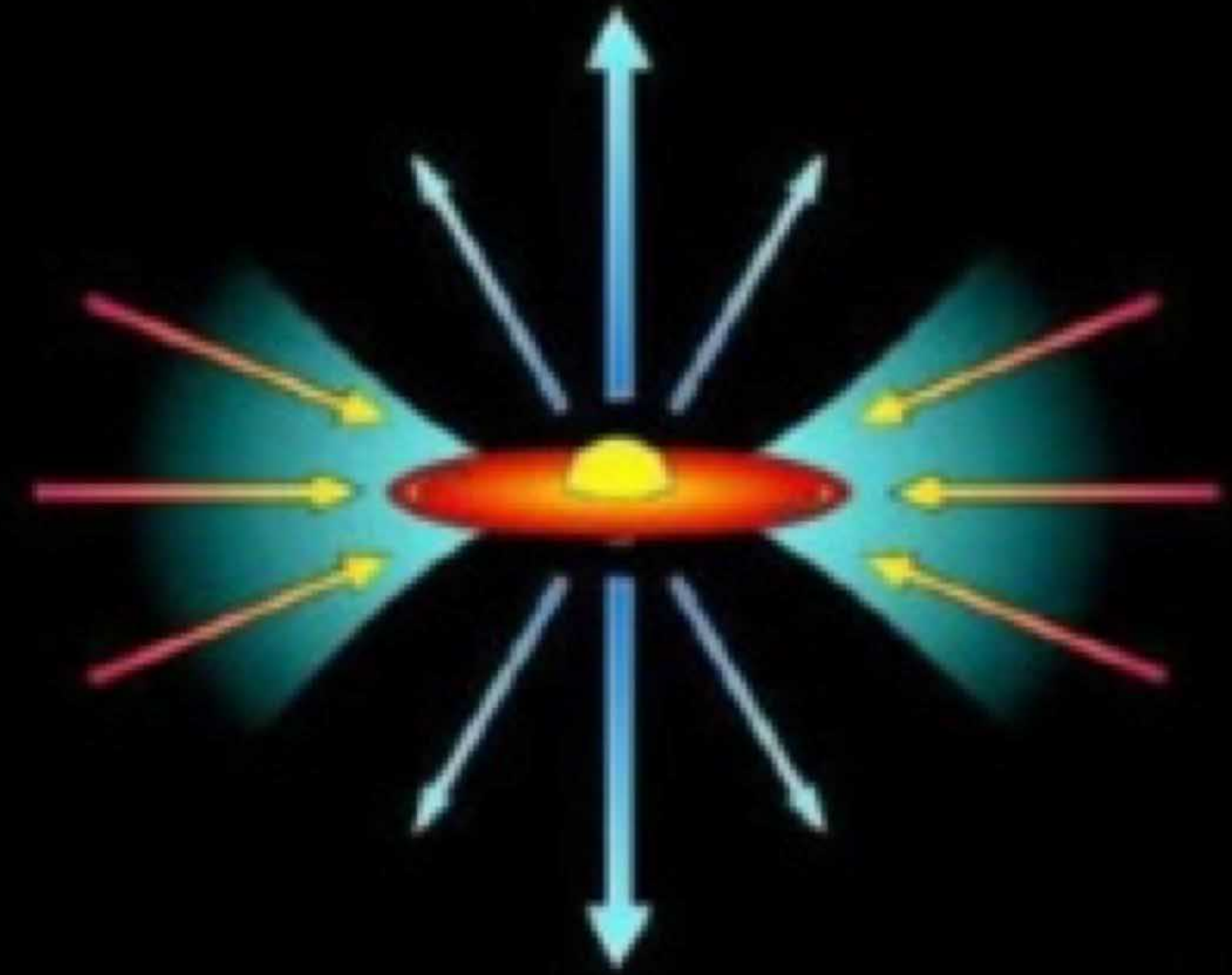
NASA/ESA/HST/Smith et al



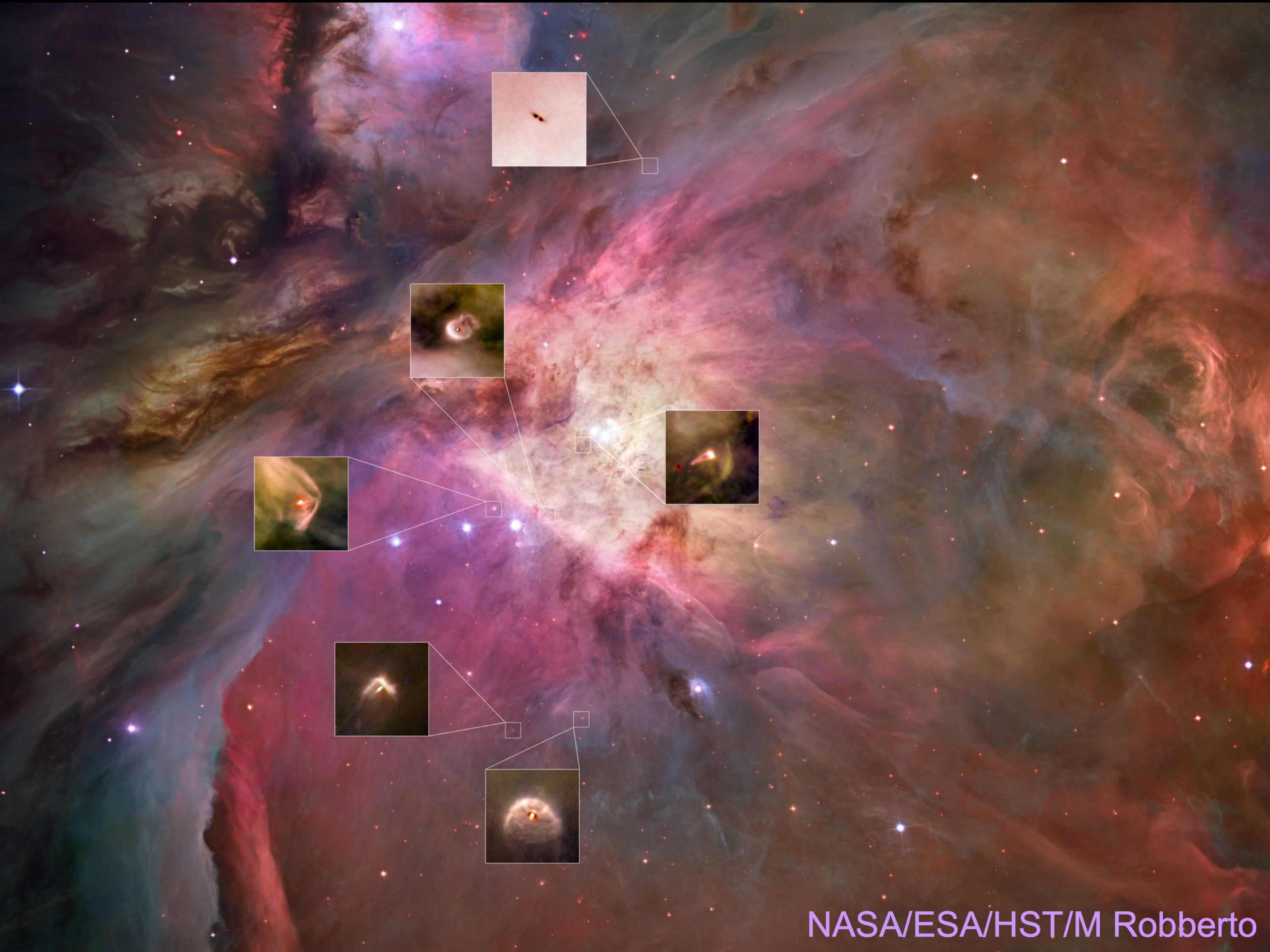
NASA/ESA/HST



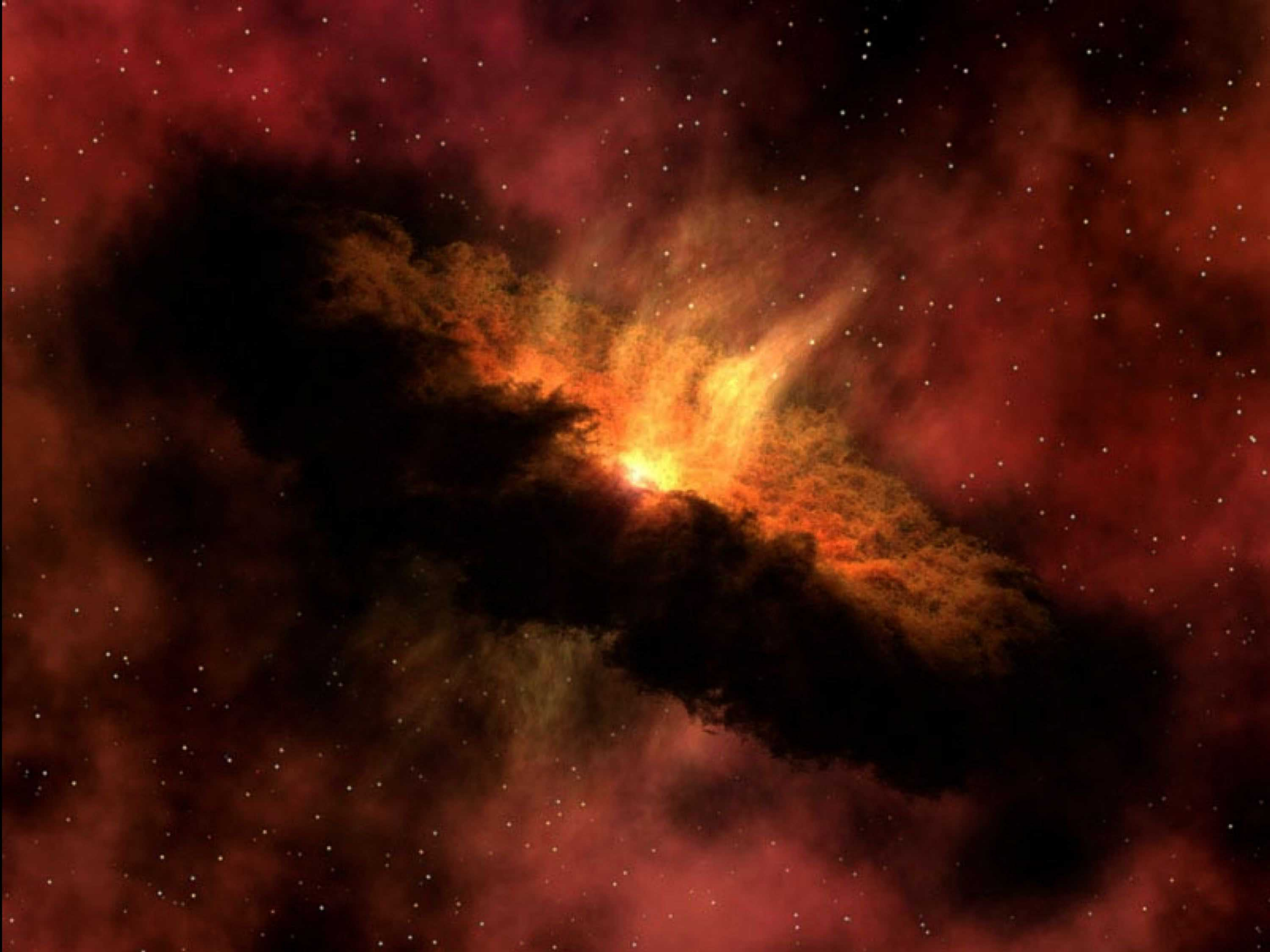
10^4 yrs; $10-10^4$ AU; 10–300K

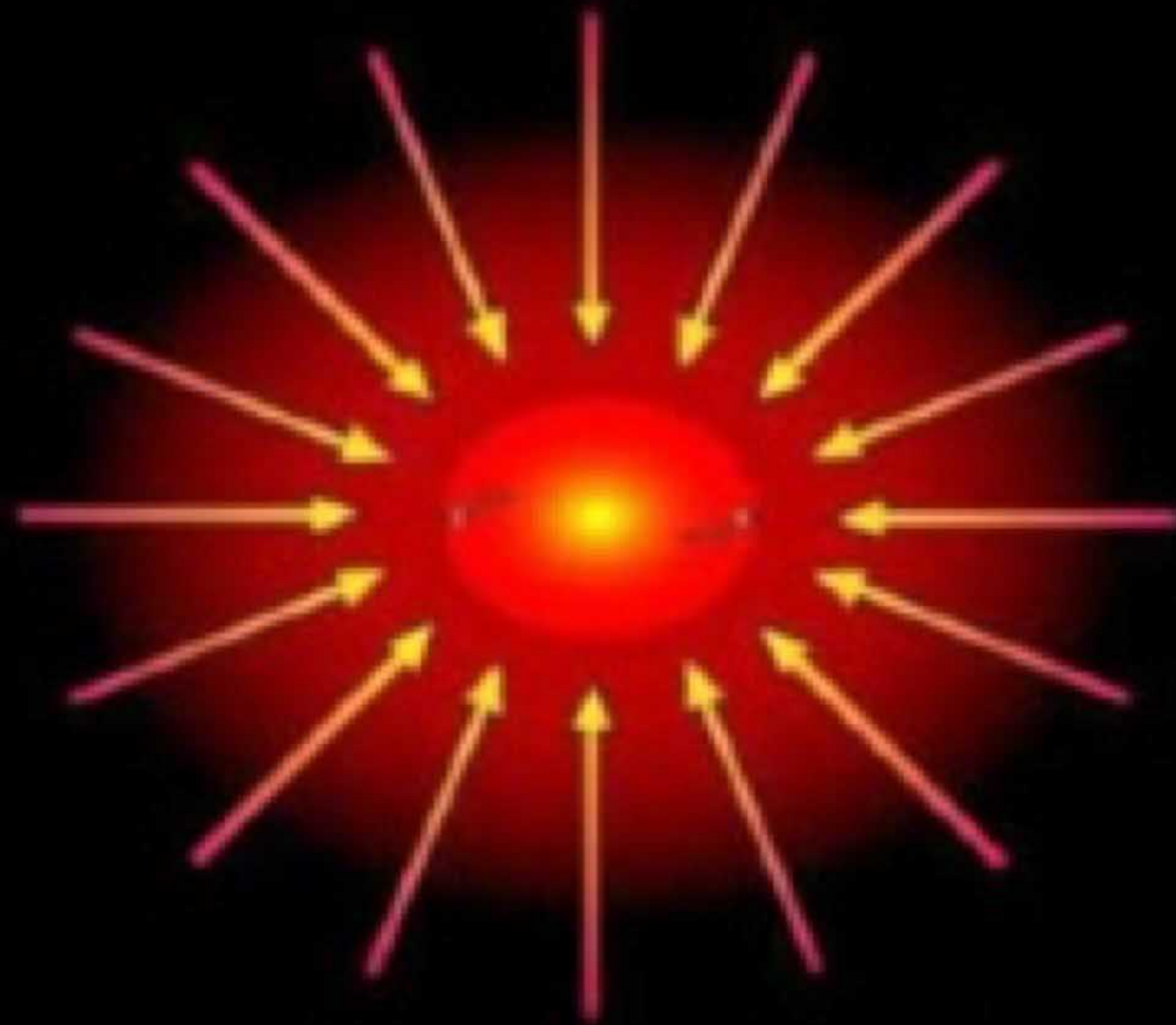


10^{5-6} yrs; 1–1000AU; 100–3000K

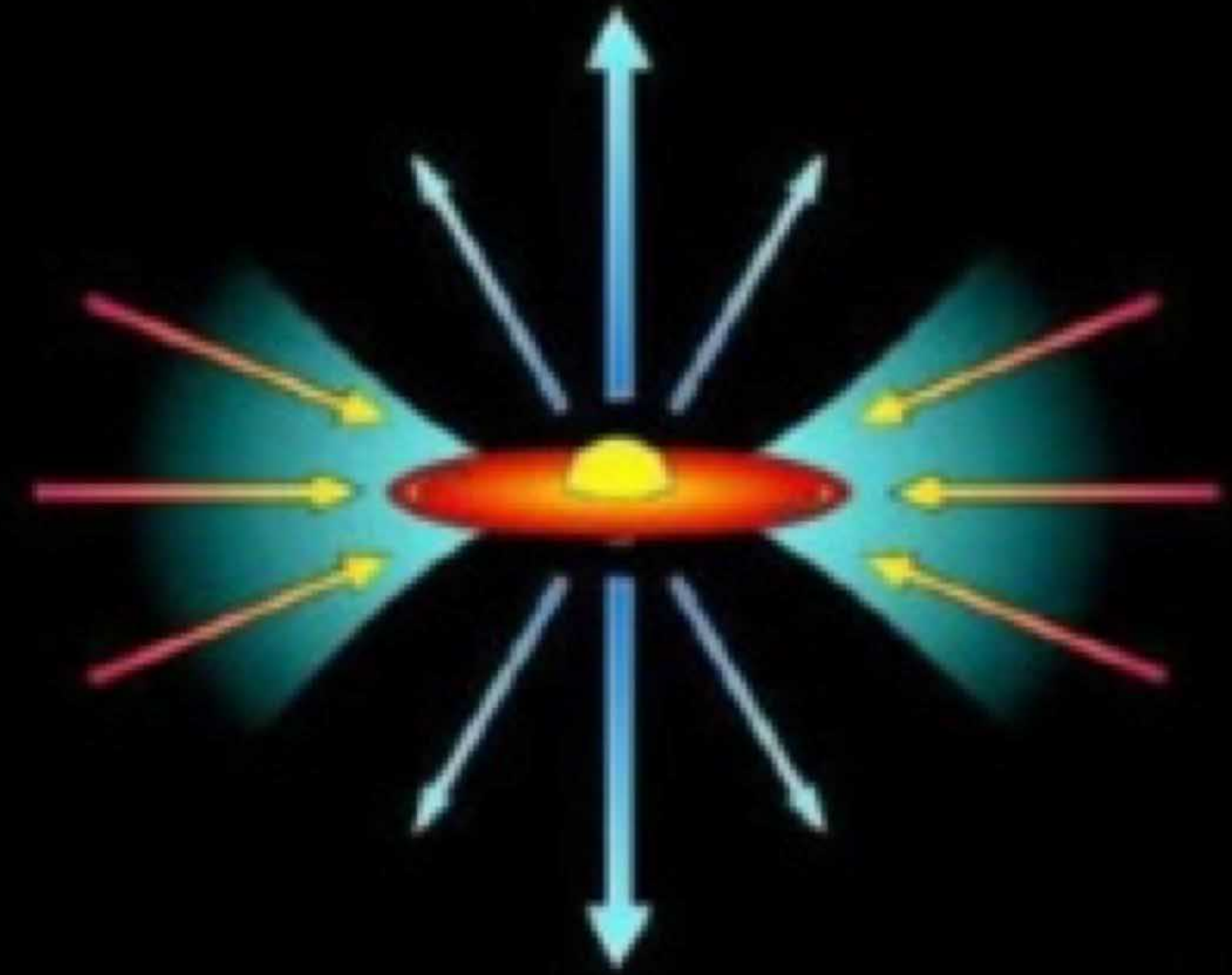


NASA/ESA/HST/M Roberto





10^4 yrs; $10-10^4$ AU; 10–300K



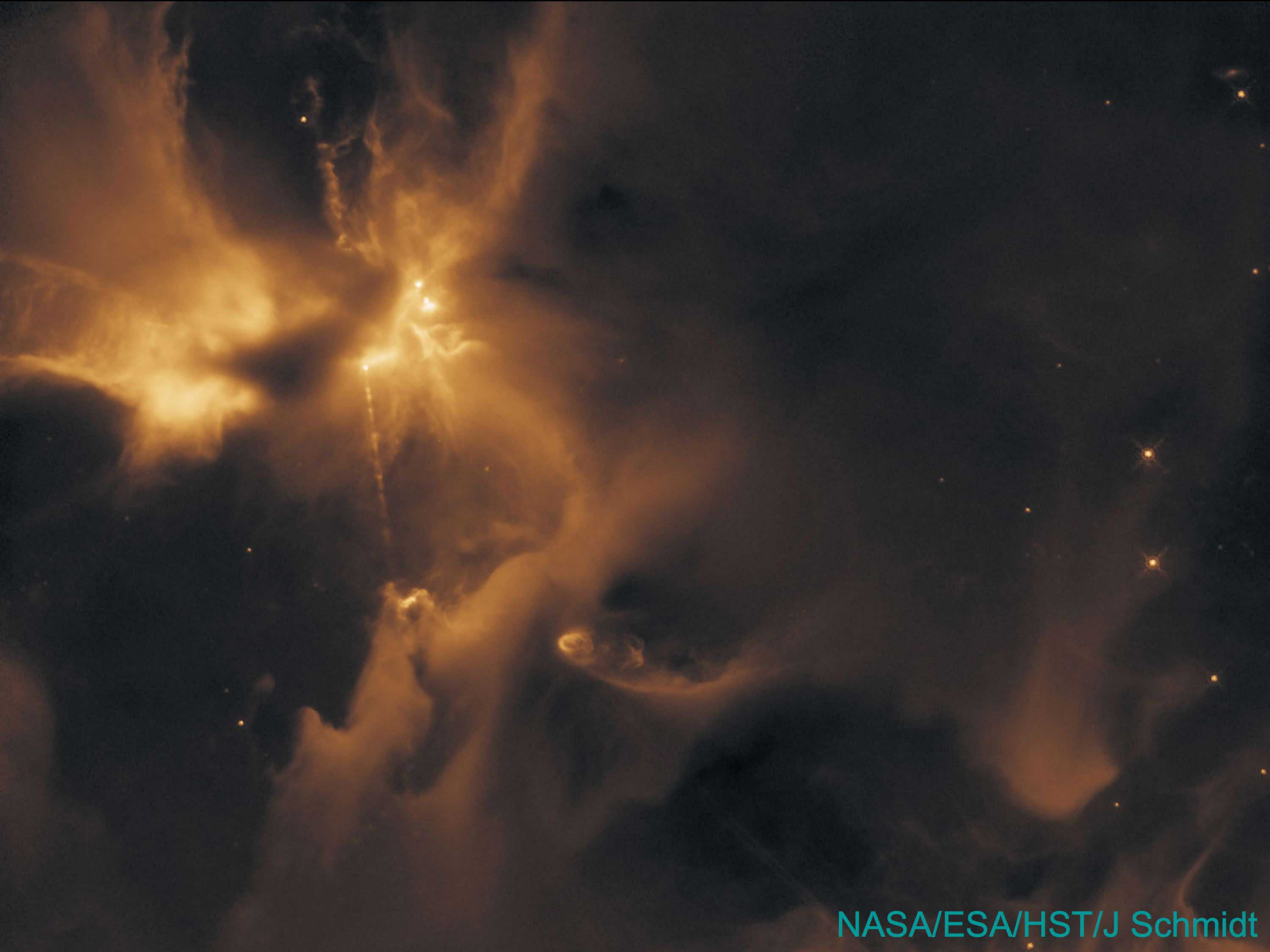
10^{5-6} yrs; 1–1000AU; 100–3000K



Wally Pacholka



NASA/ESA/HST/Smith et al



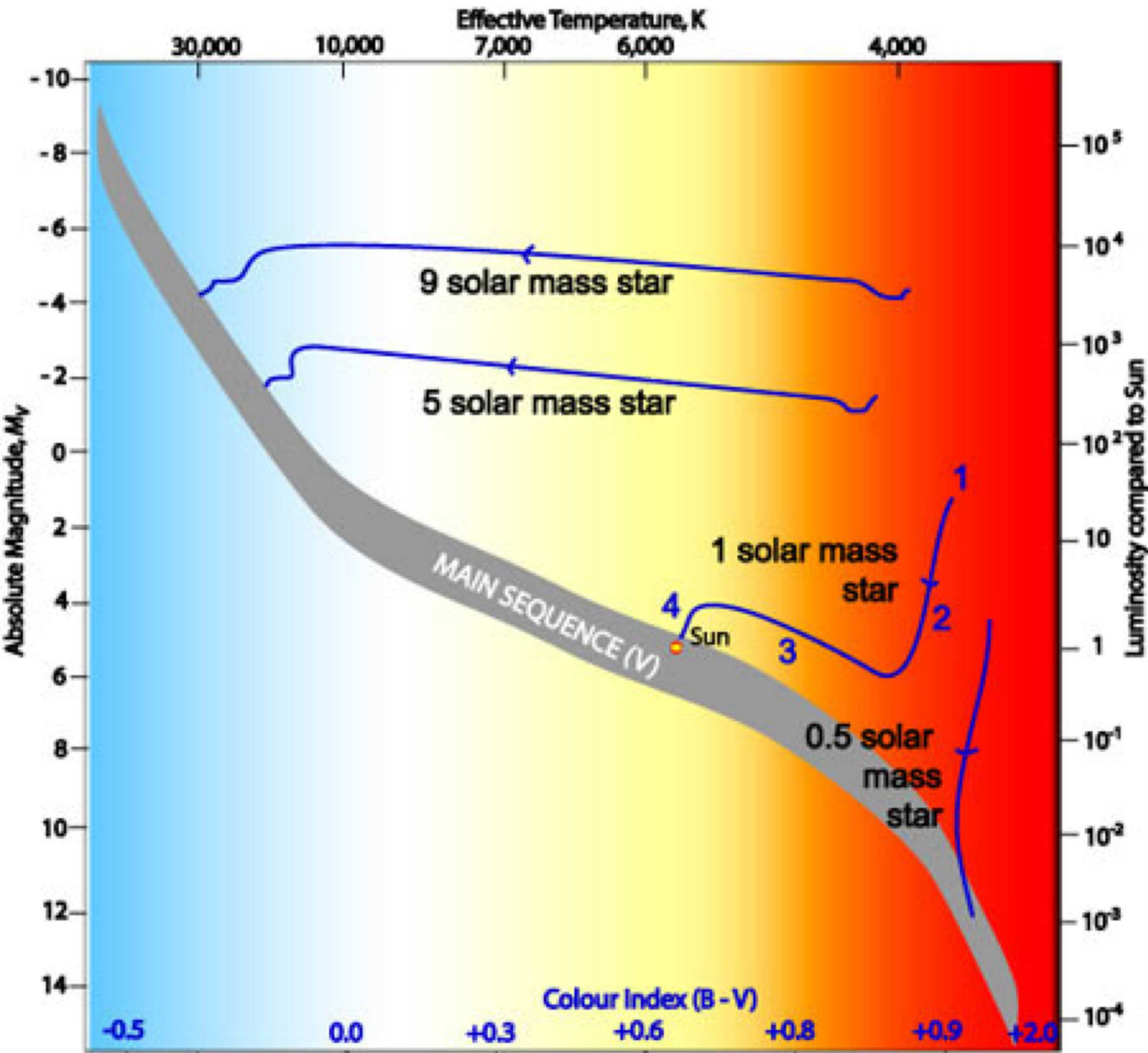
NASA/ESA/HST/J Schmidt



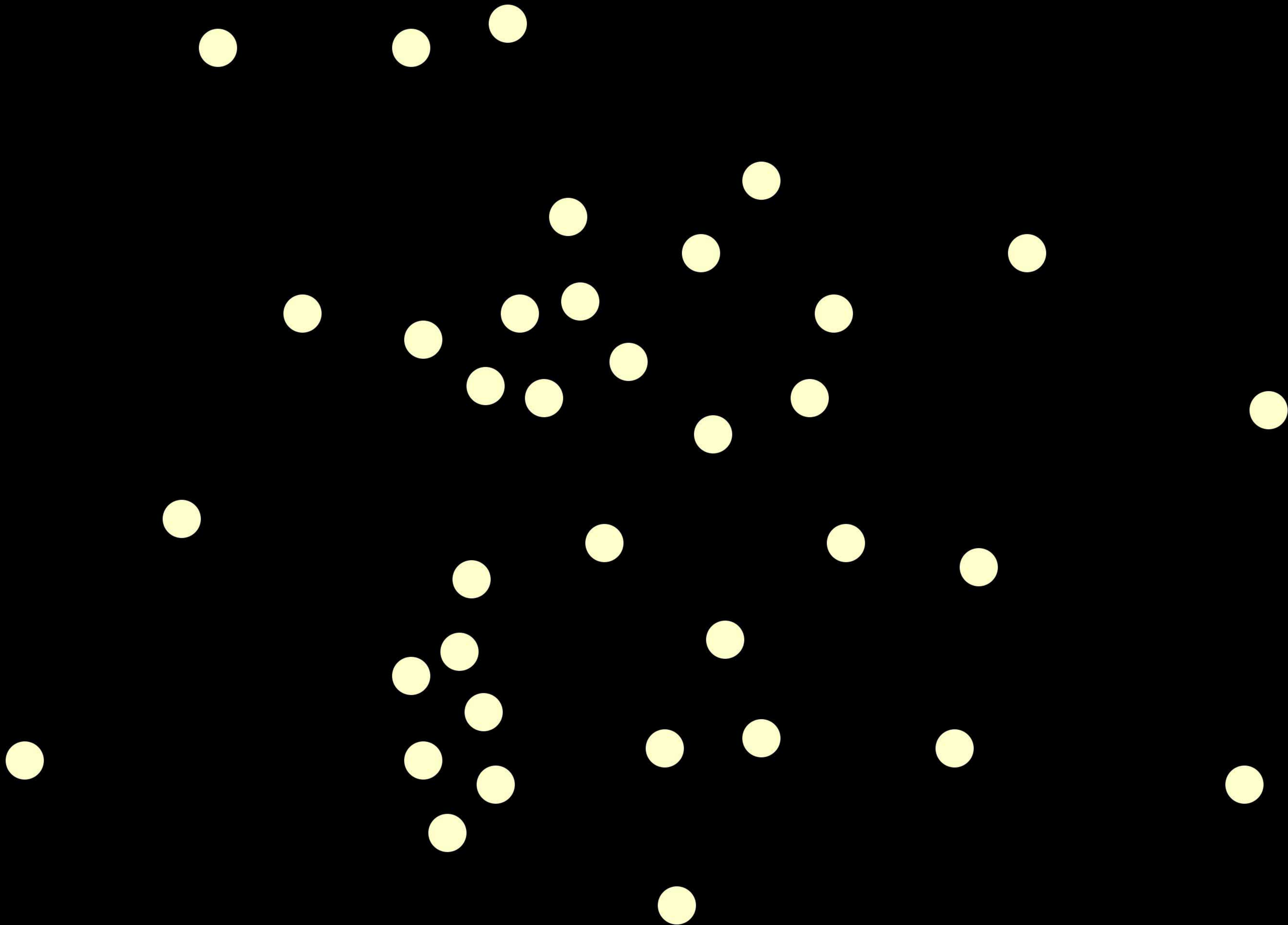
HH47

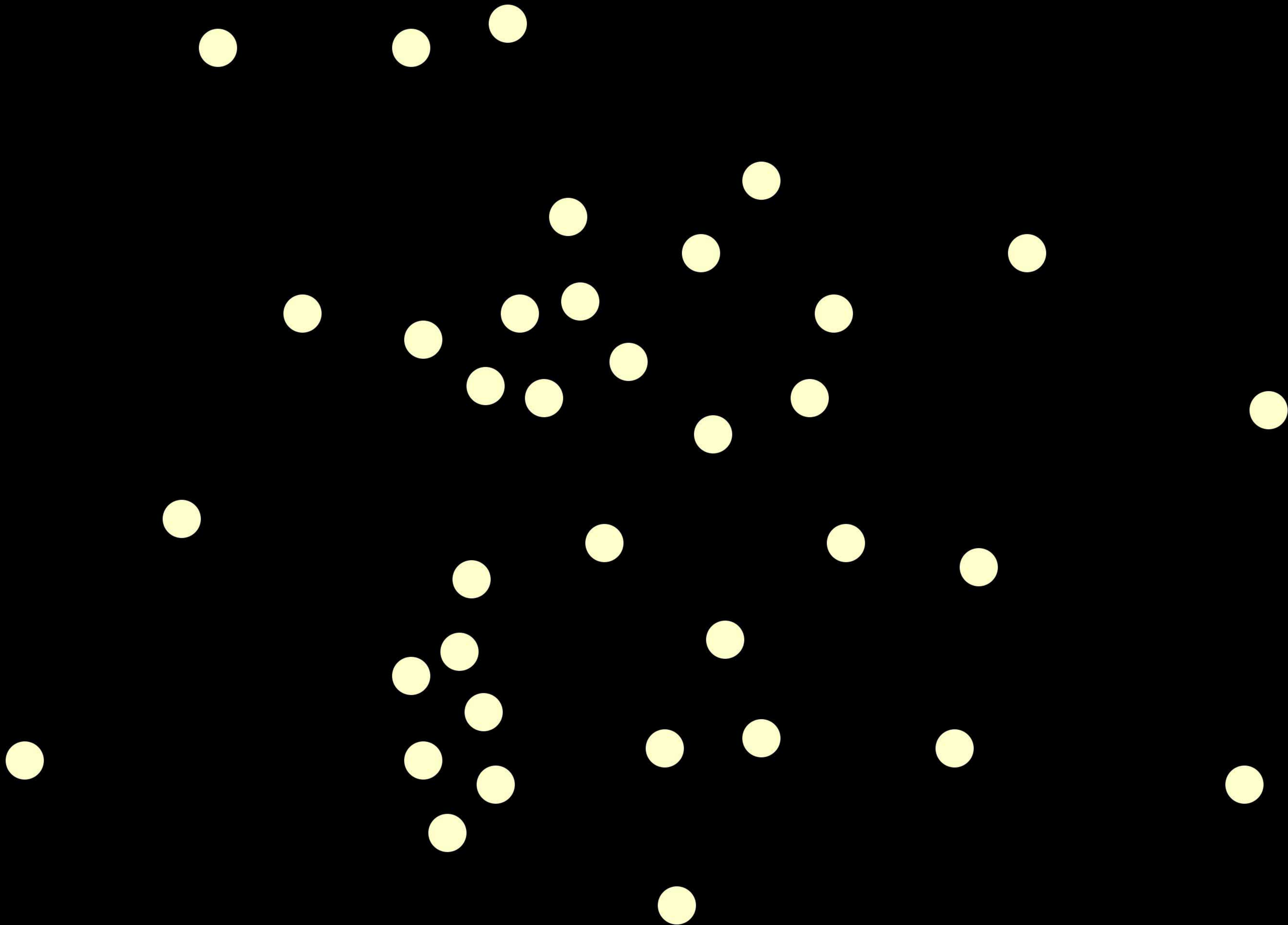
1994

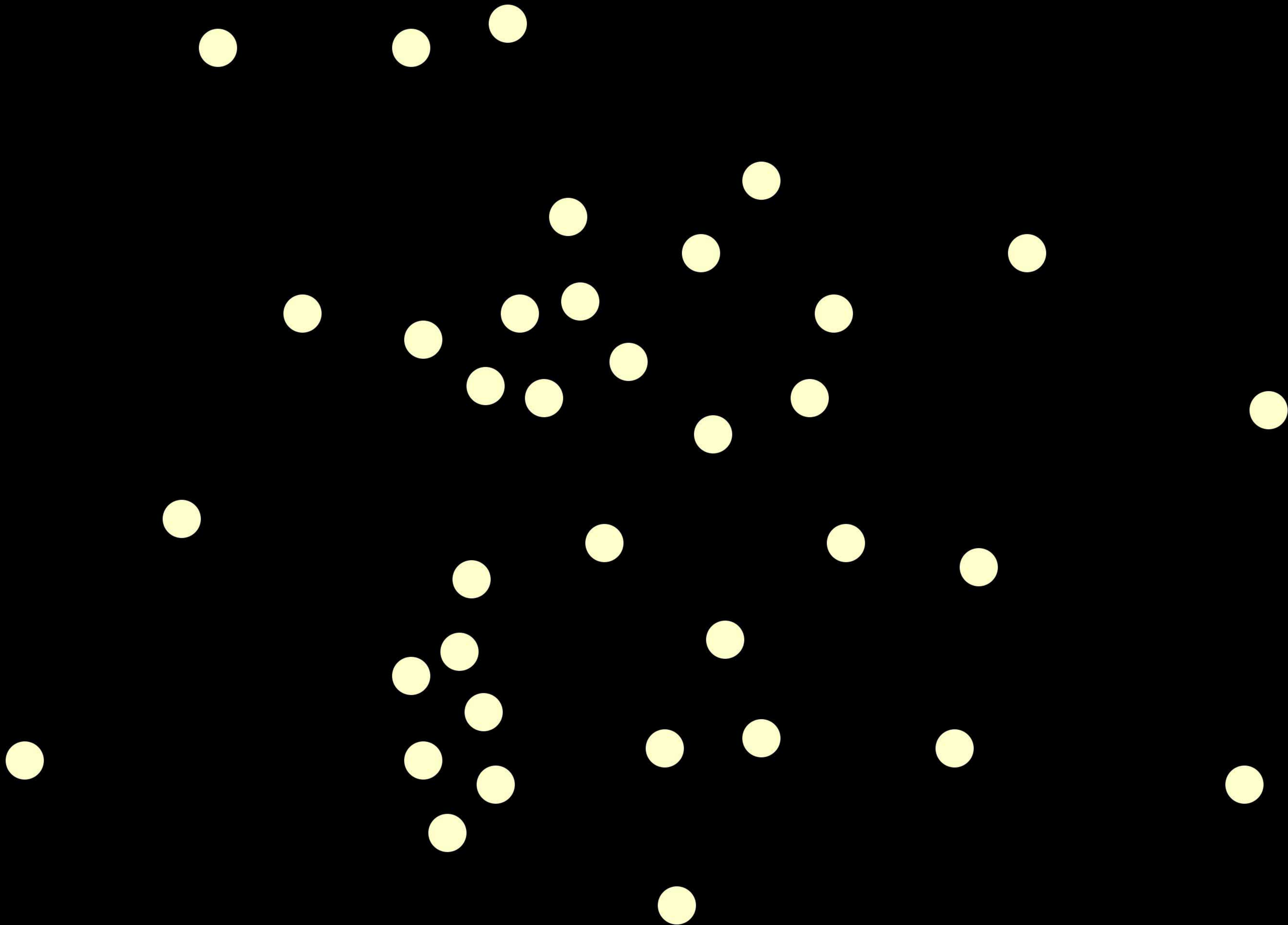
Theoretical Hayashi Tracks of Protostars



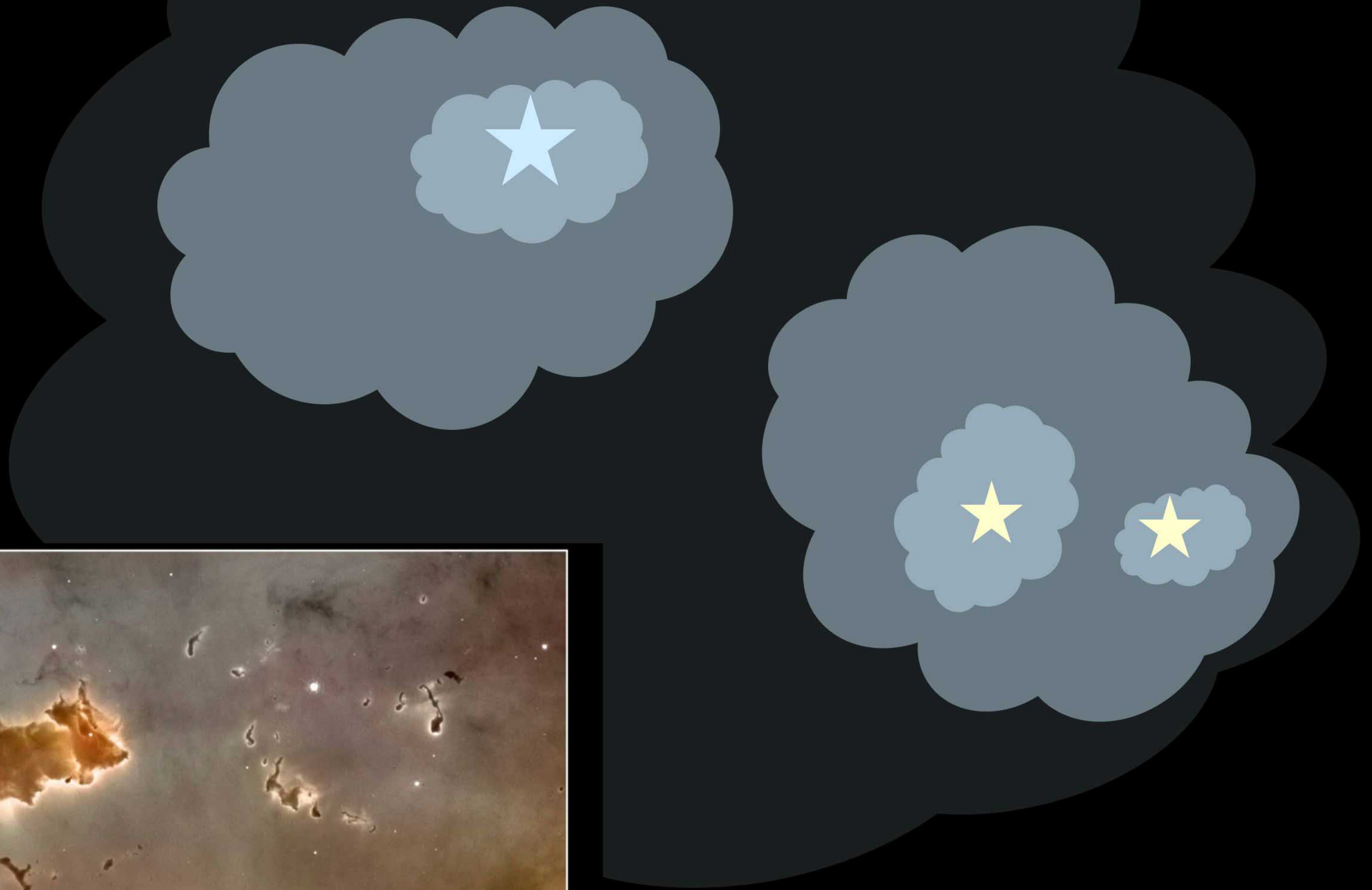




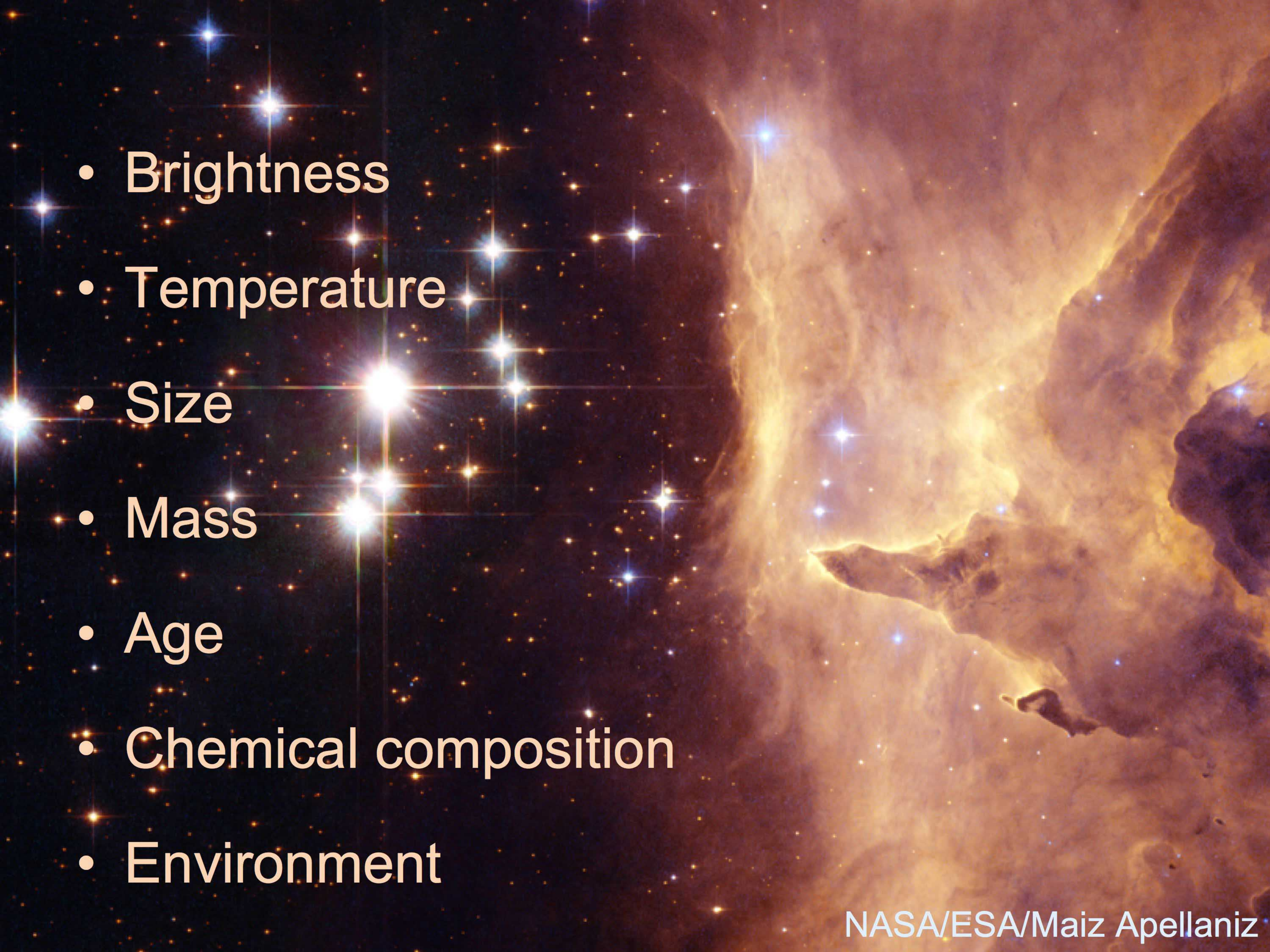


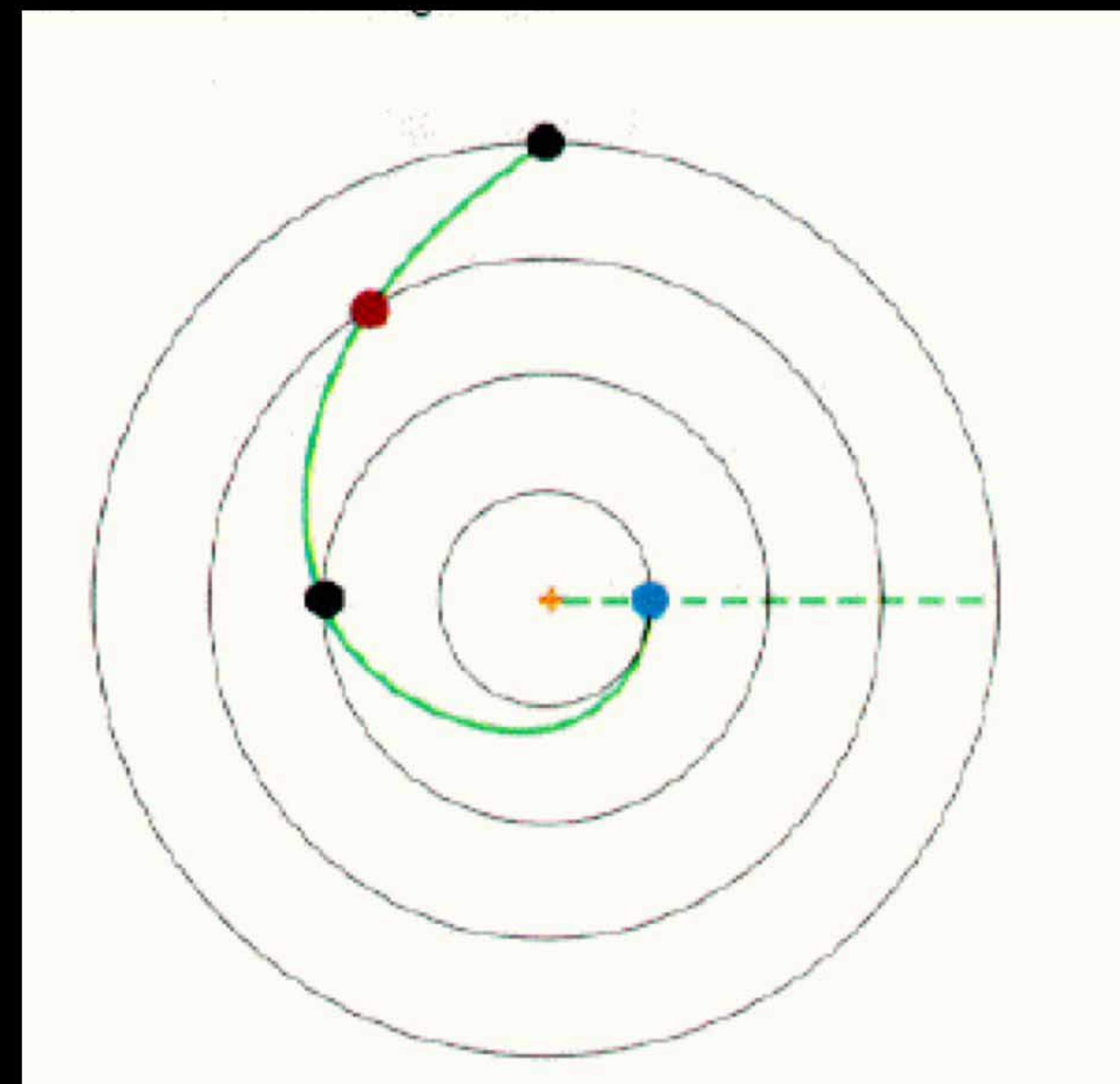
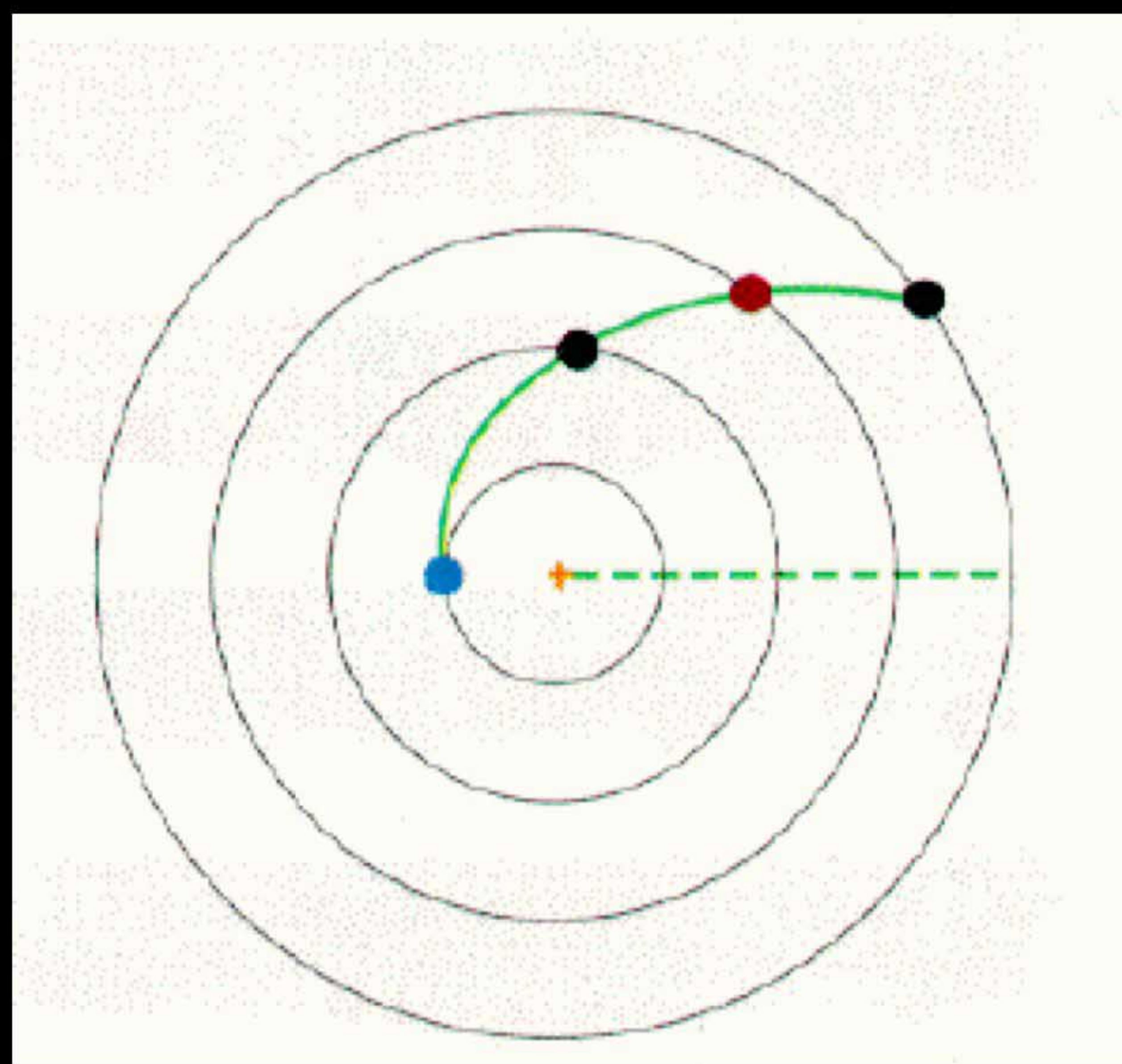
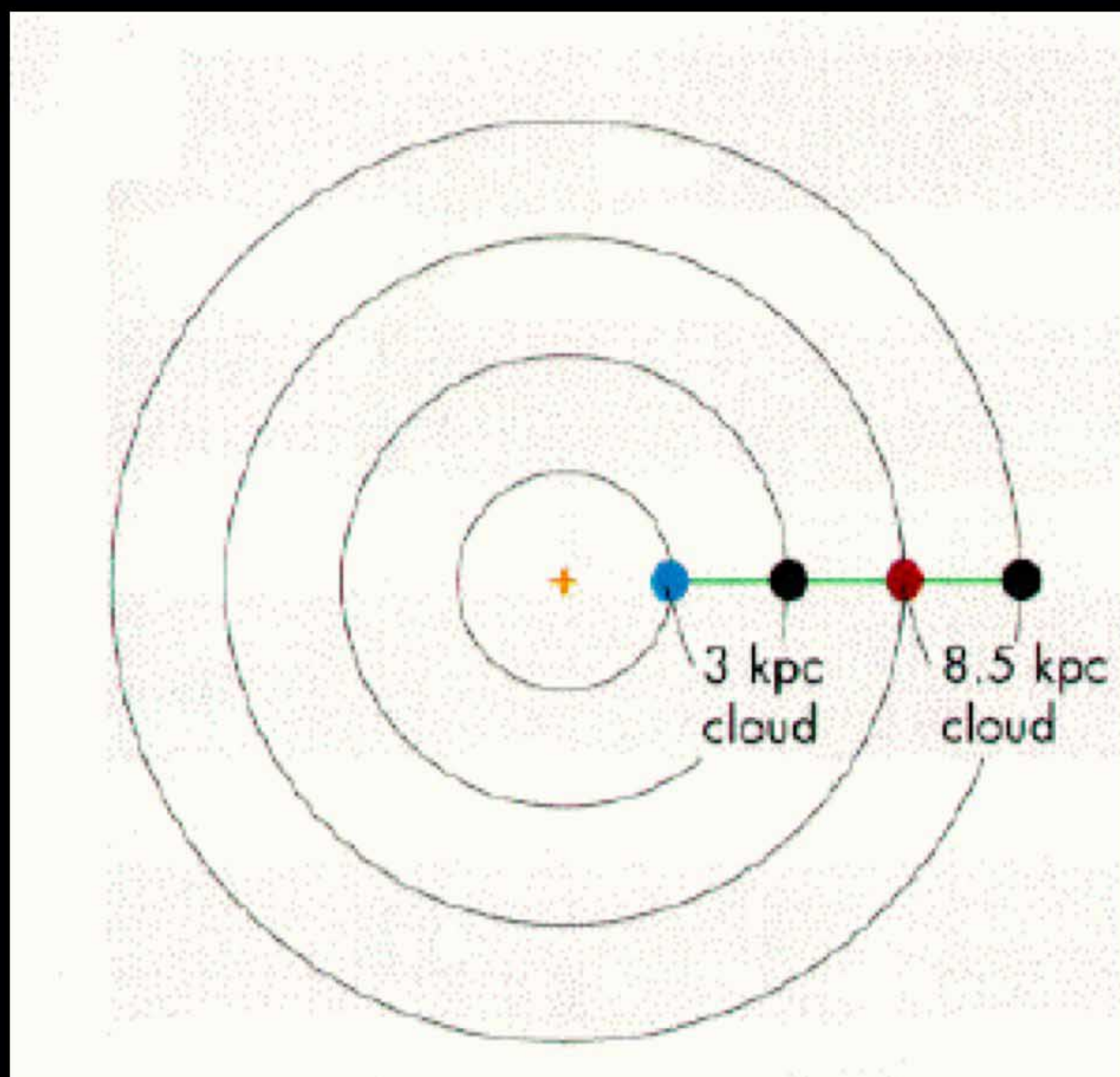


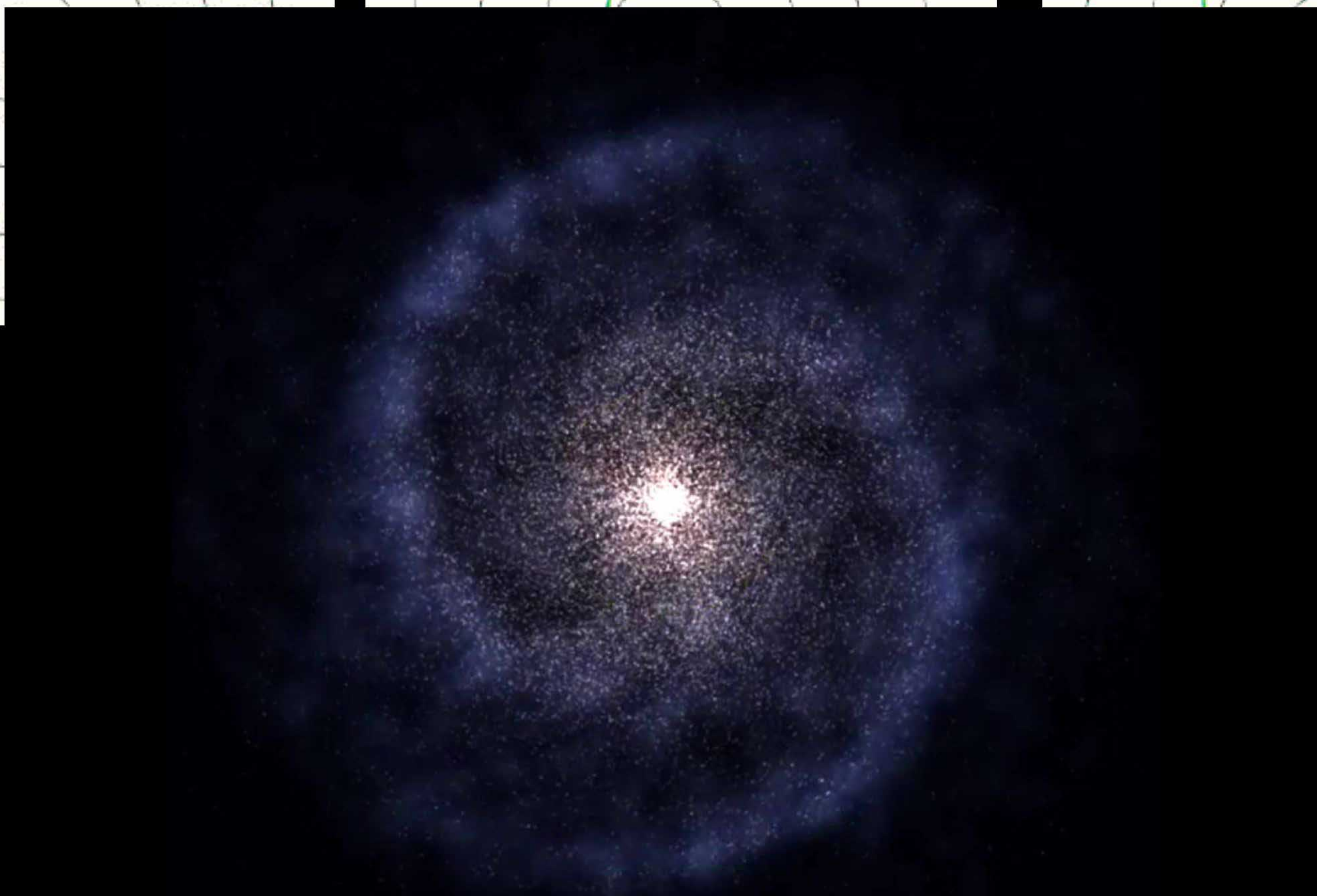
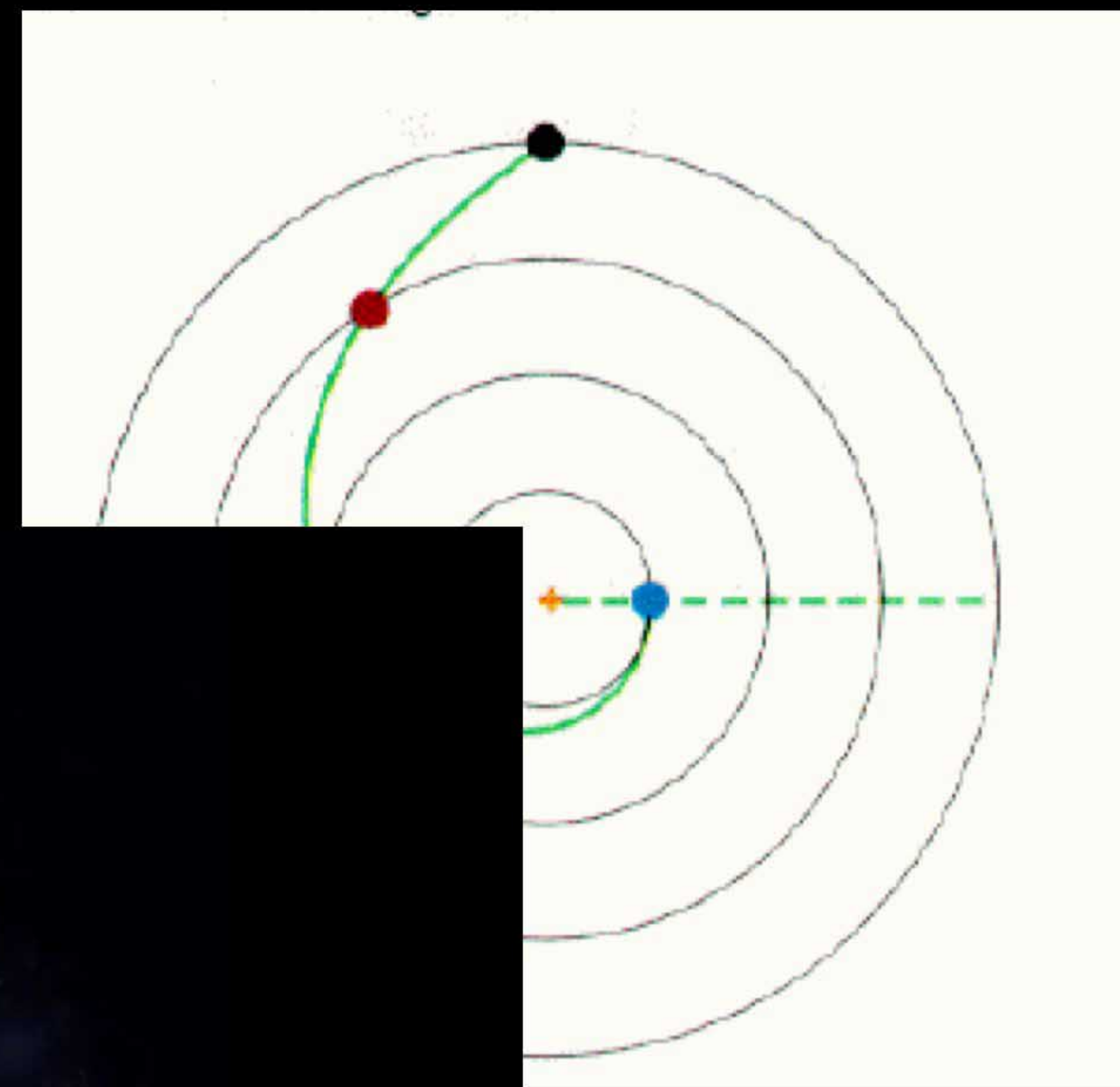
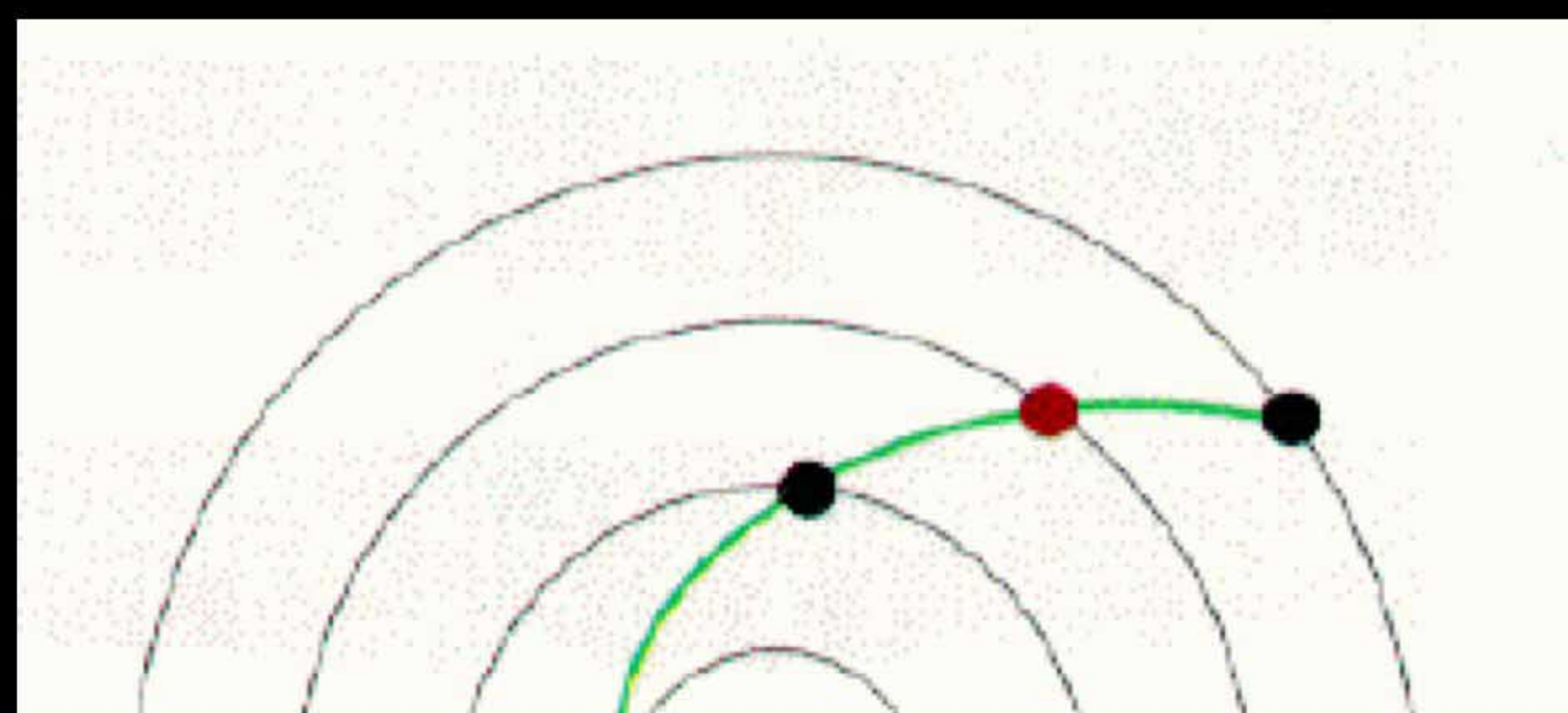
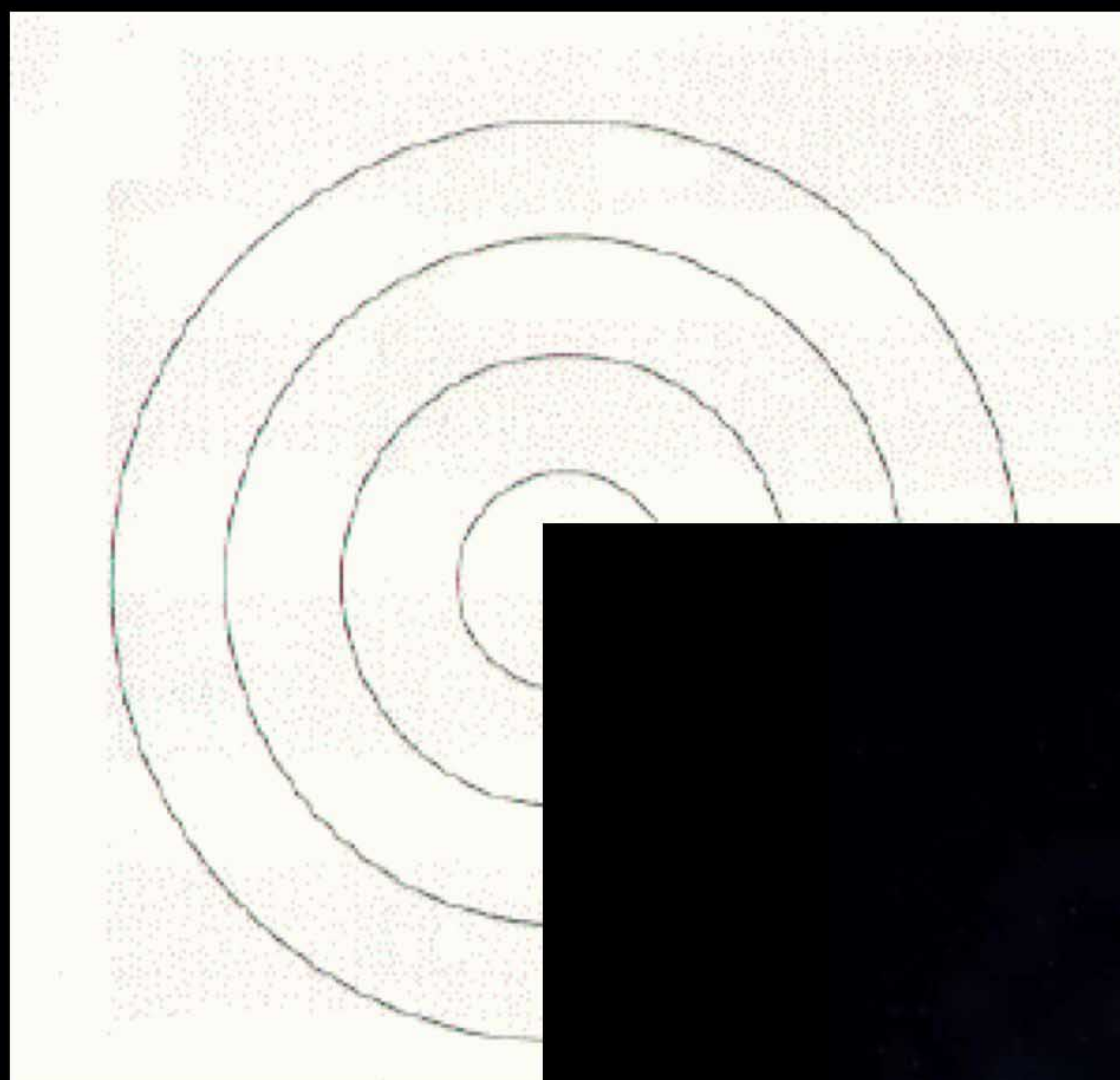
gravitational force vs. thermal pressure
density vs. temperature

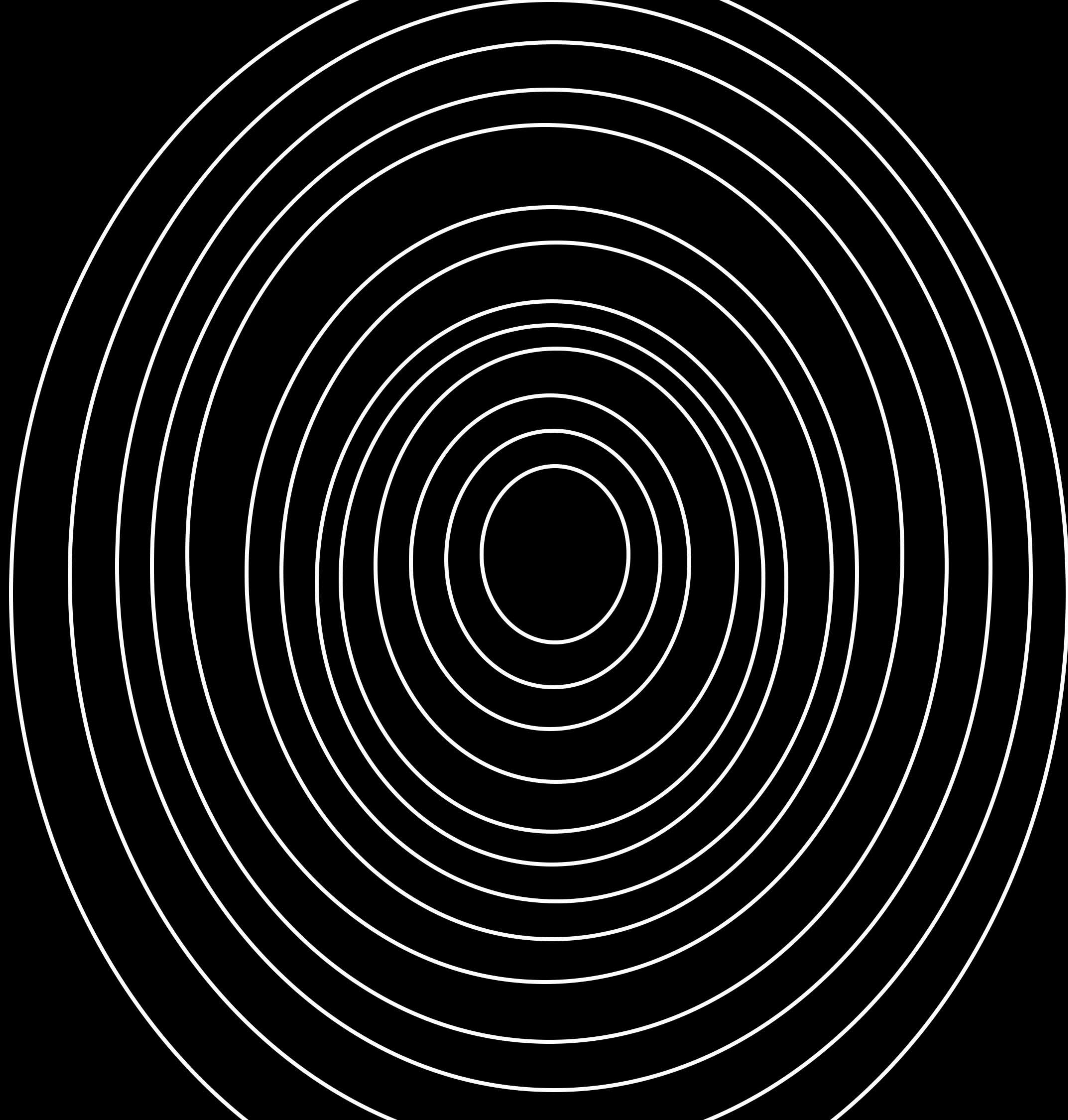


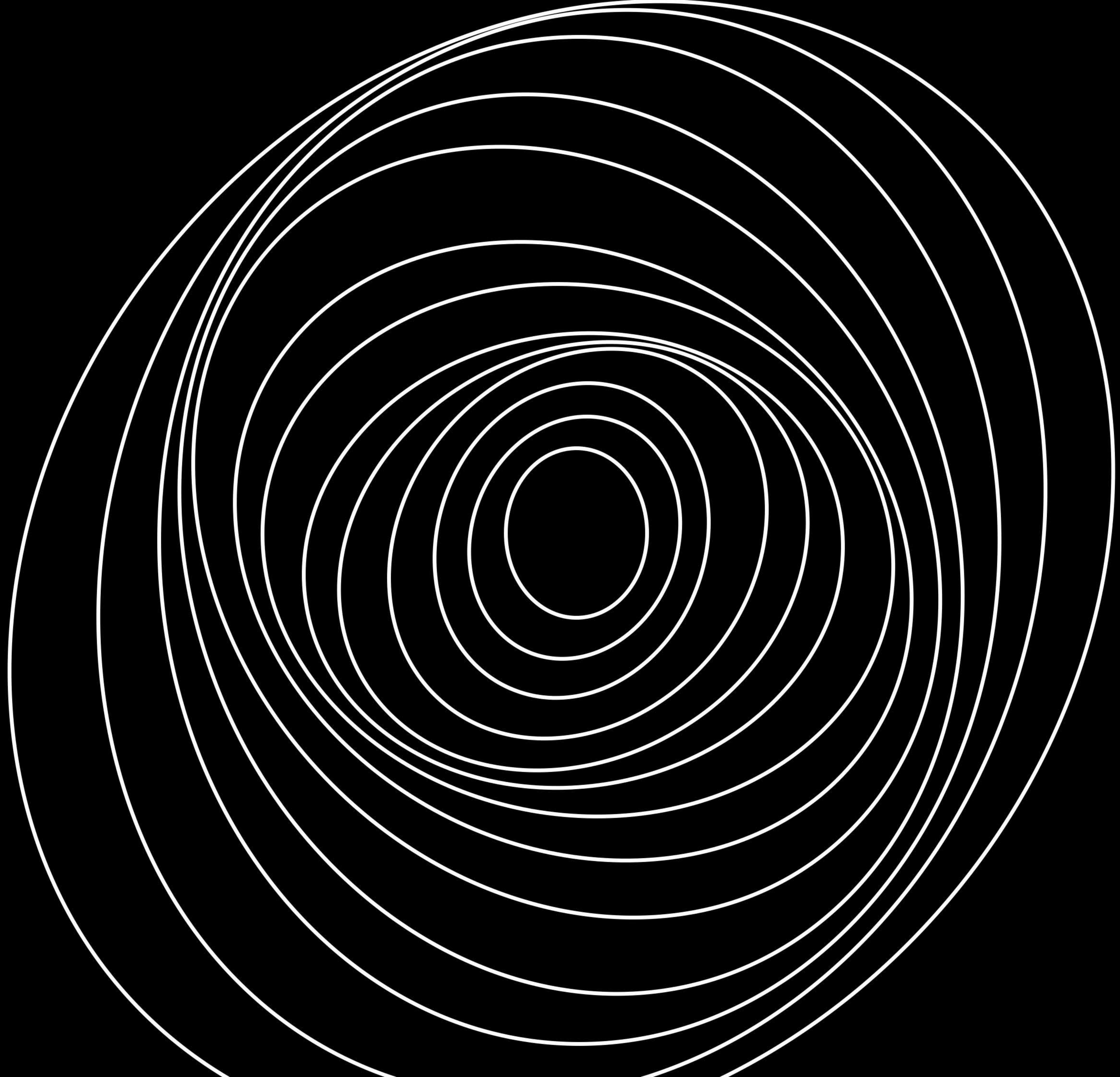


- 
- Brightness
 - Temperature
 - Size
 - Mass
 - Age
 - Chemical composition
 - Environment









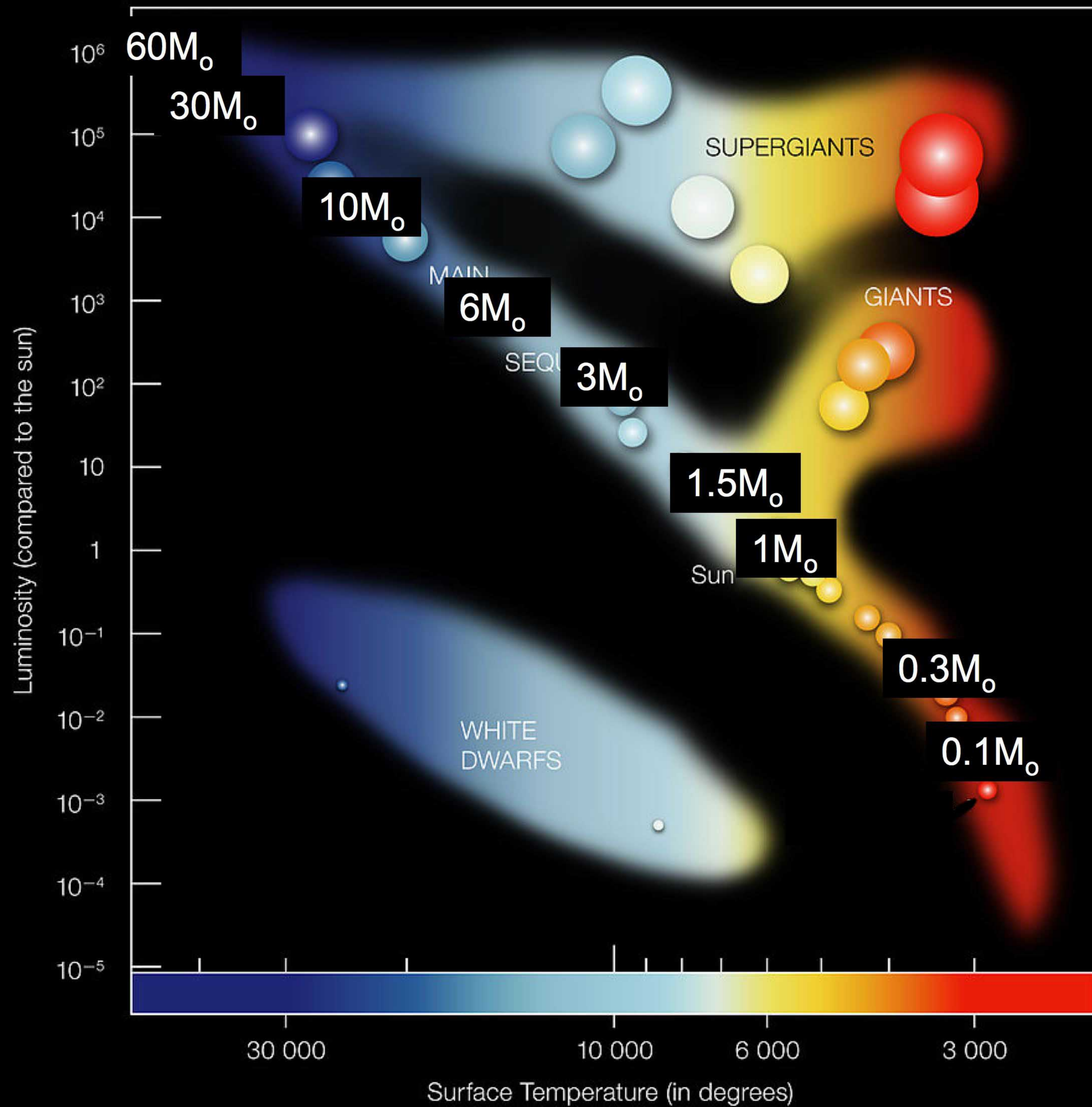


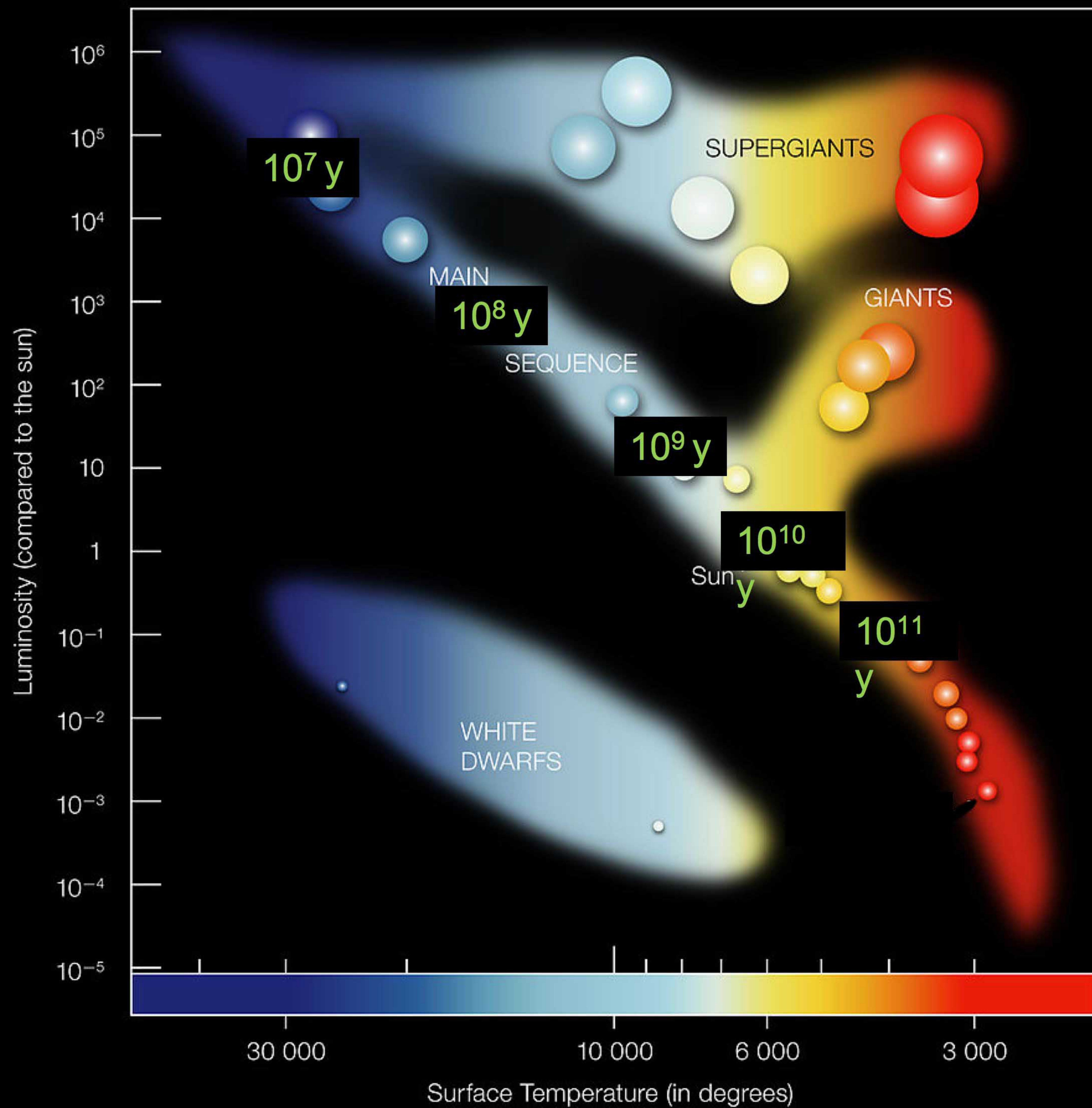


Robert Gendler

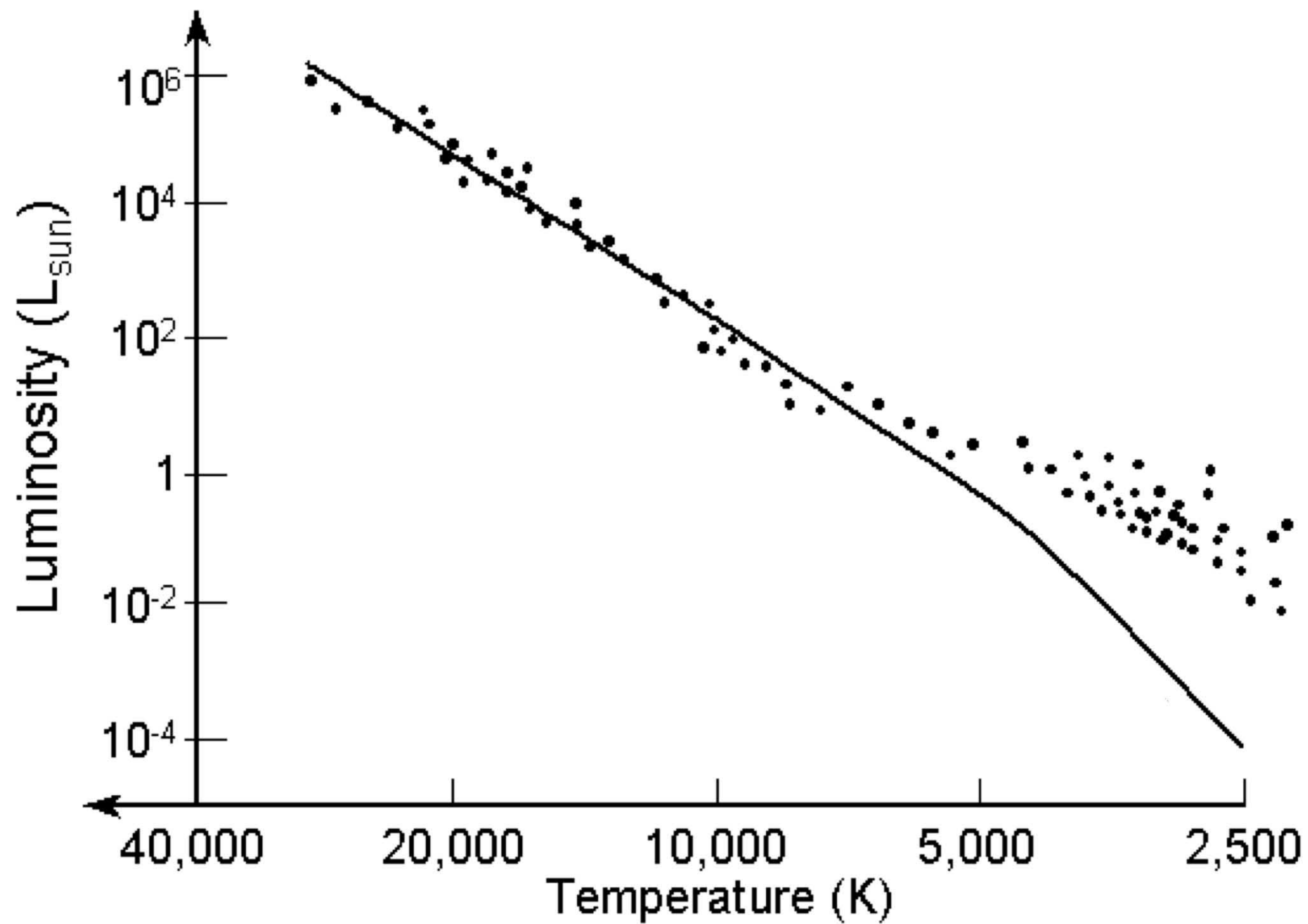


NASA/ESA/ Lennon et al



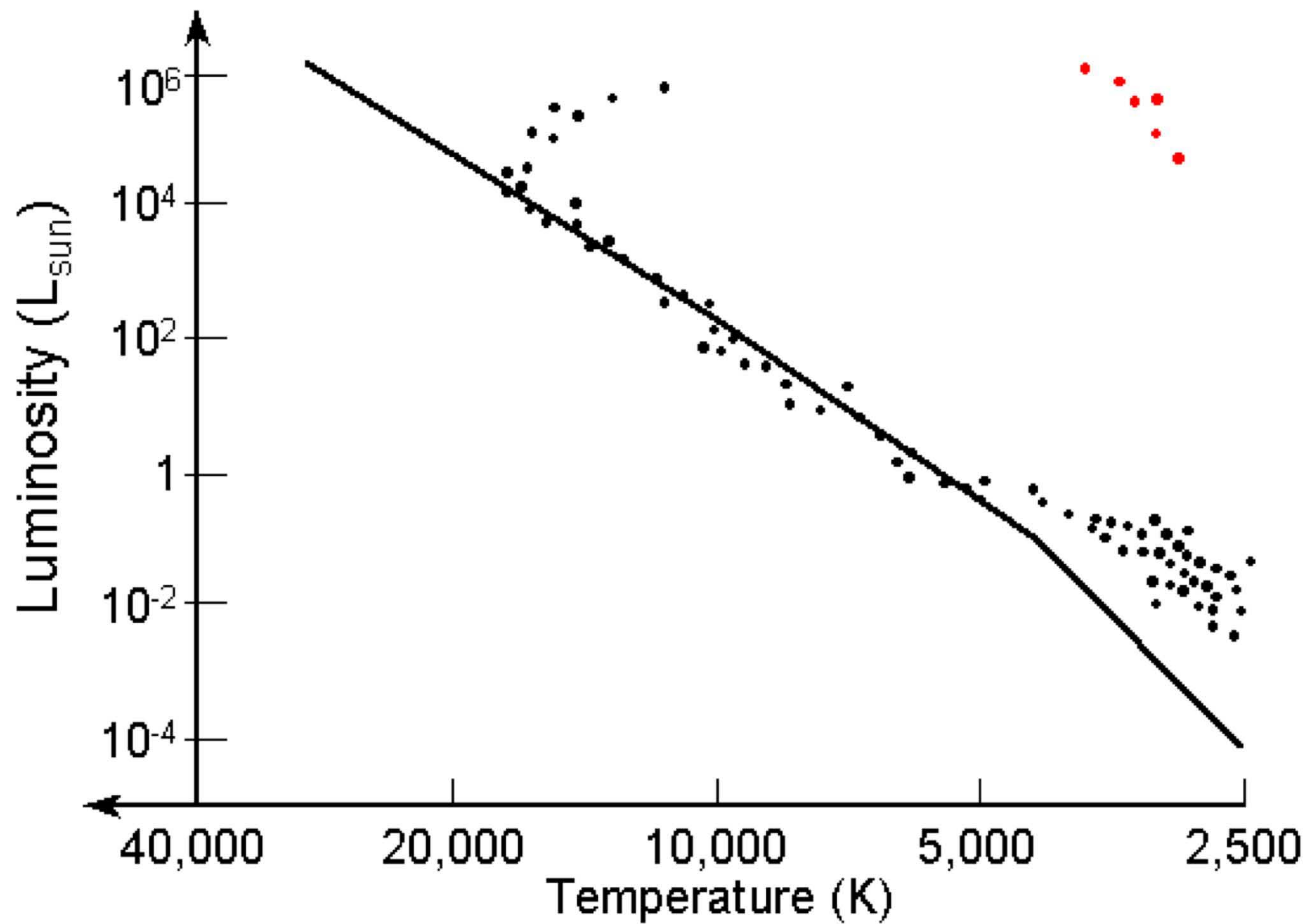


Age ~ 1 Myr

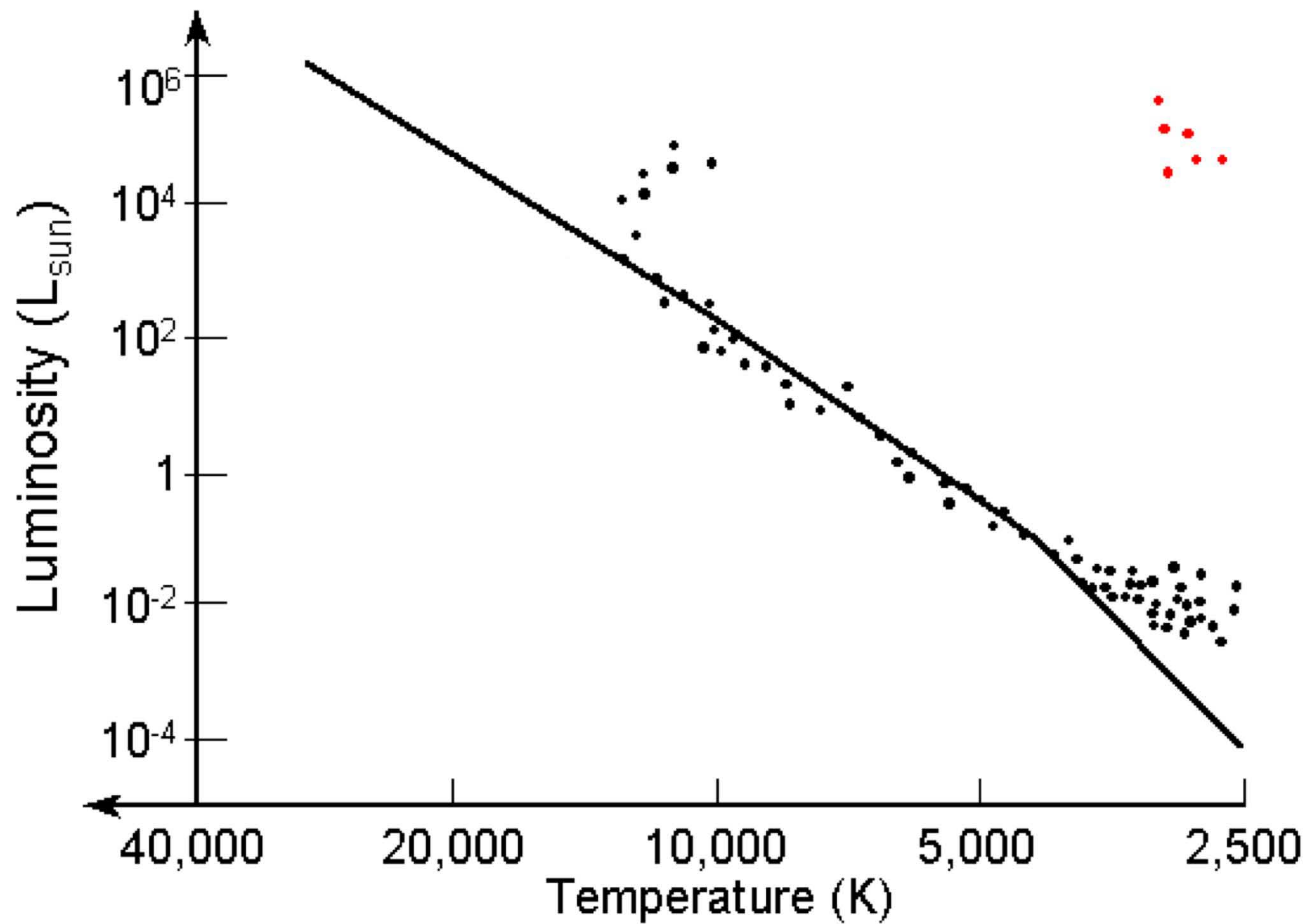




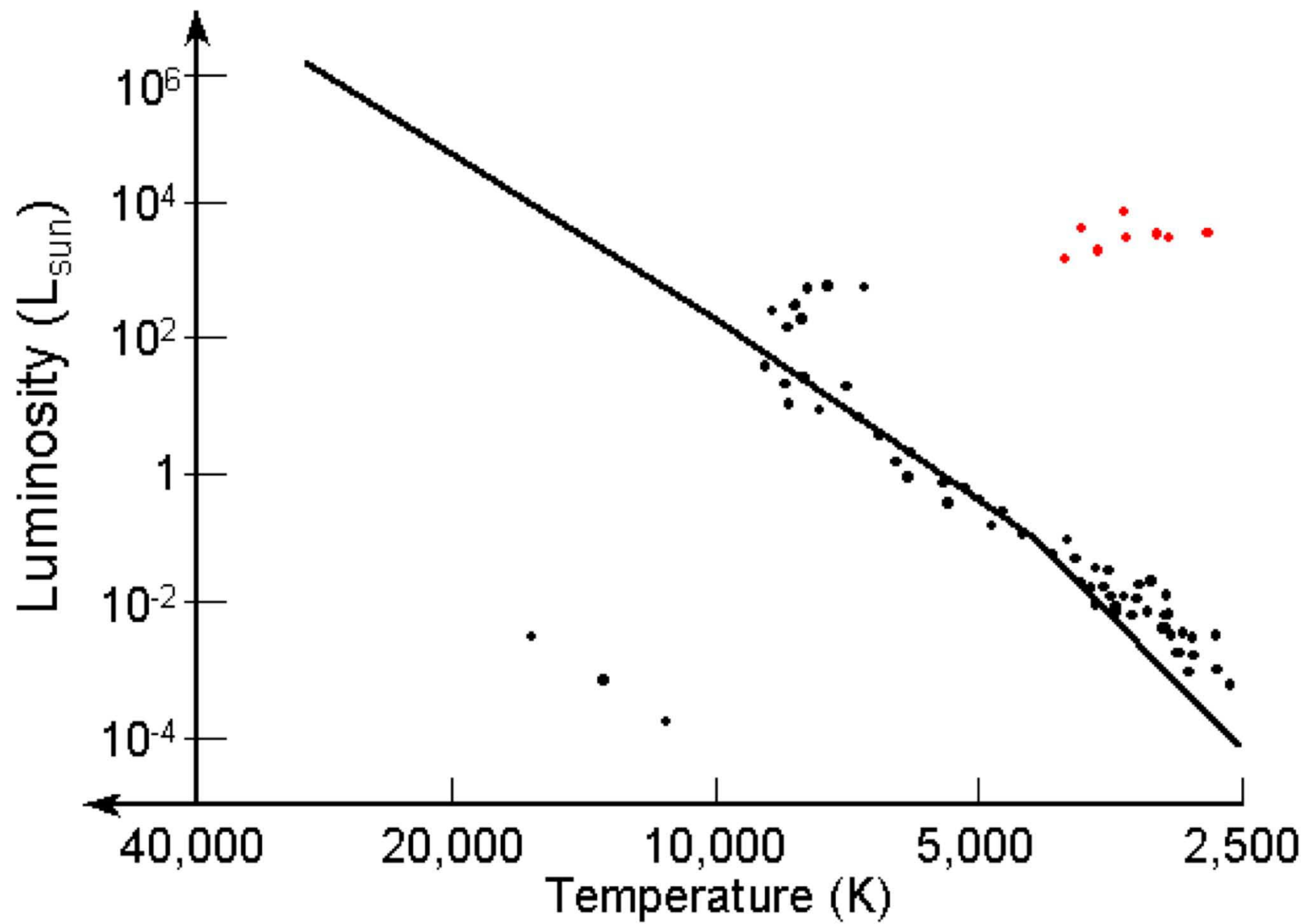
Age ~ 10 Myr



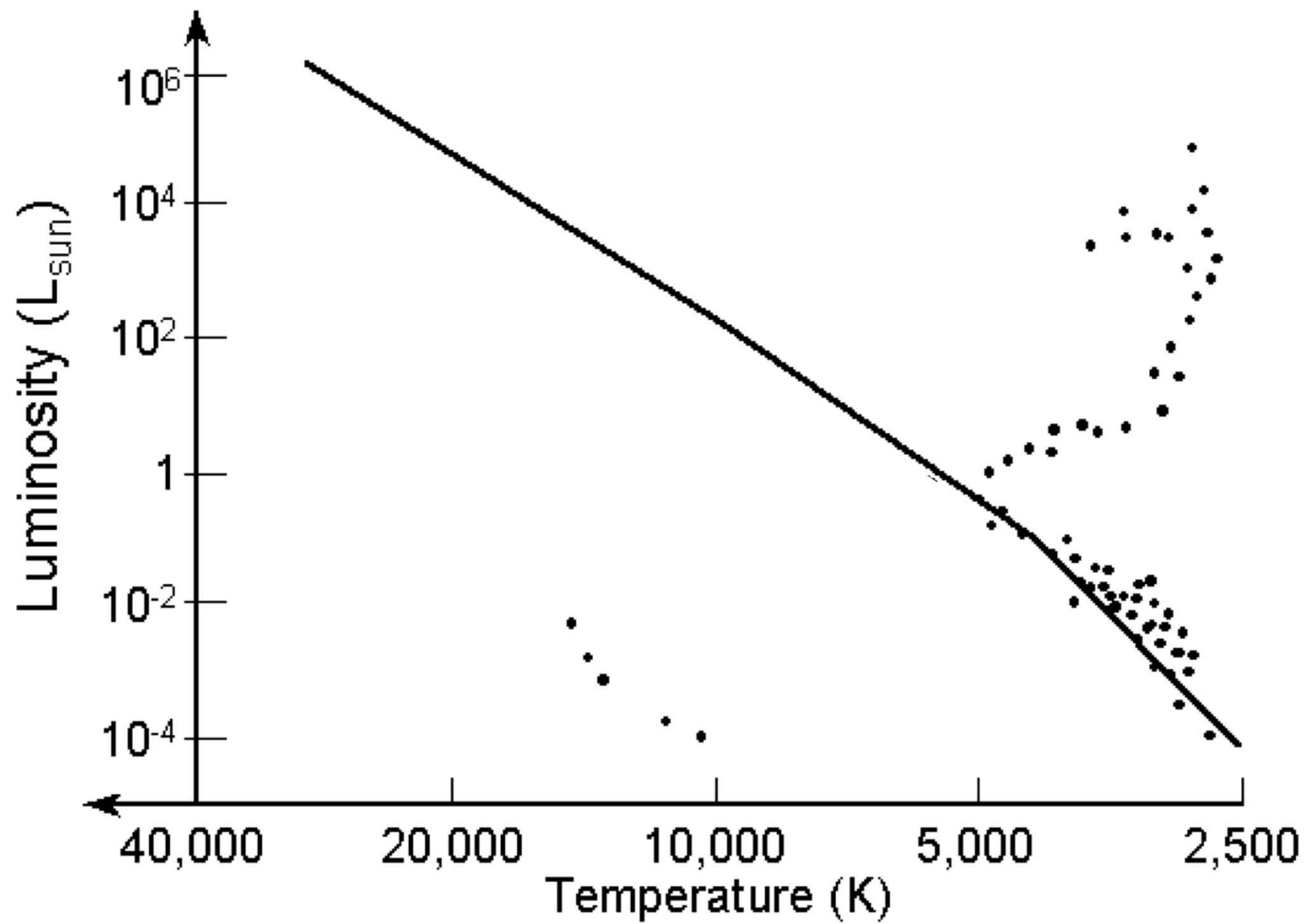
Age ~ 100 Myr



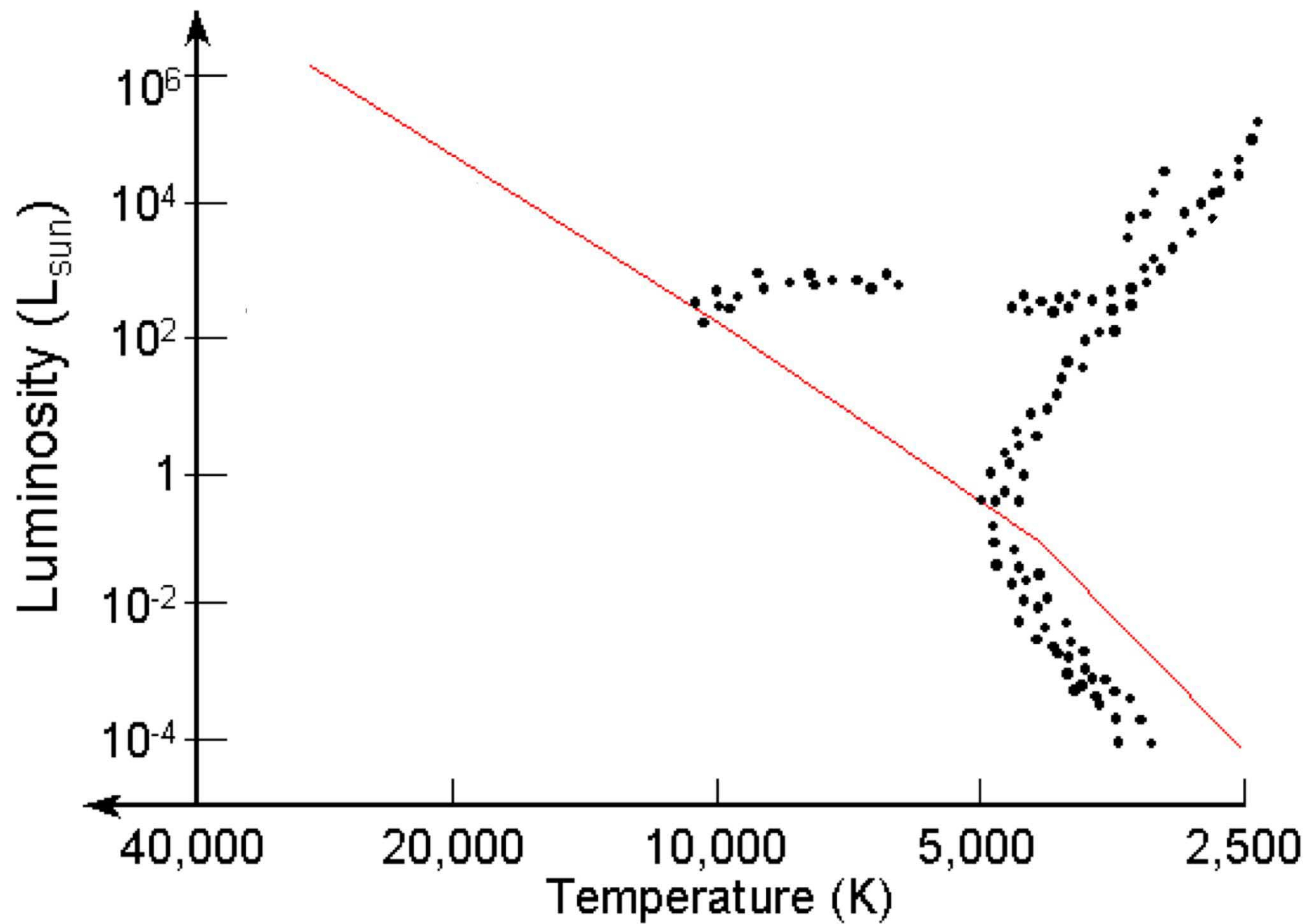
Age ~ 1 Gyr

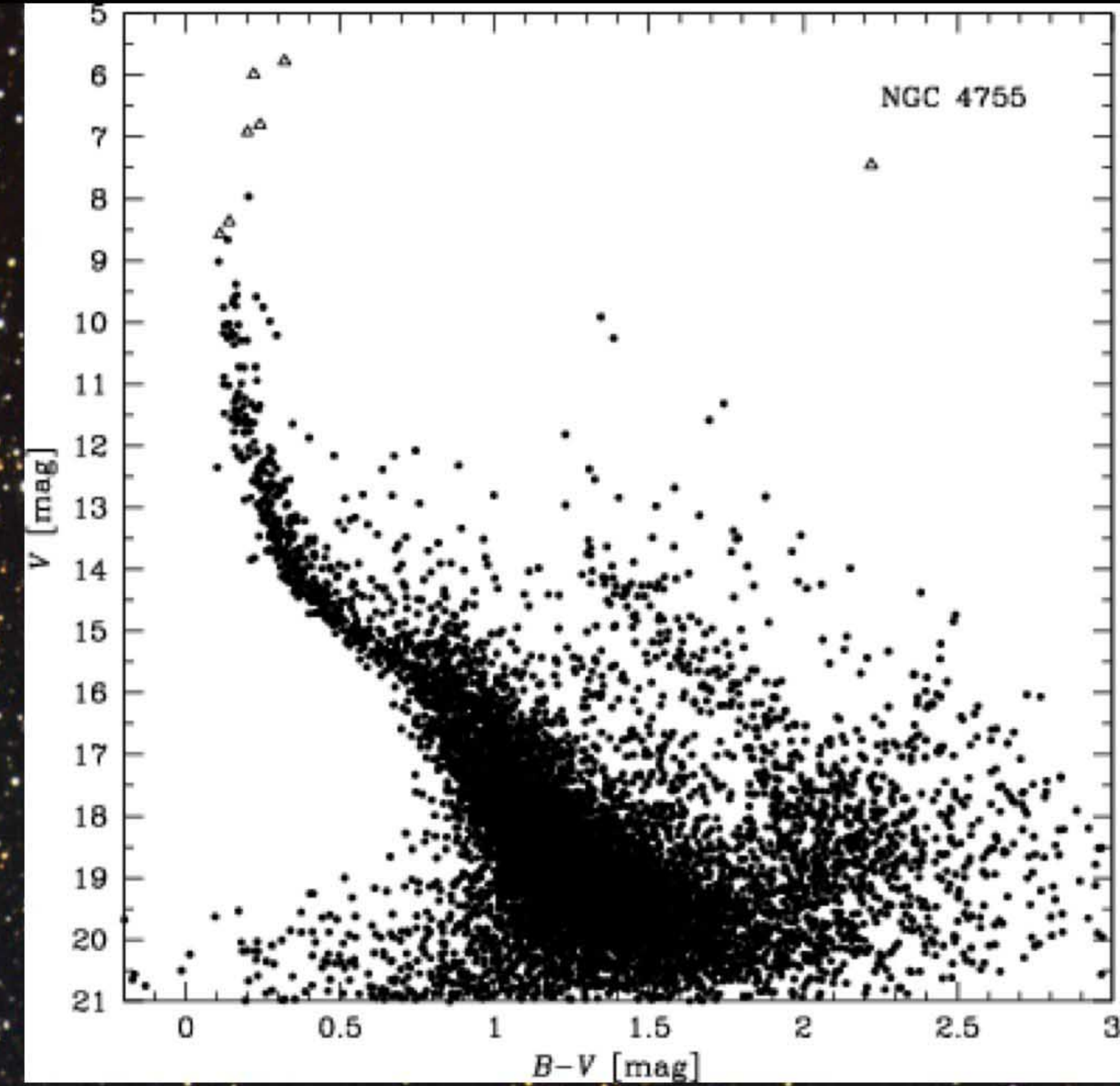
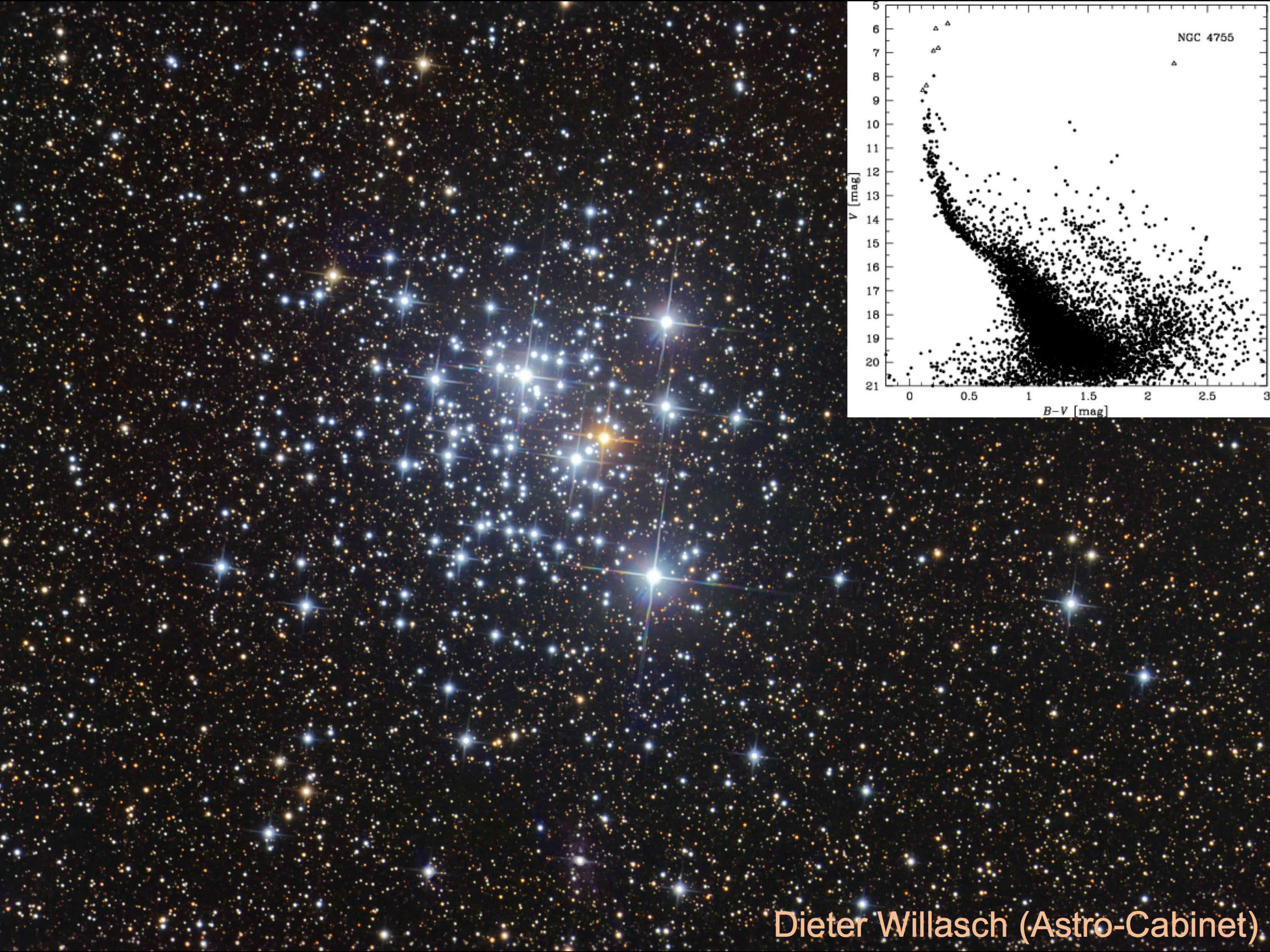


Age ~ 10 Gyr

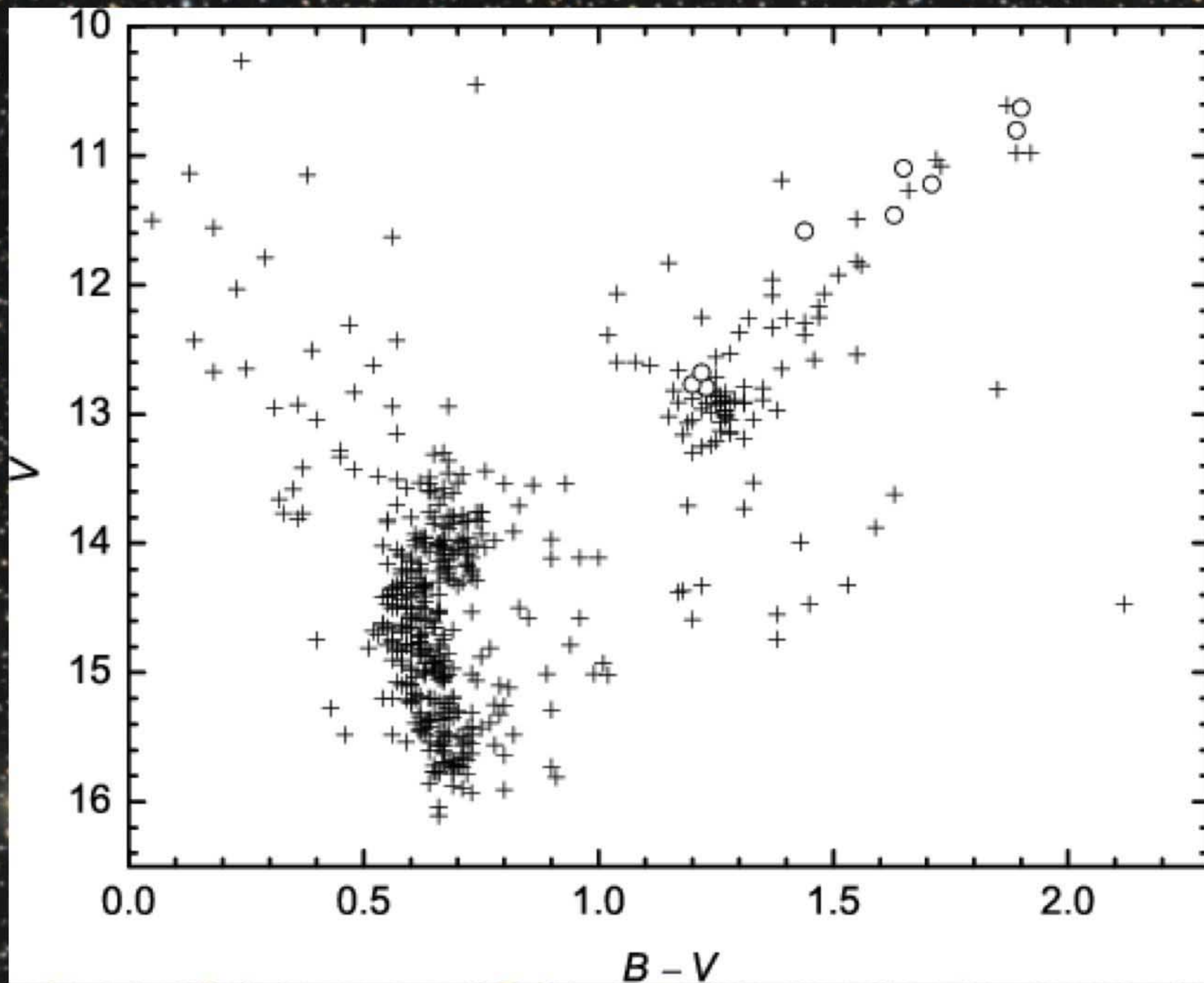


· Globular Cluster



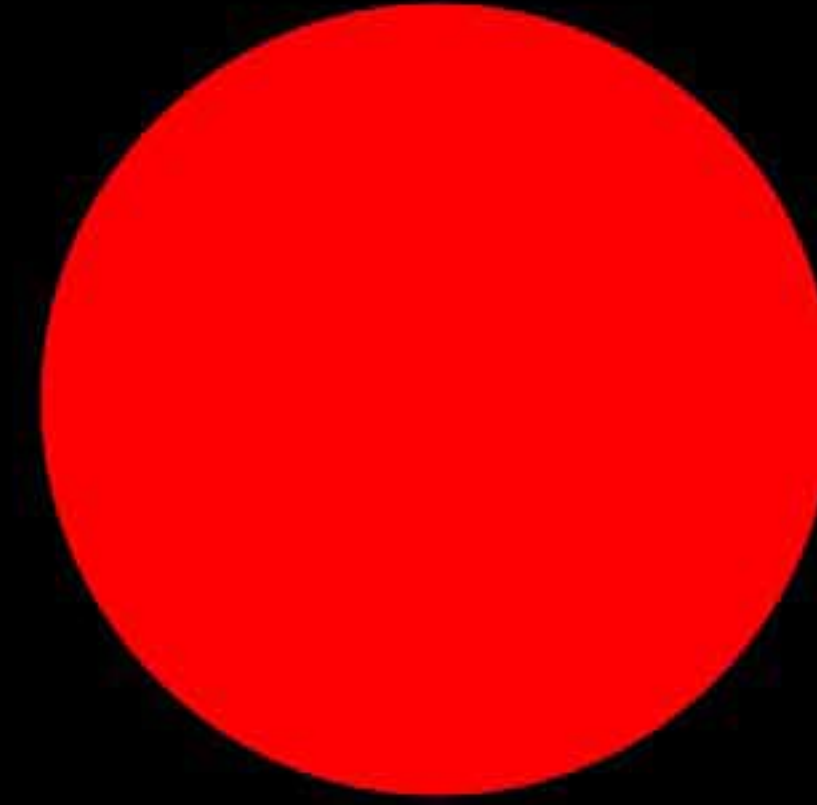


Dieter Willasch (Astro-Cabinet)



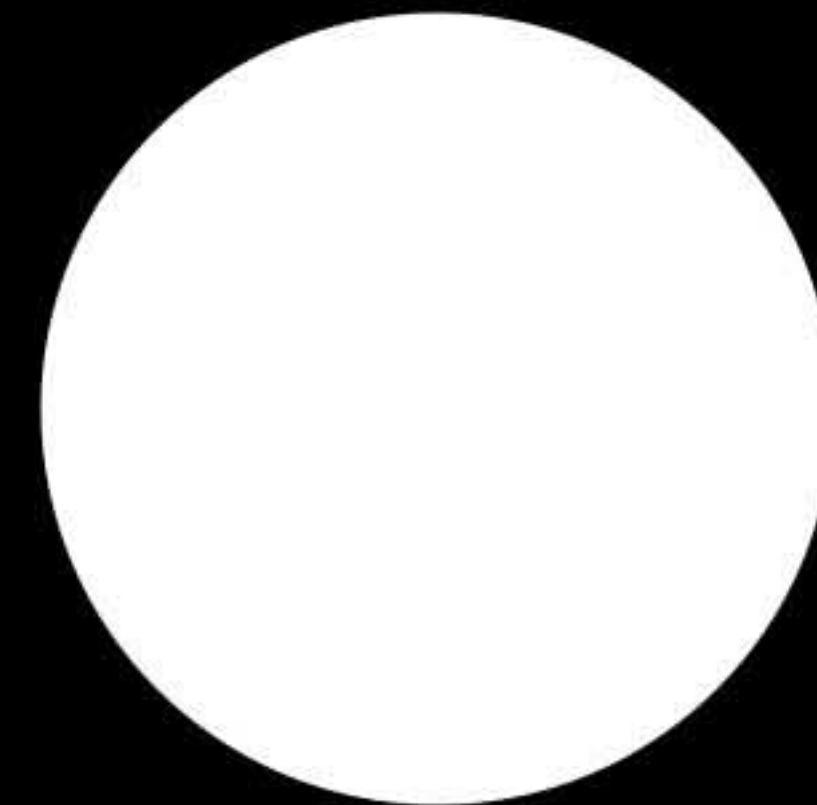
An atomic nucleus consists of

:



positively charged

protons



electrically neutral

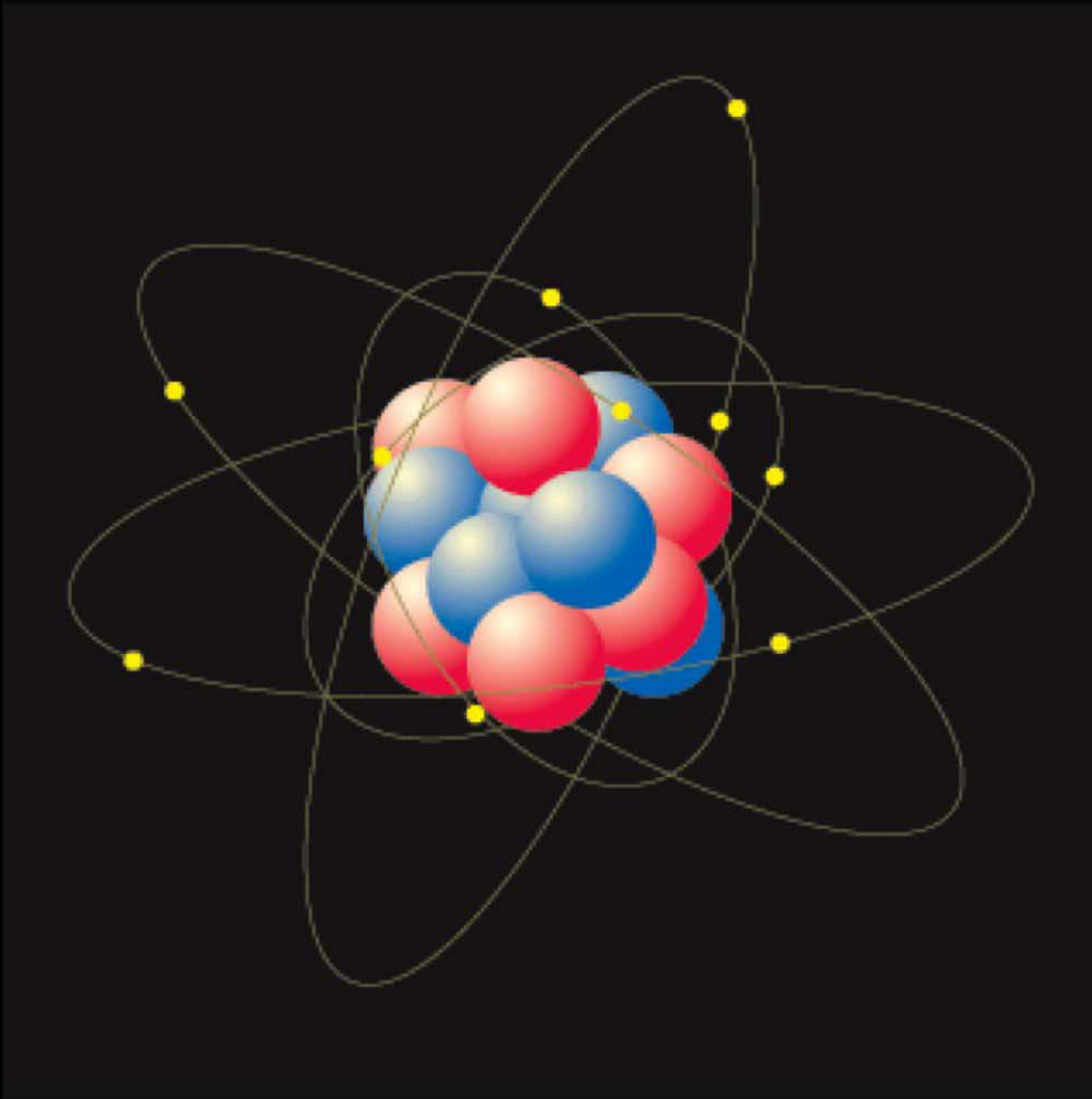
neutrons

surrounded by a cloud of

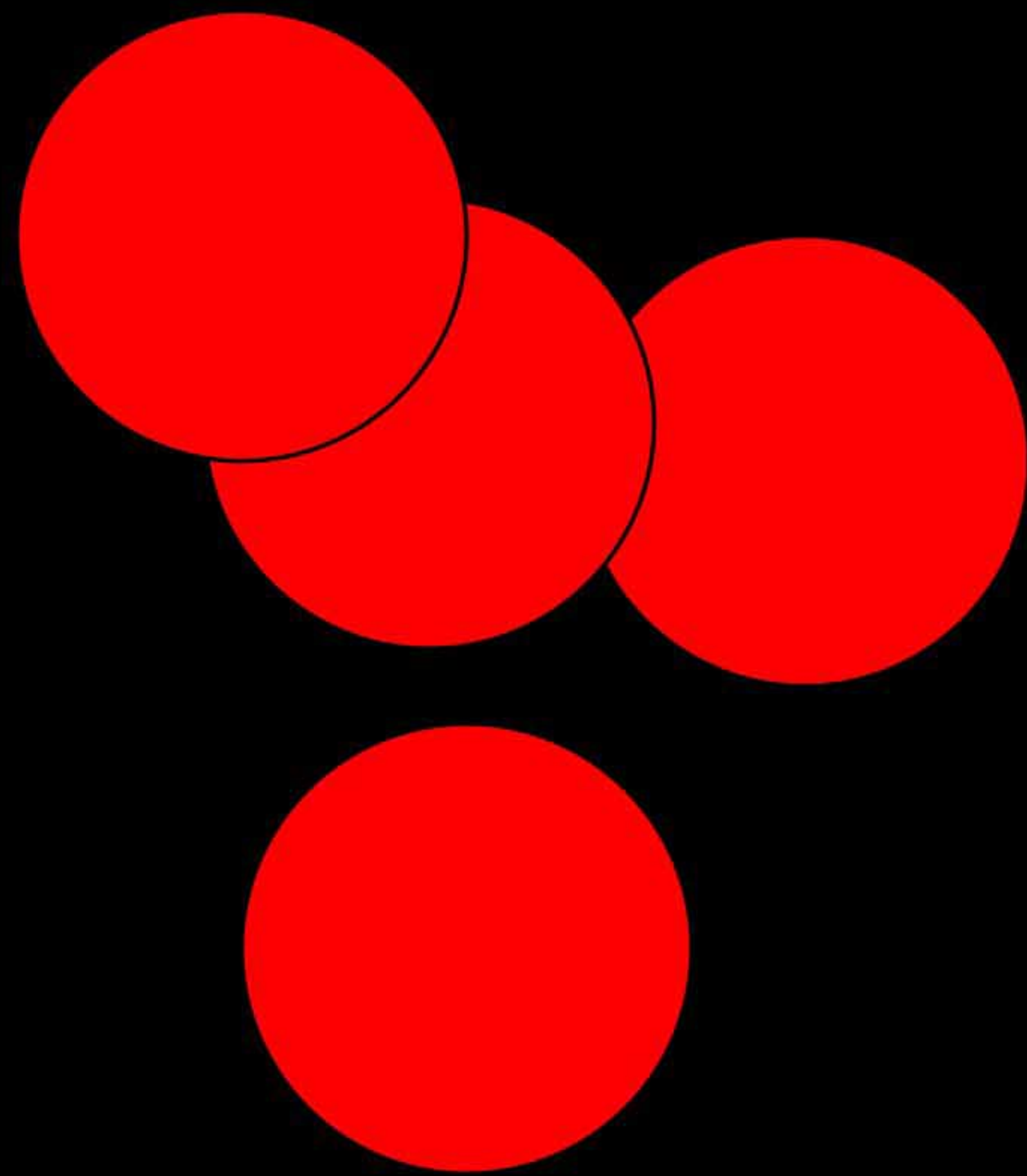


negatively charged

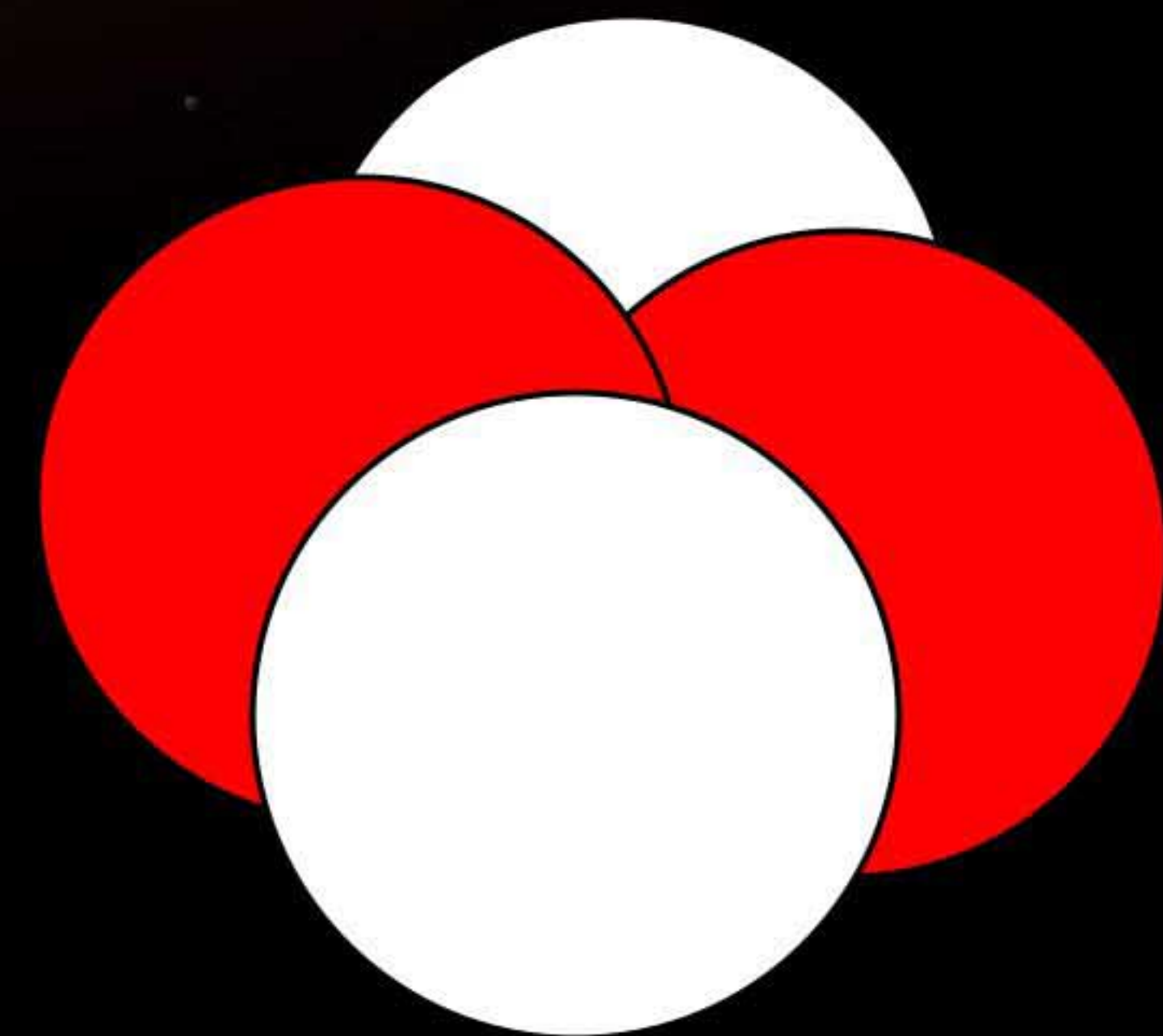
Atoms of different chemical elements have **electrons**
different numbers of **protons** in the nucleus

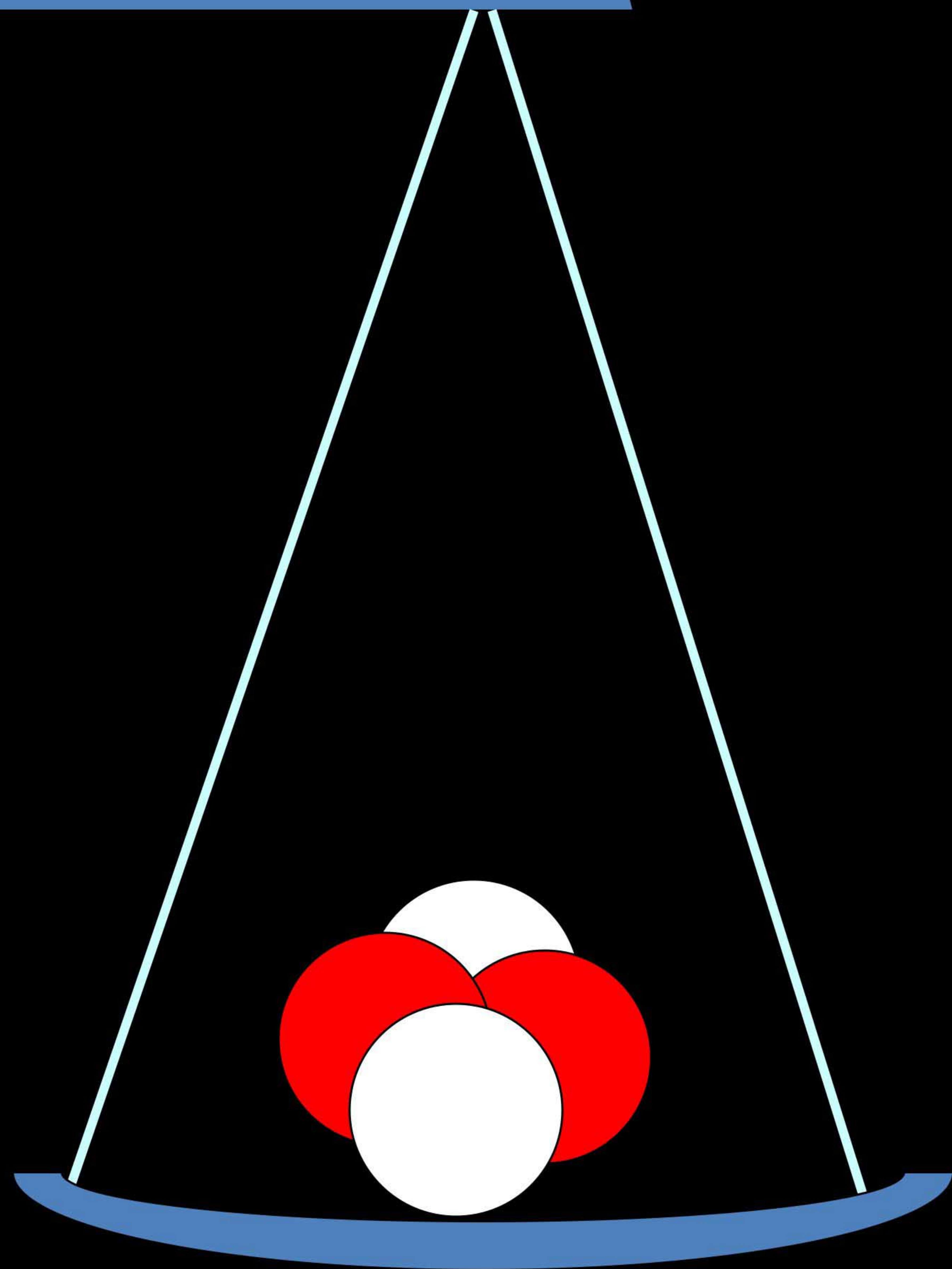
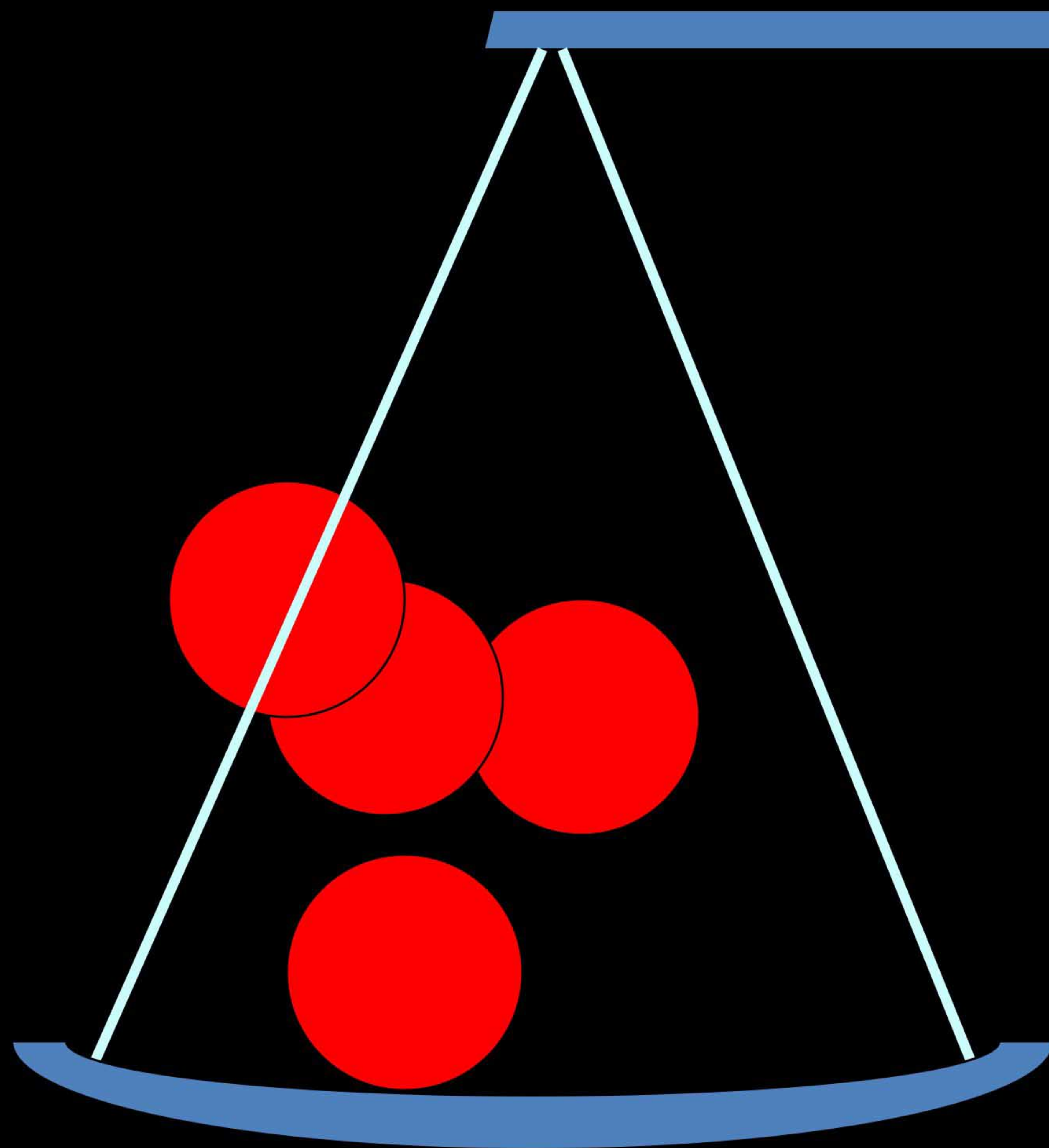


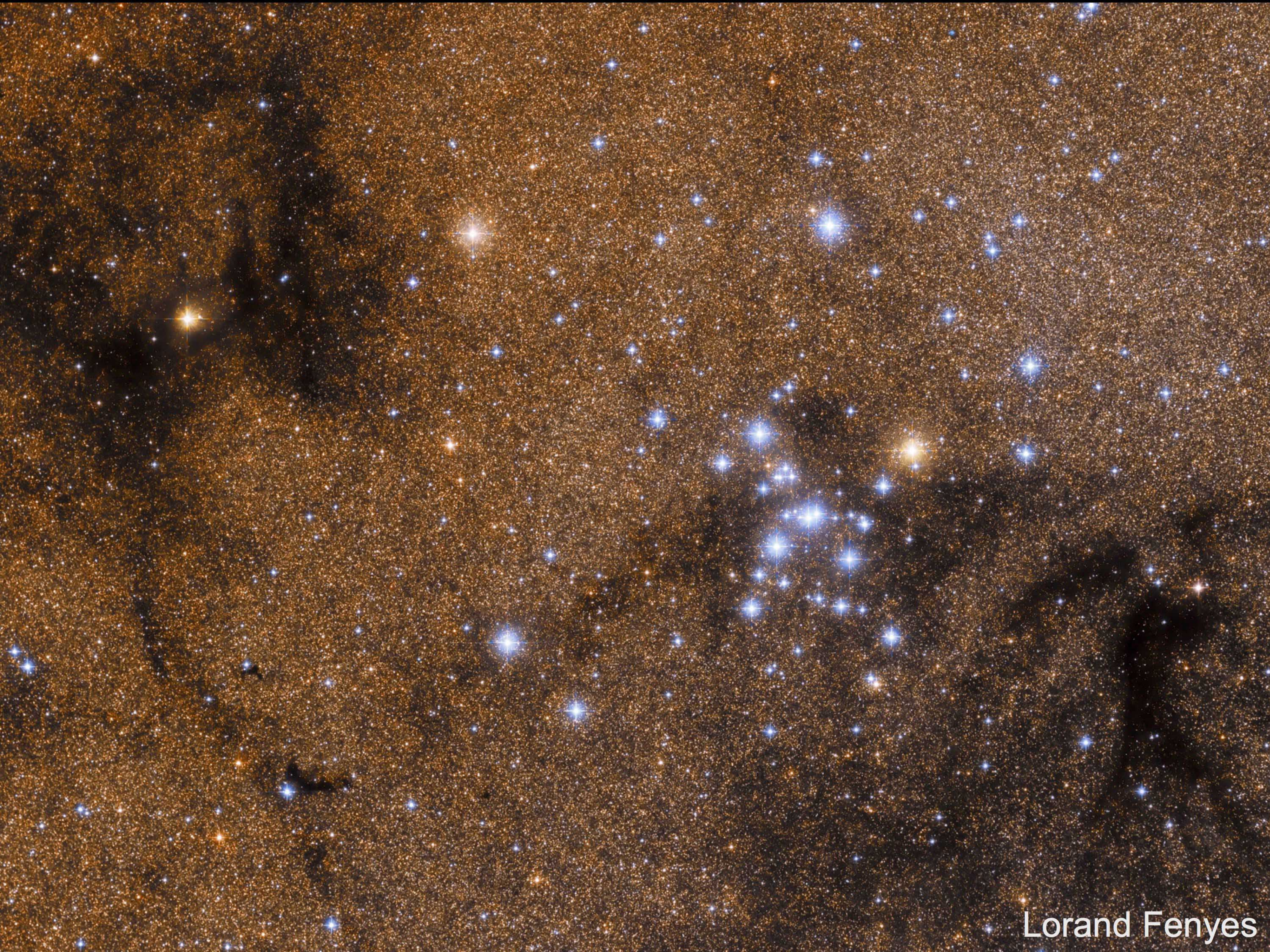
4 protons



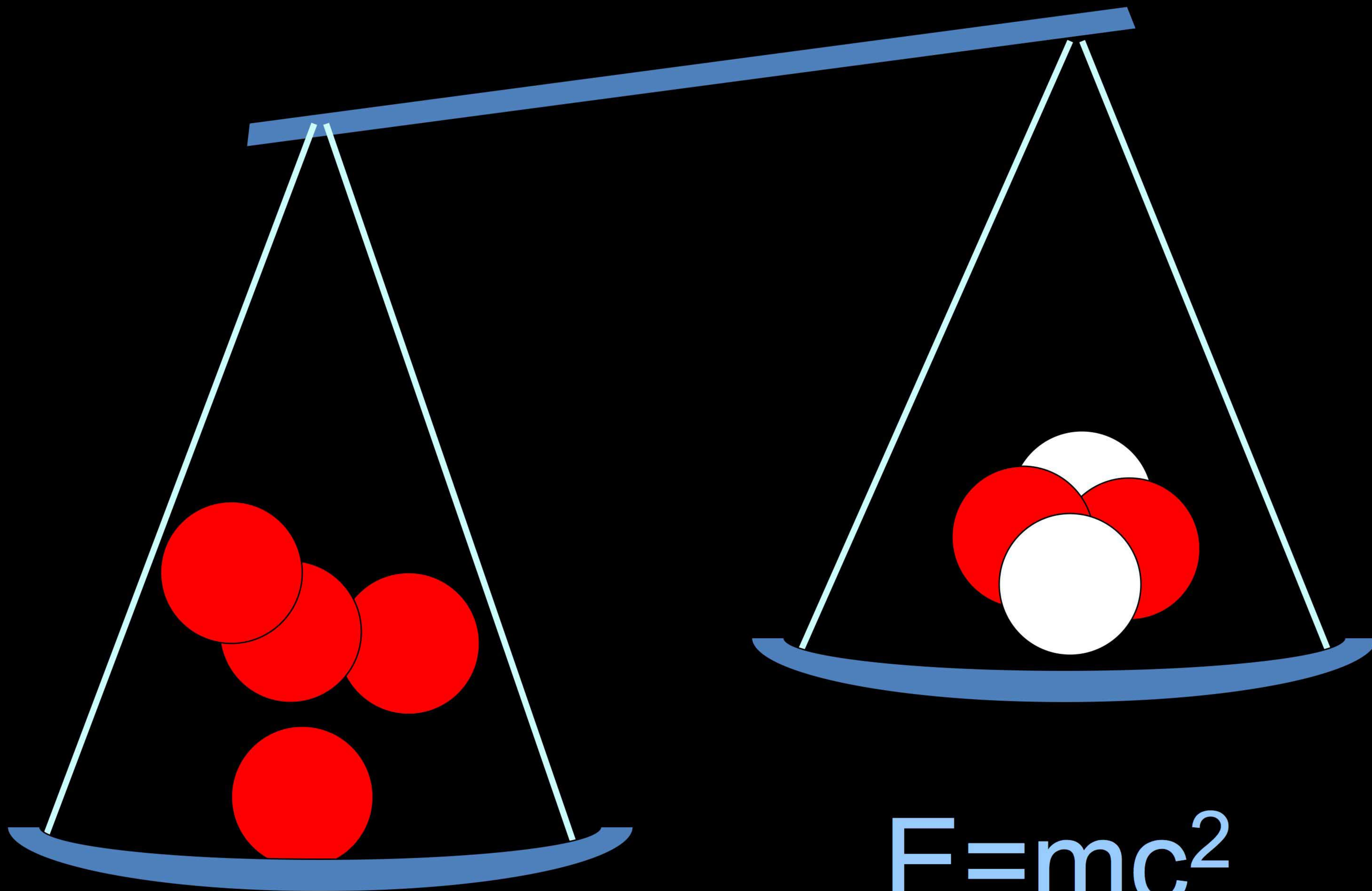
He nucleus
(α -particle)







Lorand Fenyes

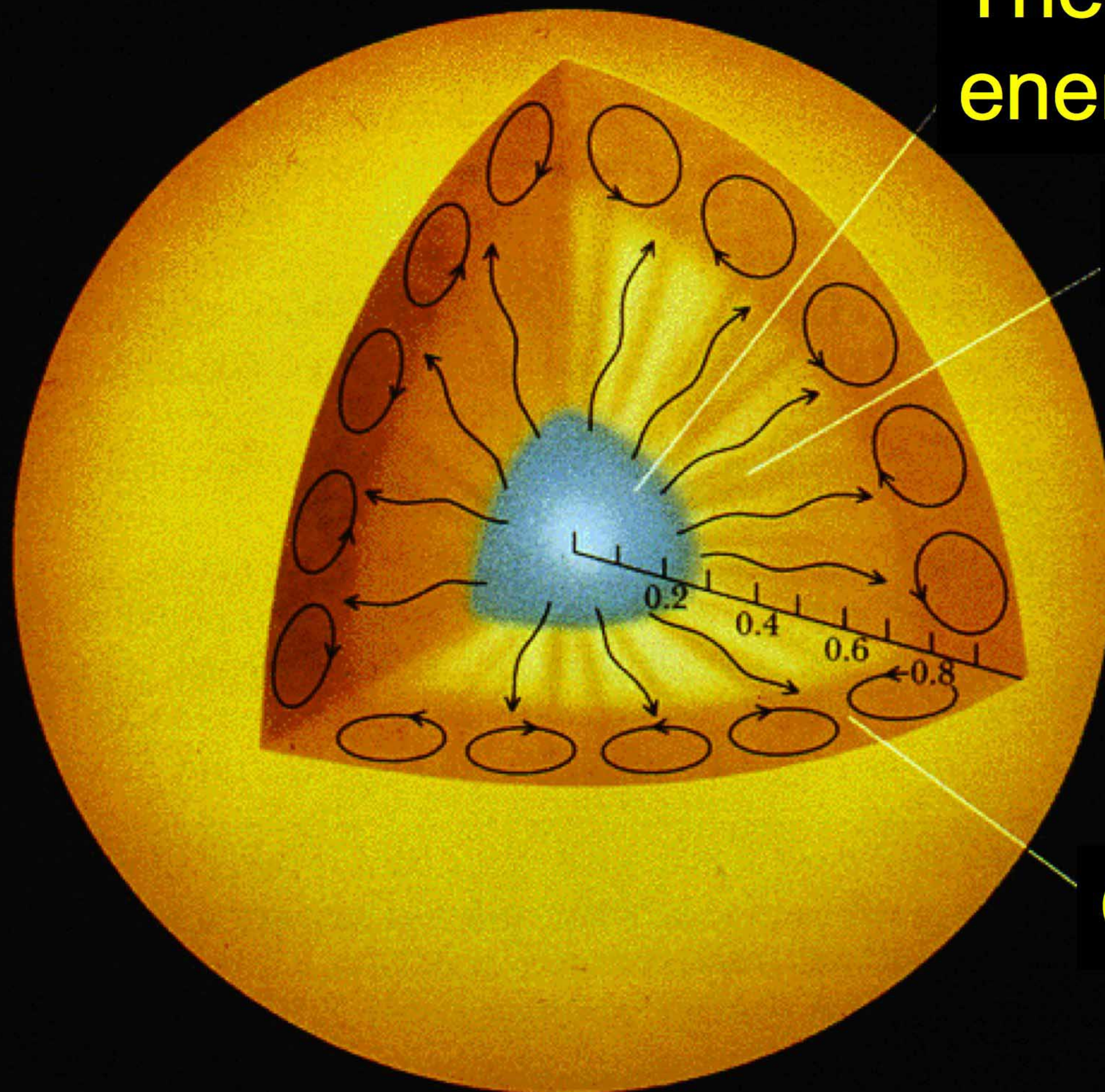


$$E=mc^2$$

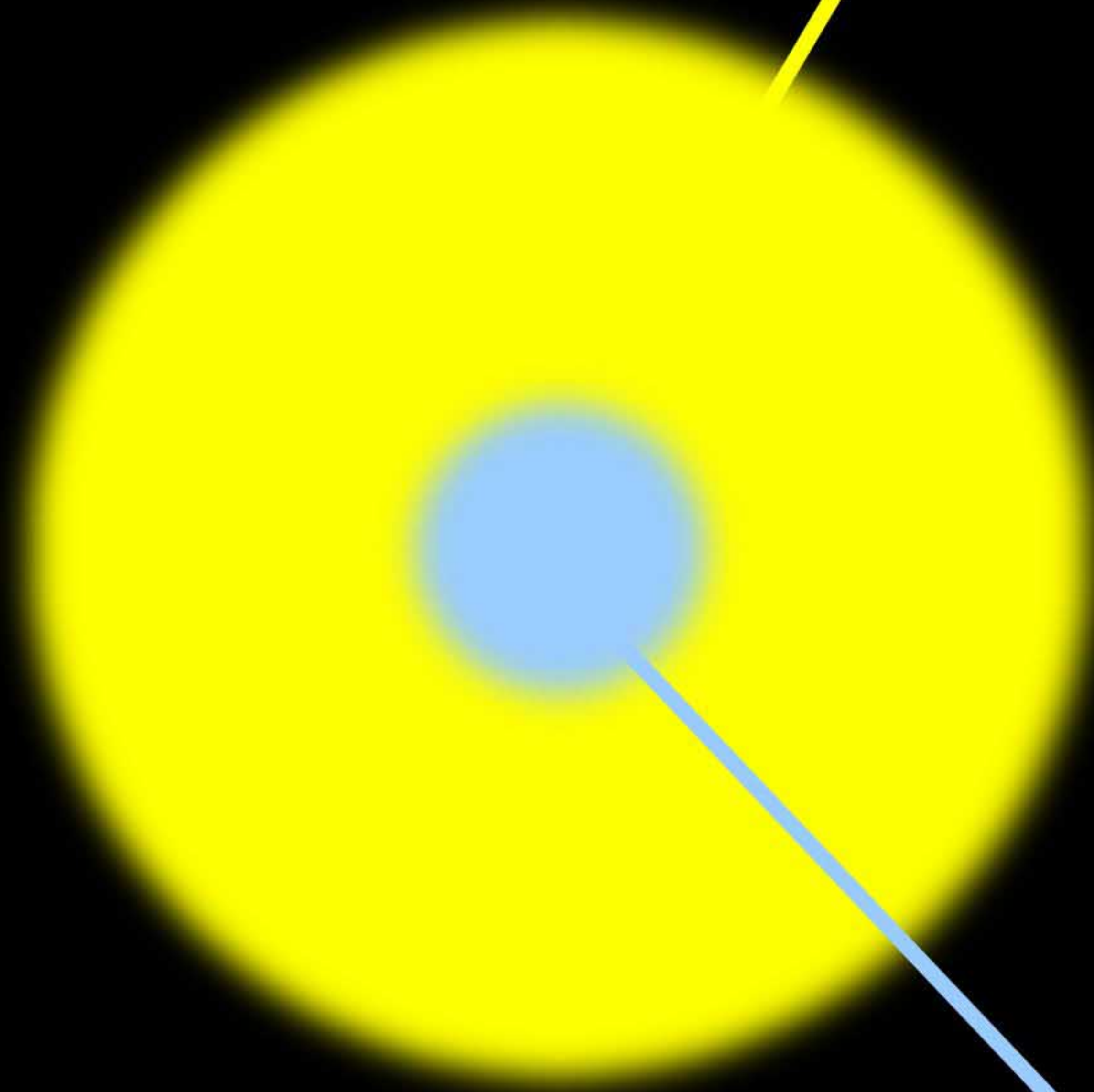
Thermonuclear
energy in core

Radiative zone

Convective zone



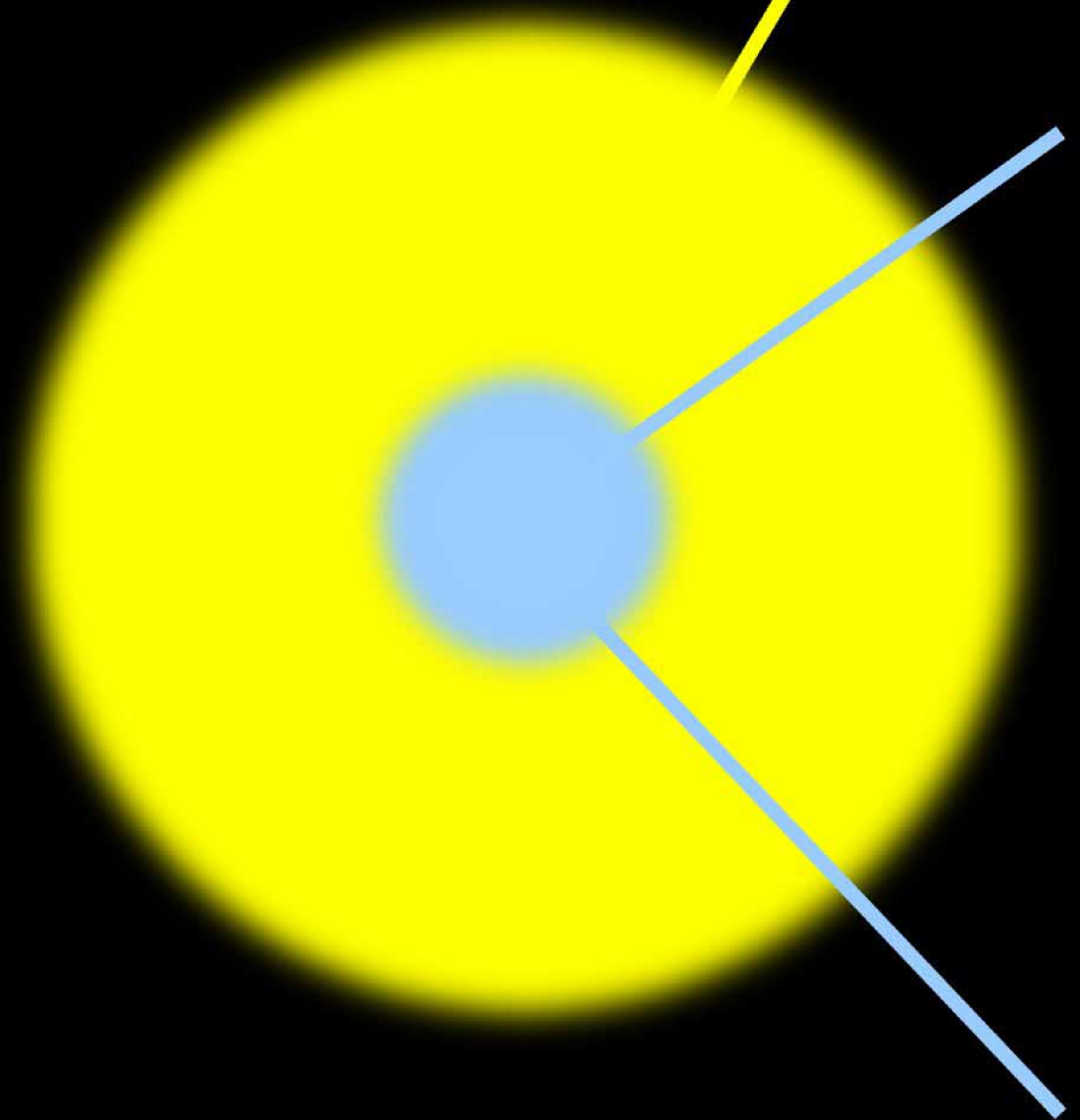
outer layer: no nuclear
reactions



Hydrogen-fusing core

main sequence star

outer layer: no nuclear
reactions



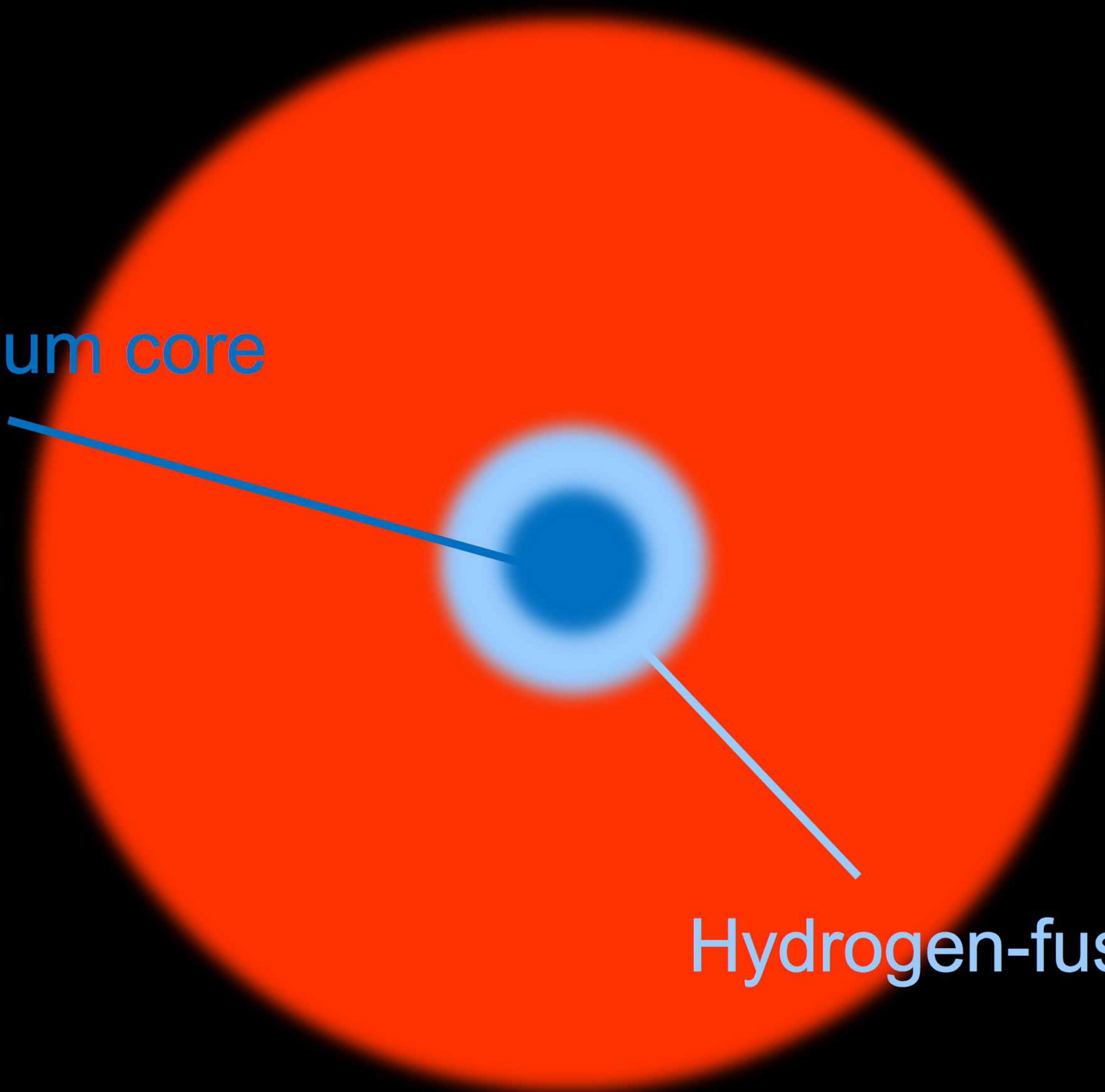
Helium-rich core

Hydrogen-burning shell

inert Helium core

Hydrogen-fusing shell

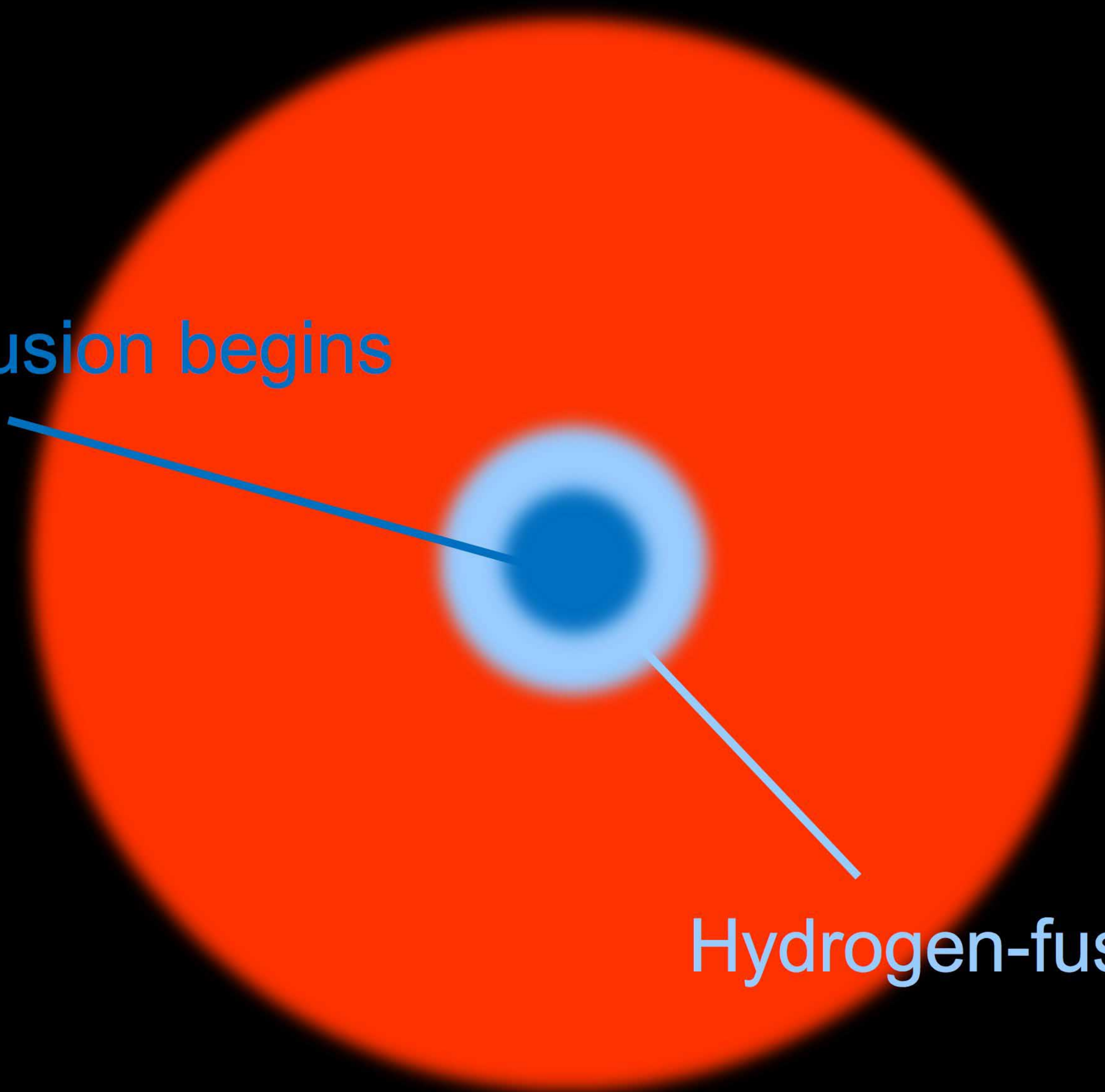
red giant star



Helium fusion begins

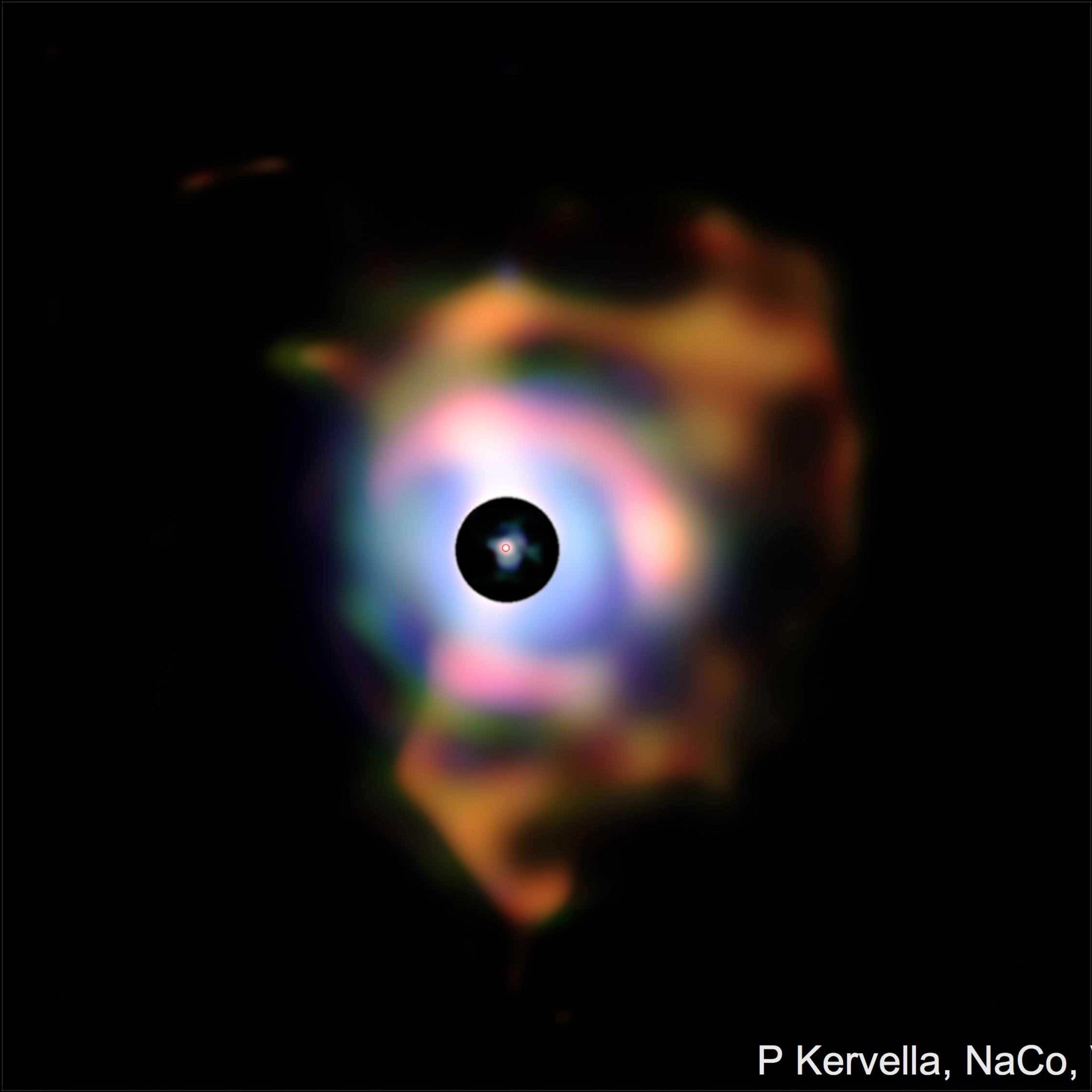
Hydrogen-fusing shell

red giant star



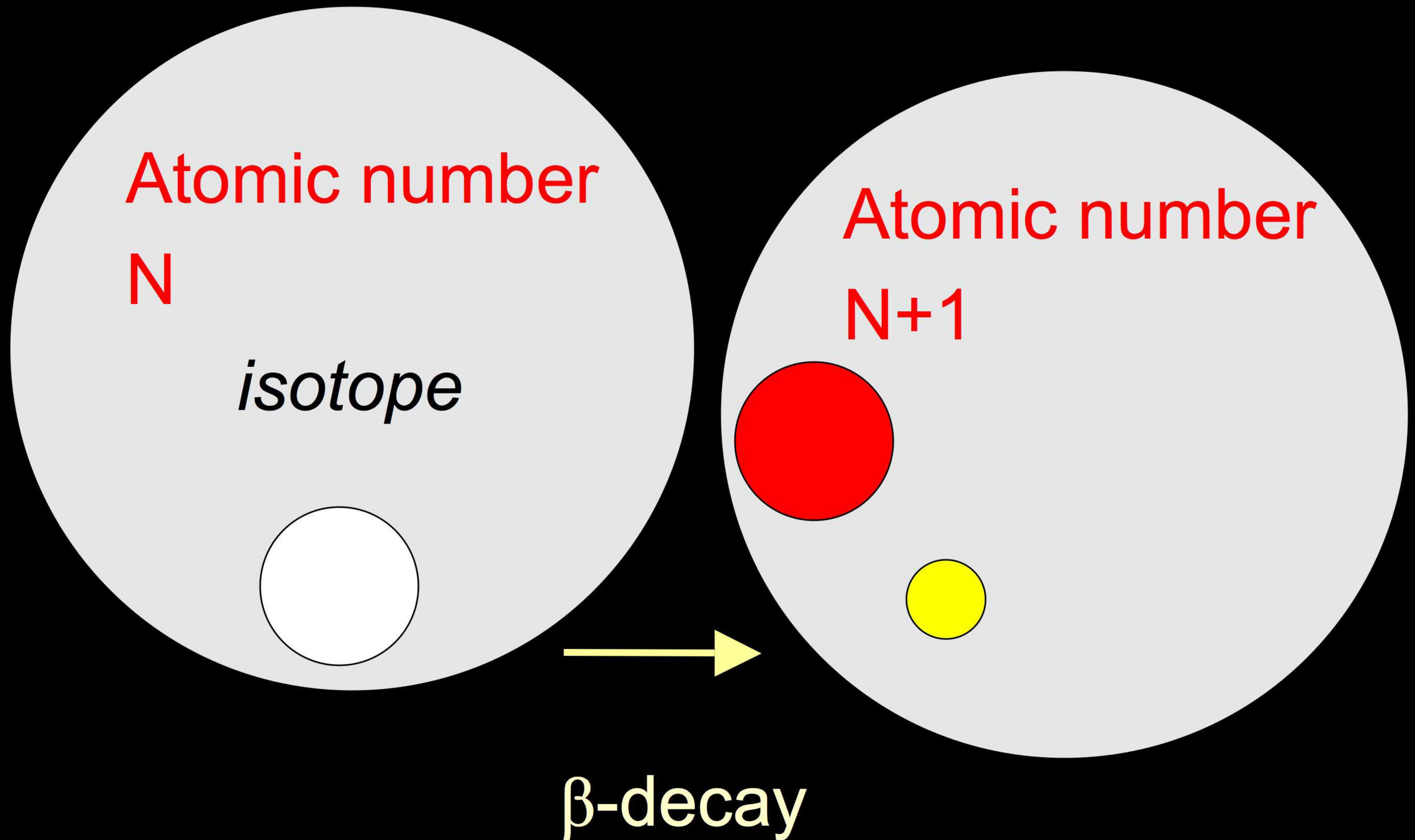






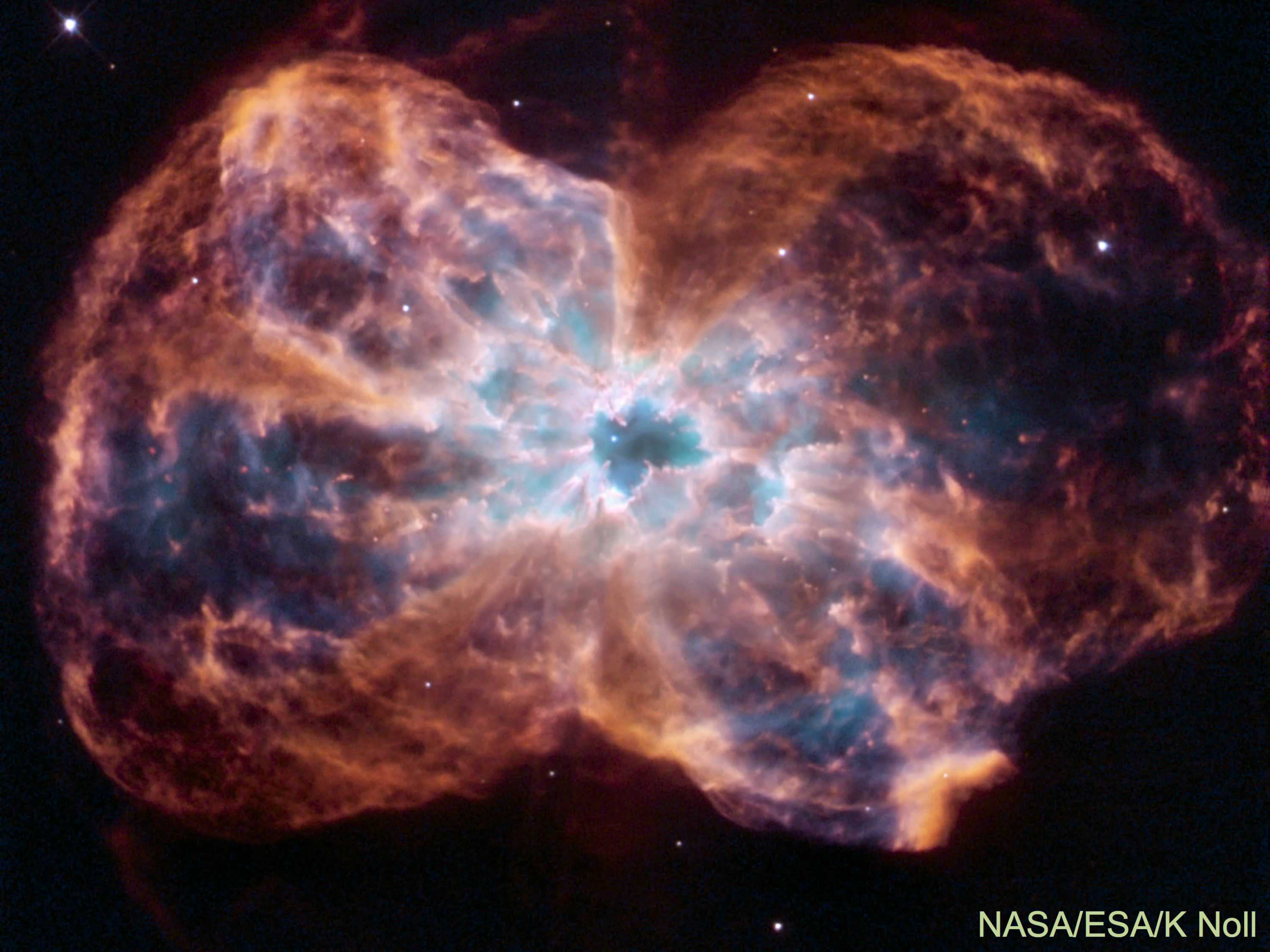
P Kervella, NaCo, VLT/ESO

S – process (slow neutron capture)





NASA/ESA/Hubble Heritage





NASA/ESA/Hubble Heritage

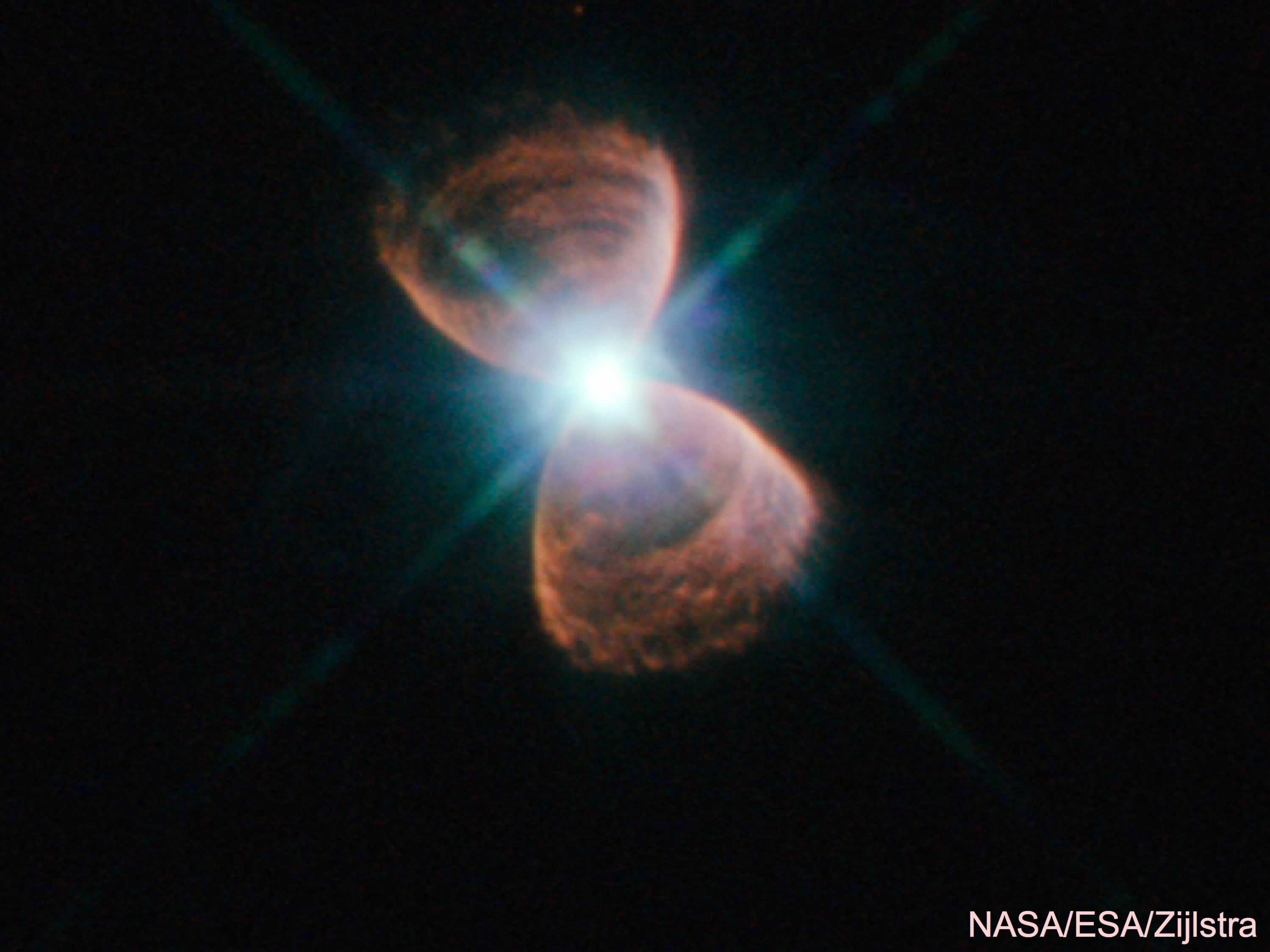






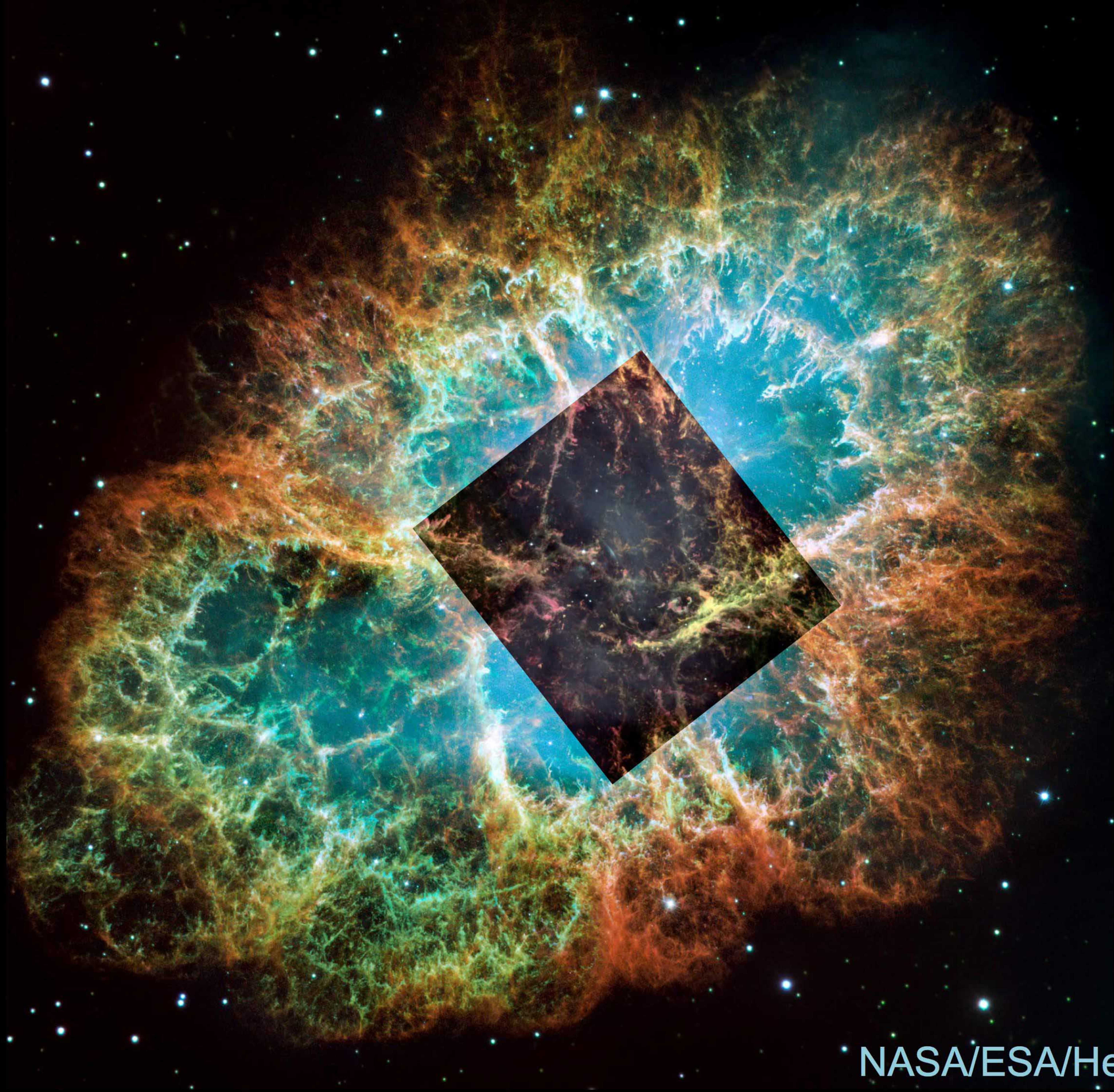


Johannes Schedler

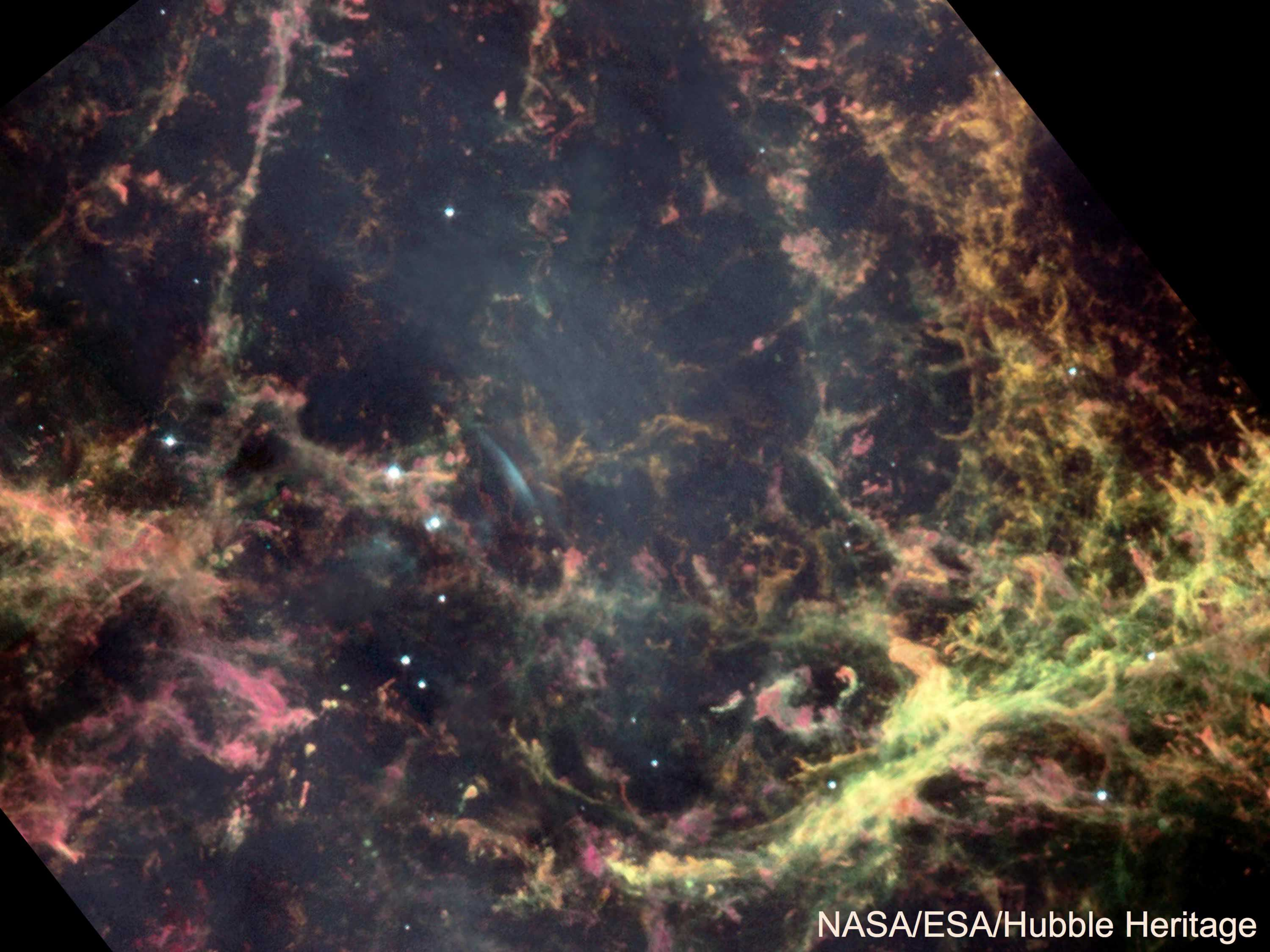




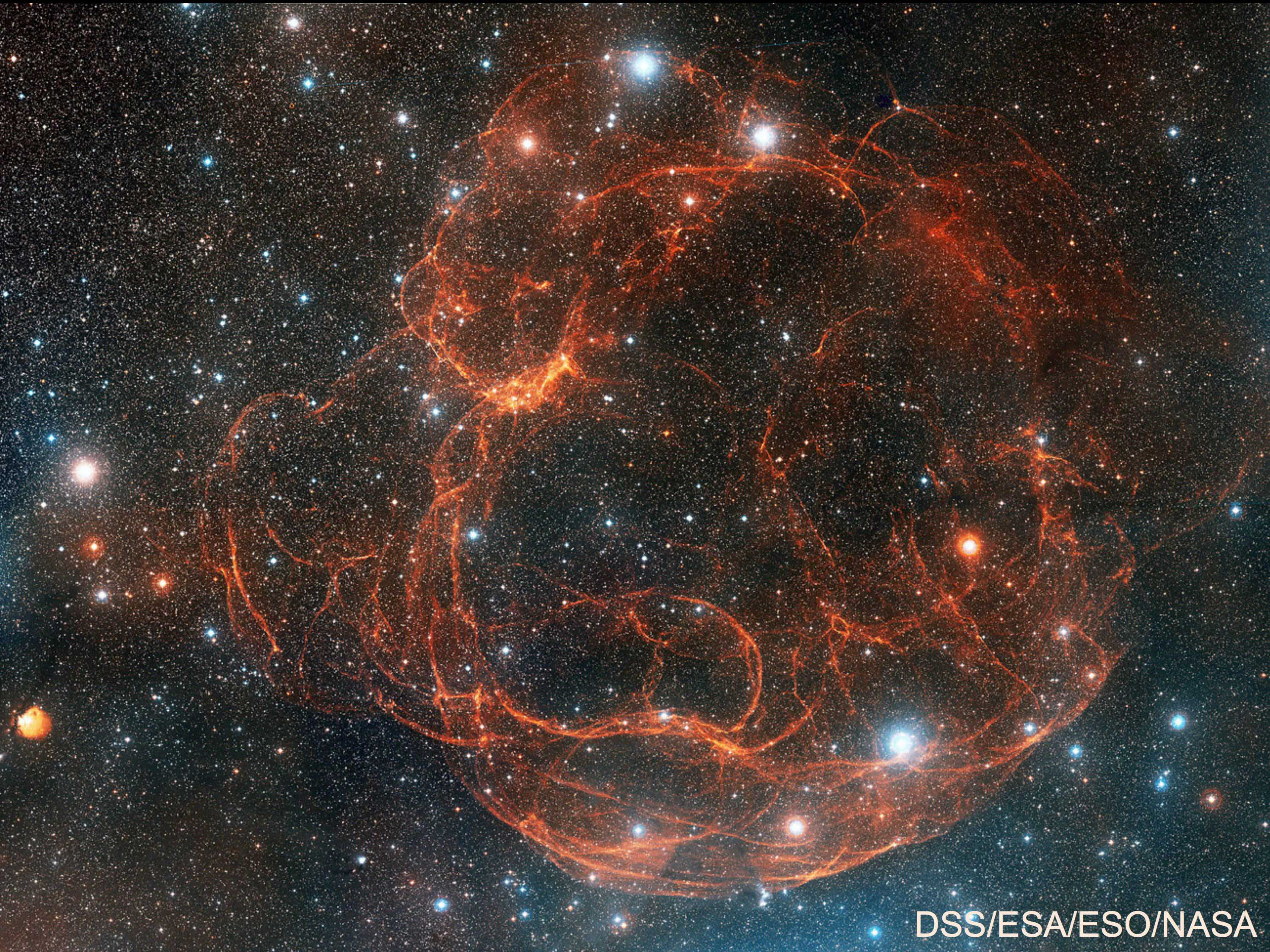
NASA/ESA/HST



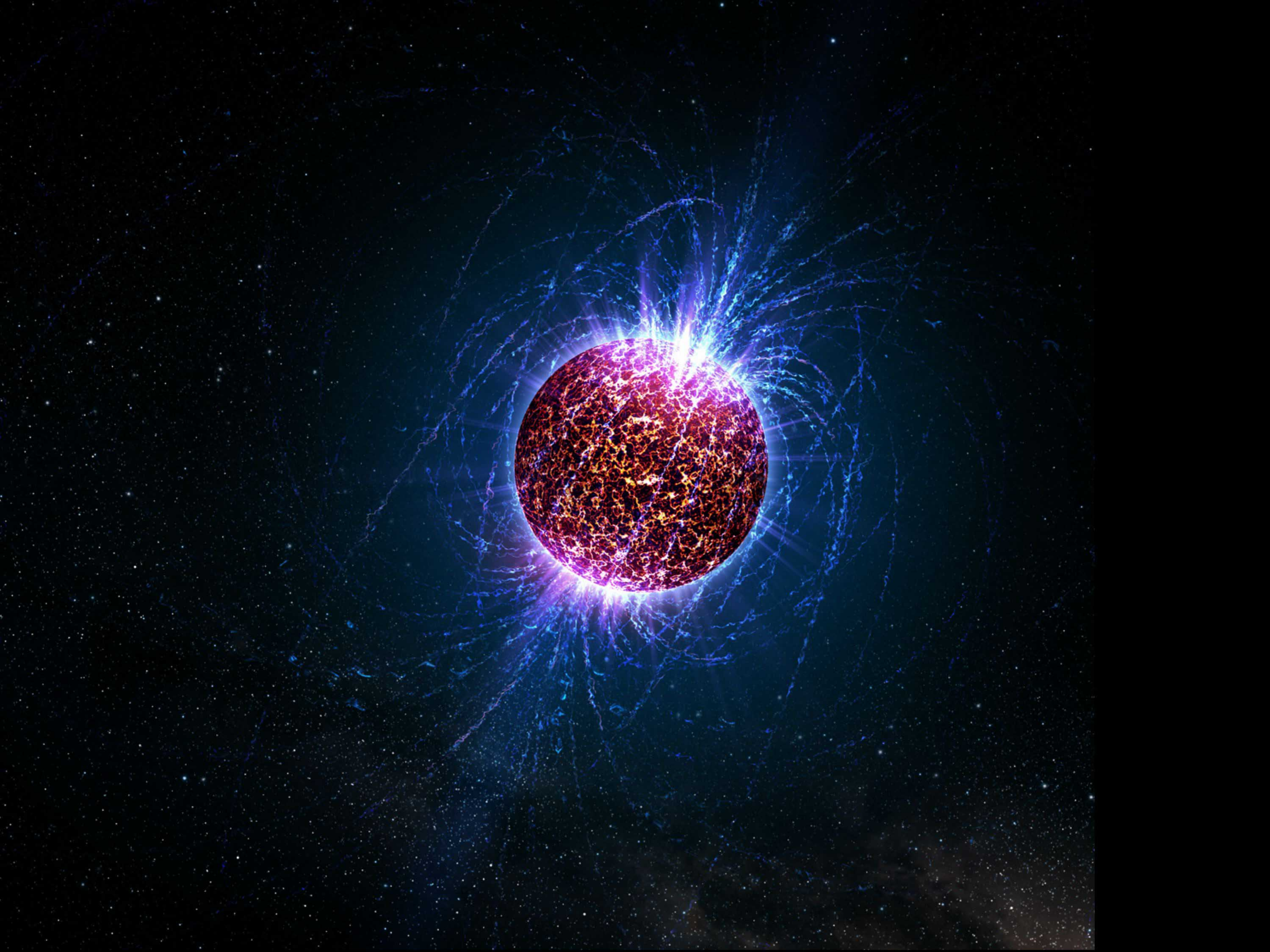
NASA/ESA/Hester & Loll

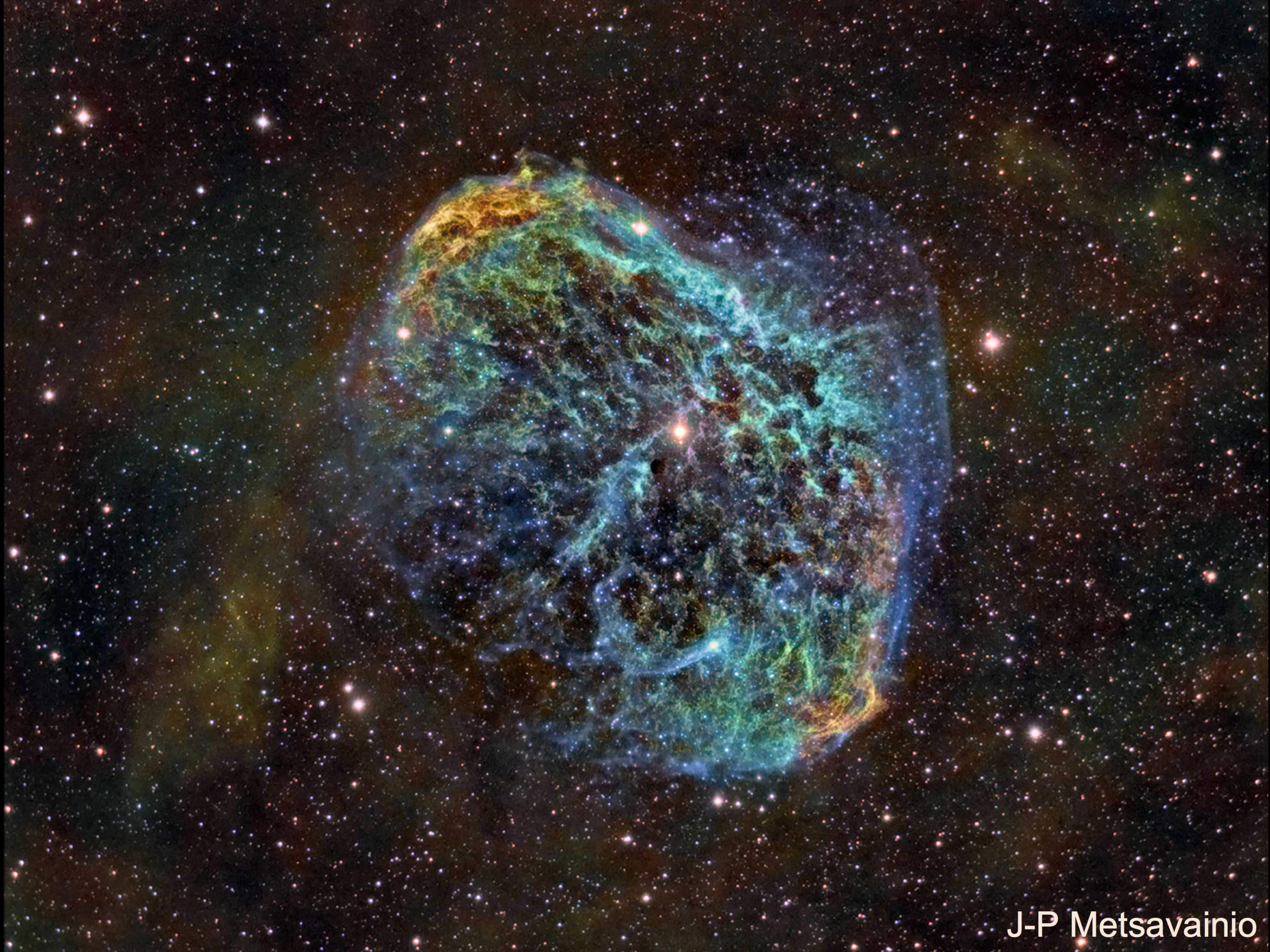






DSS/ESA/ESO/NASA

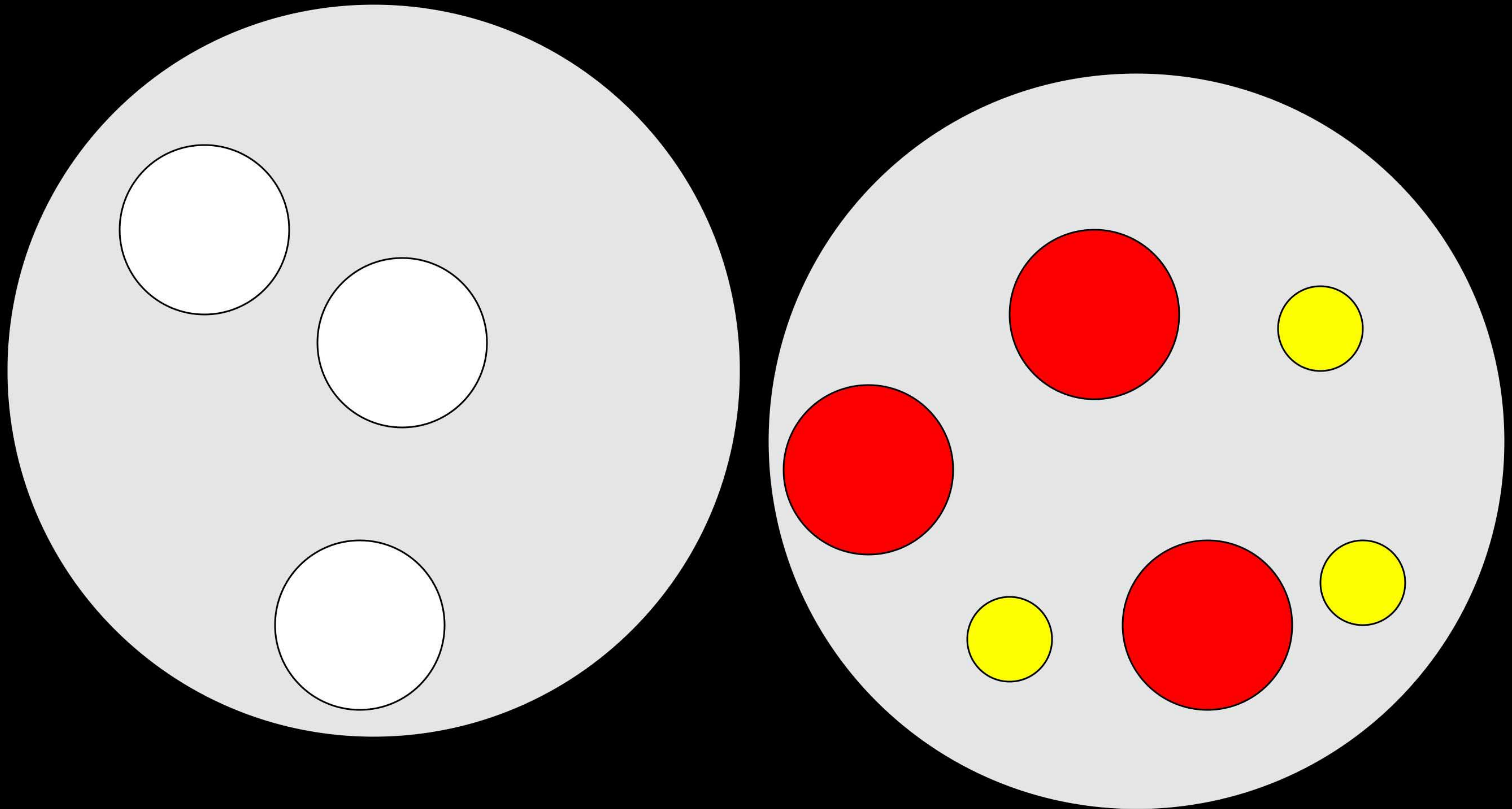


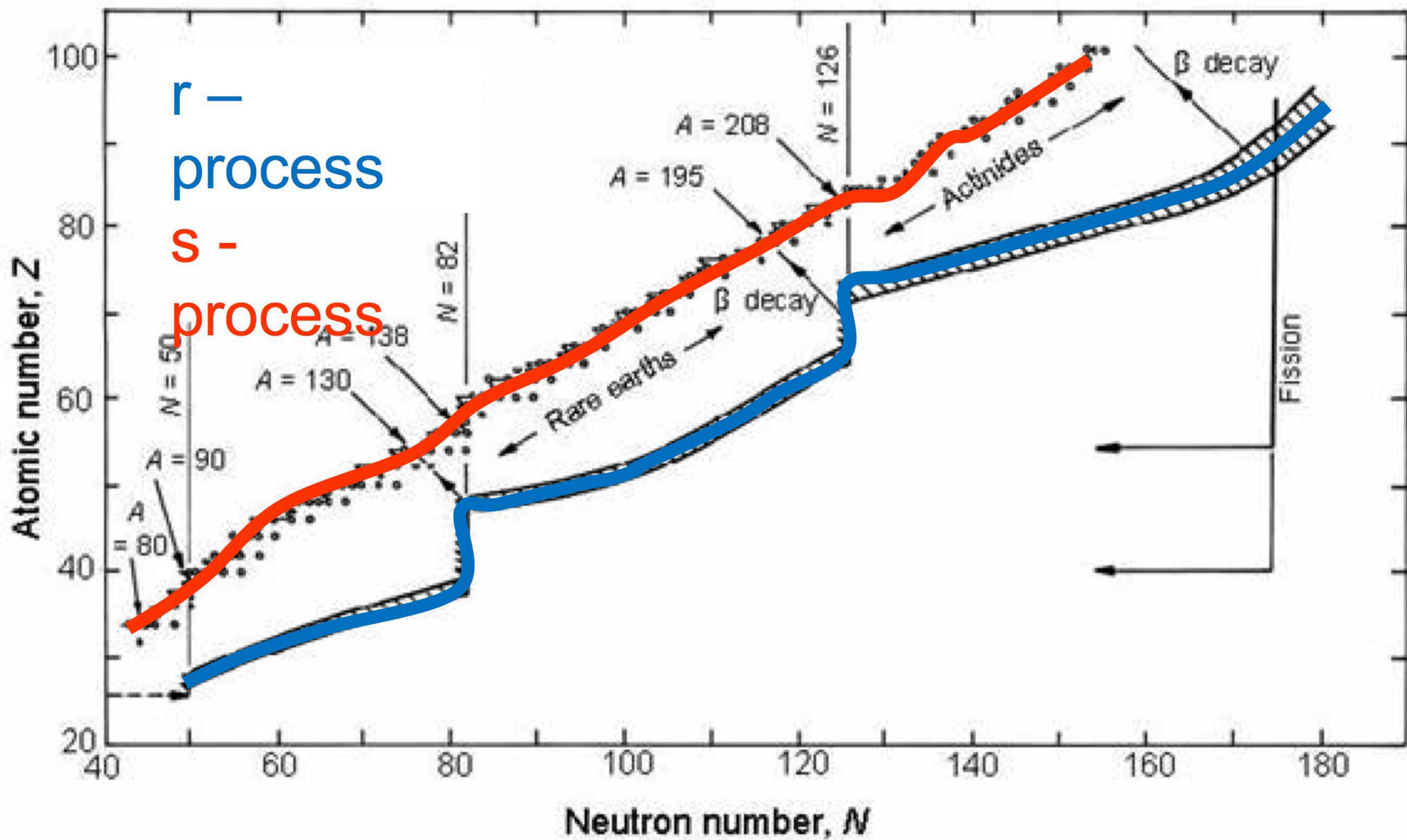


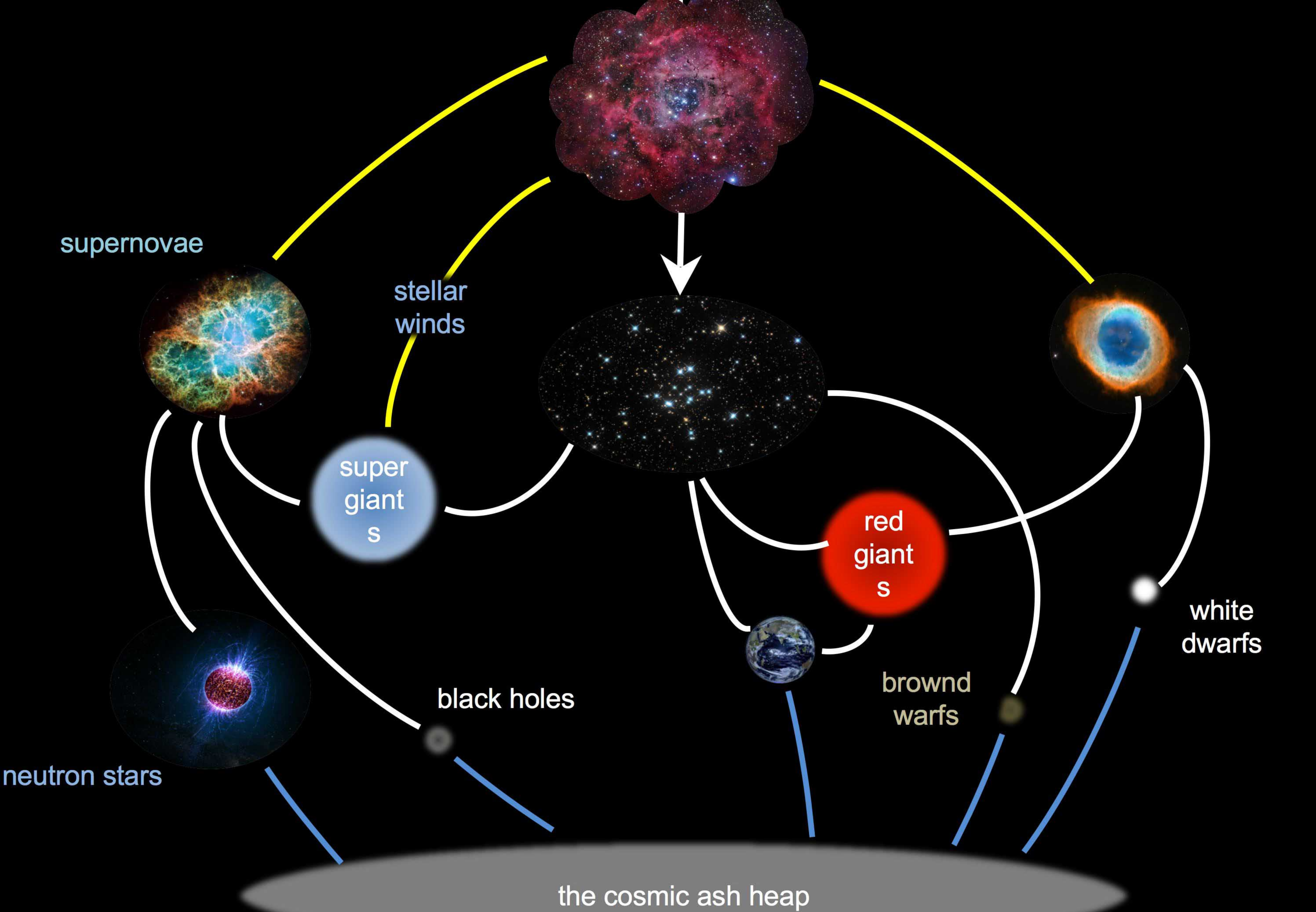


Jeff Hustead

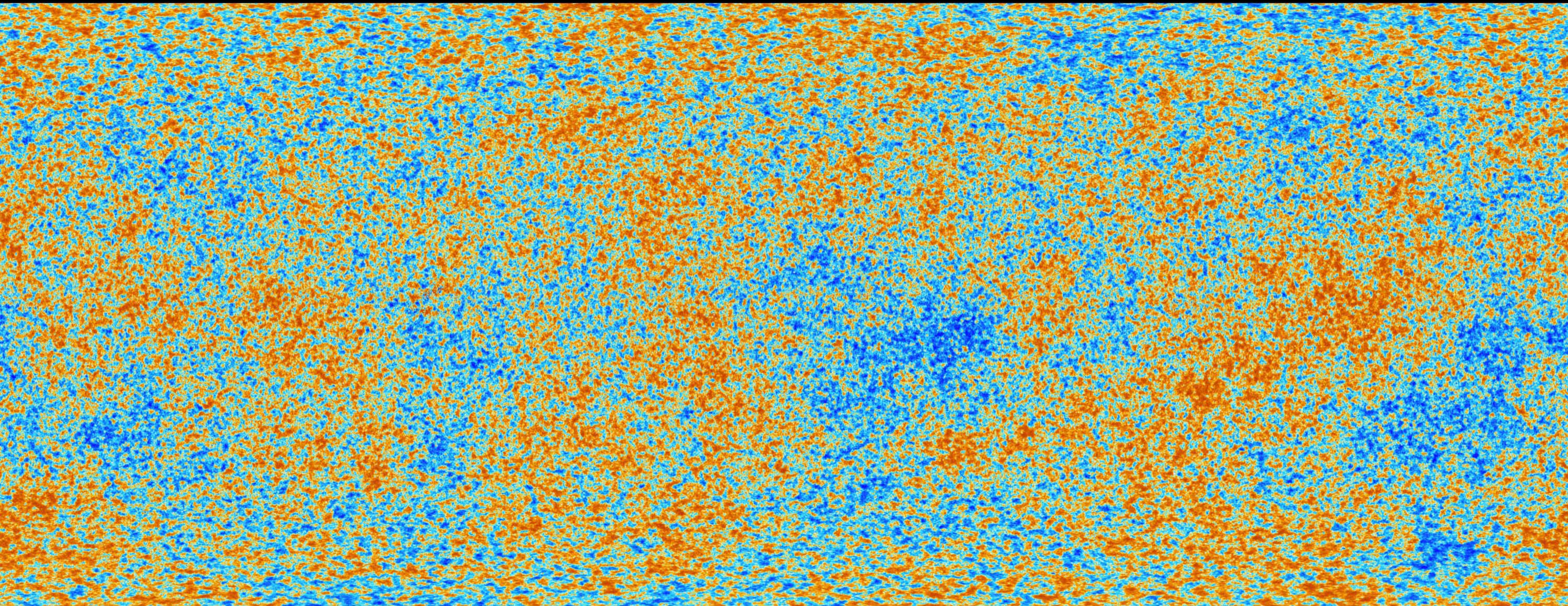
r – process (rapid neutron capture)



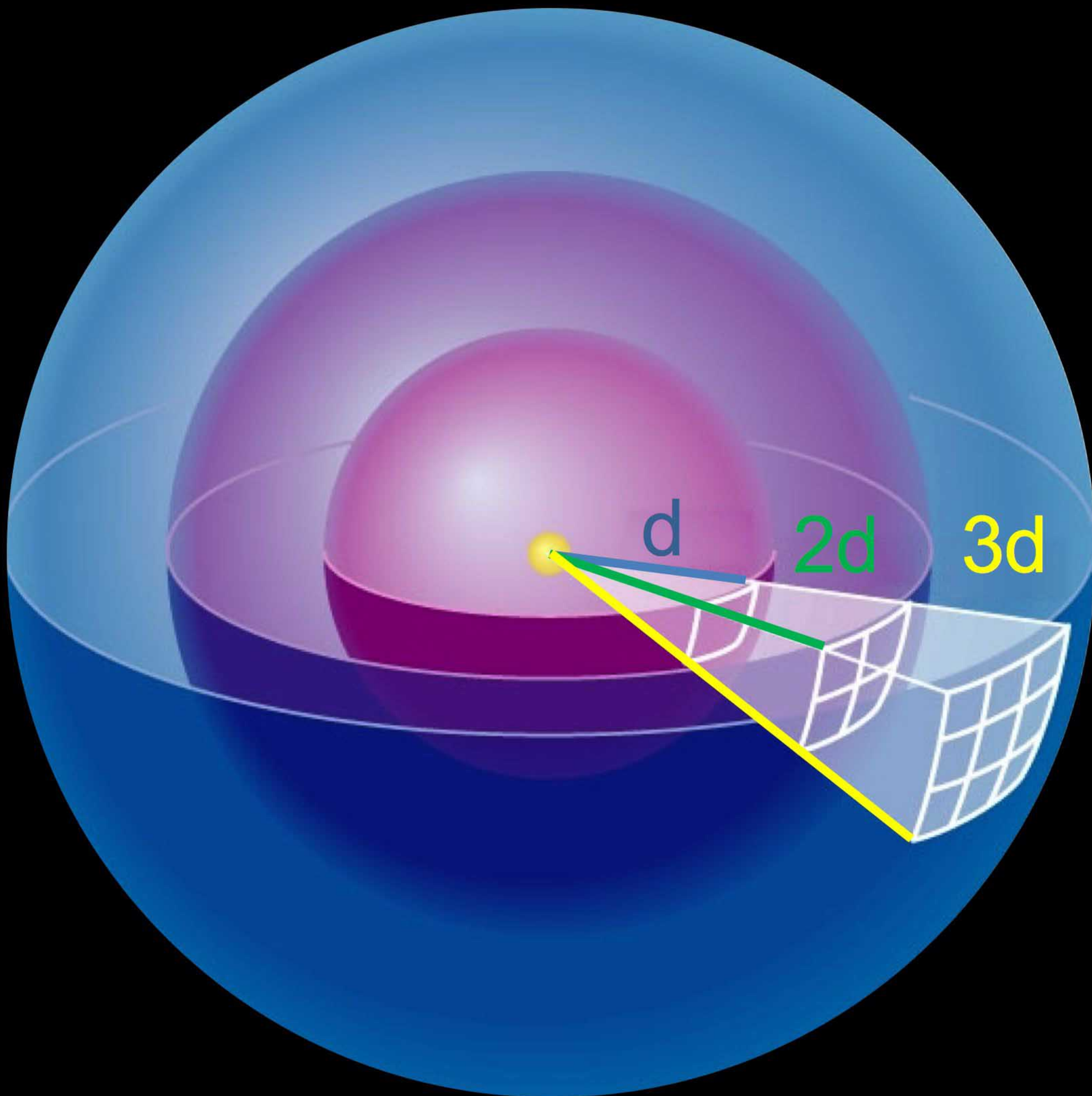




ECHOES OF THE BIG BANG



WED 5TH MARCH 1PM



$$\text{Flux} = \frac{\text{Luminosity}}{4\pi d^2}$$

$$F_1 = \frac{1}{4\pi} \frac{L}{d^2}$$

$$F_2 = \frac{L}{4\pi (2d)^2} = \frac{1}{16\pi} \frac{L}{d^2}$$

$$F_3 = \frac{L}{4\pi (3d)^2} = \frac{1}{36\pi} \frac{L}{d^2}$$