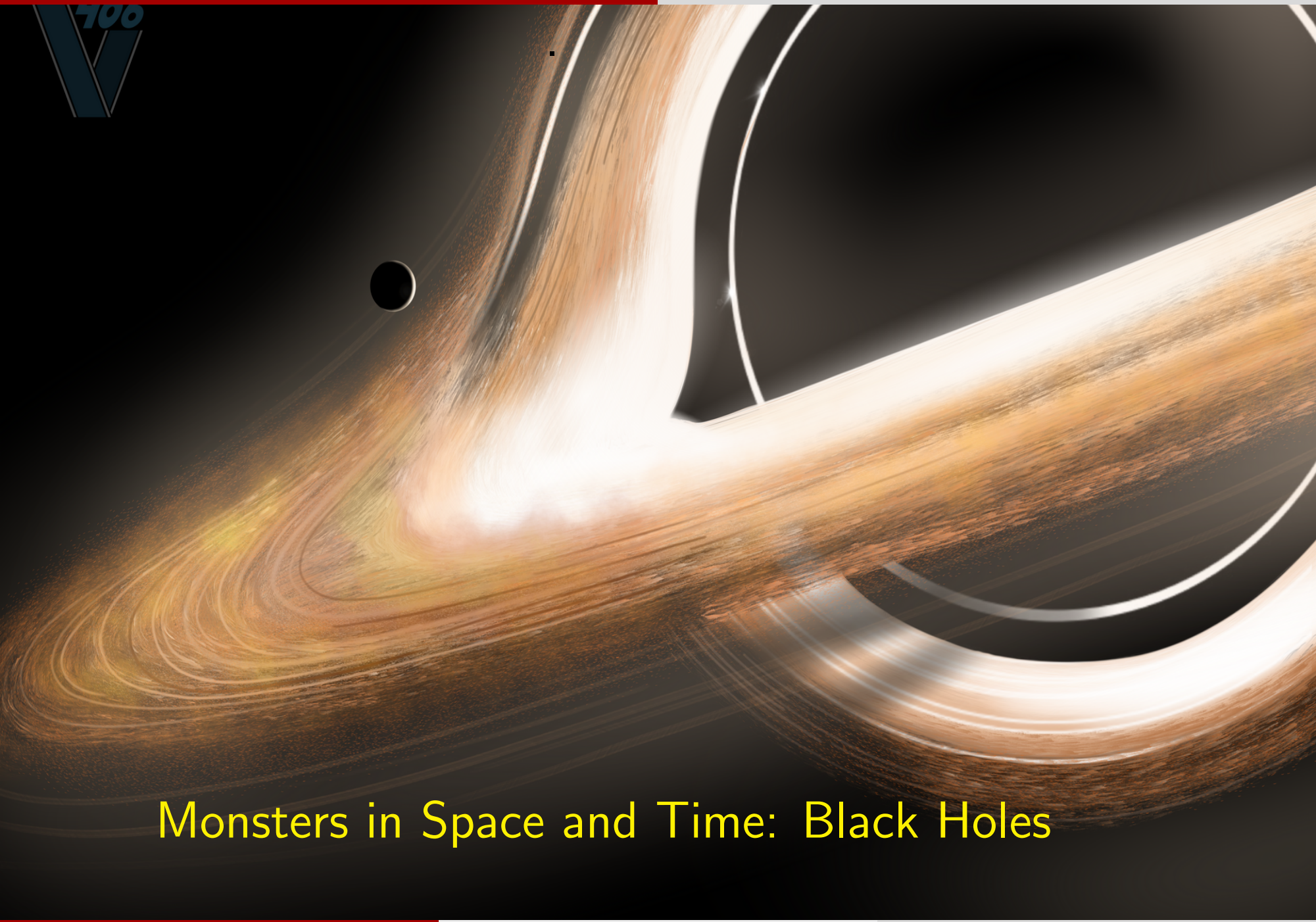
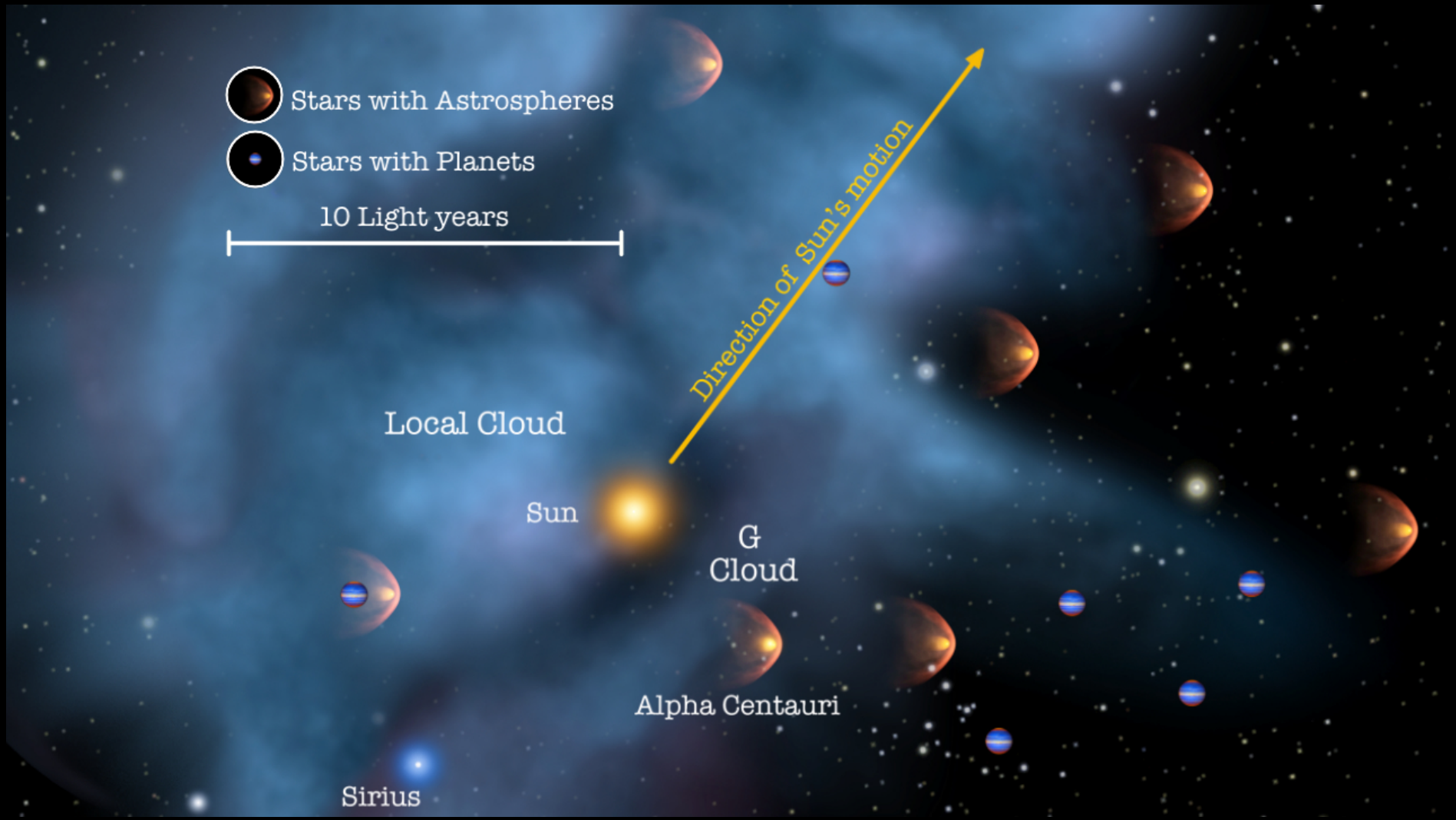
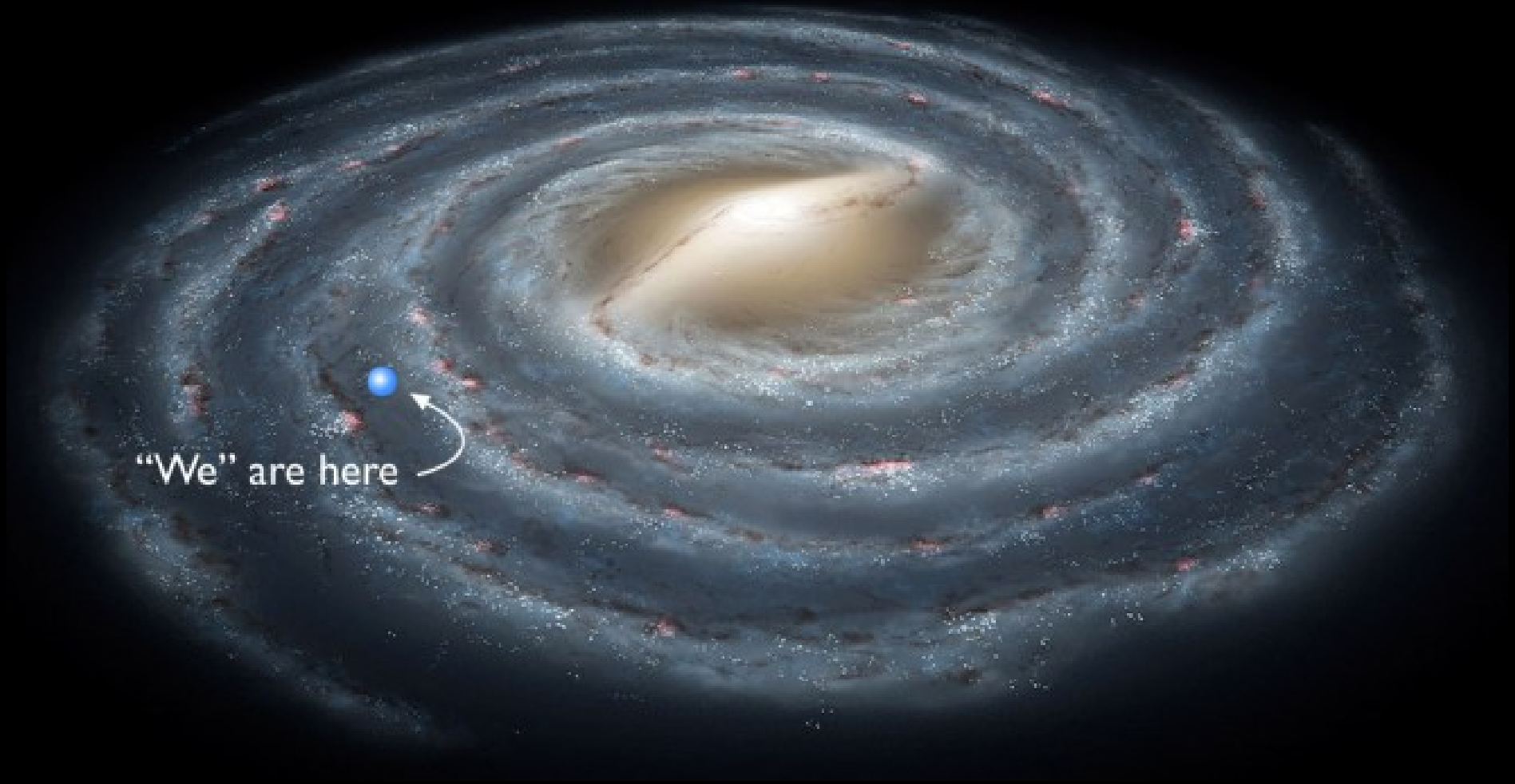


Monsters in Space and Time: Black Holes

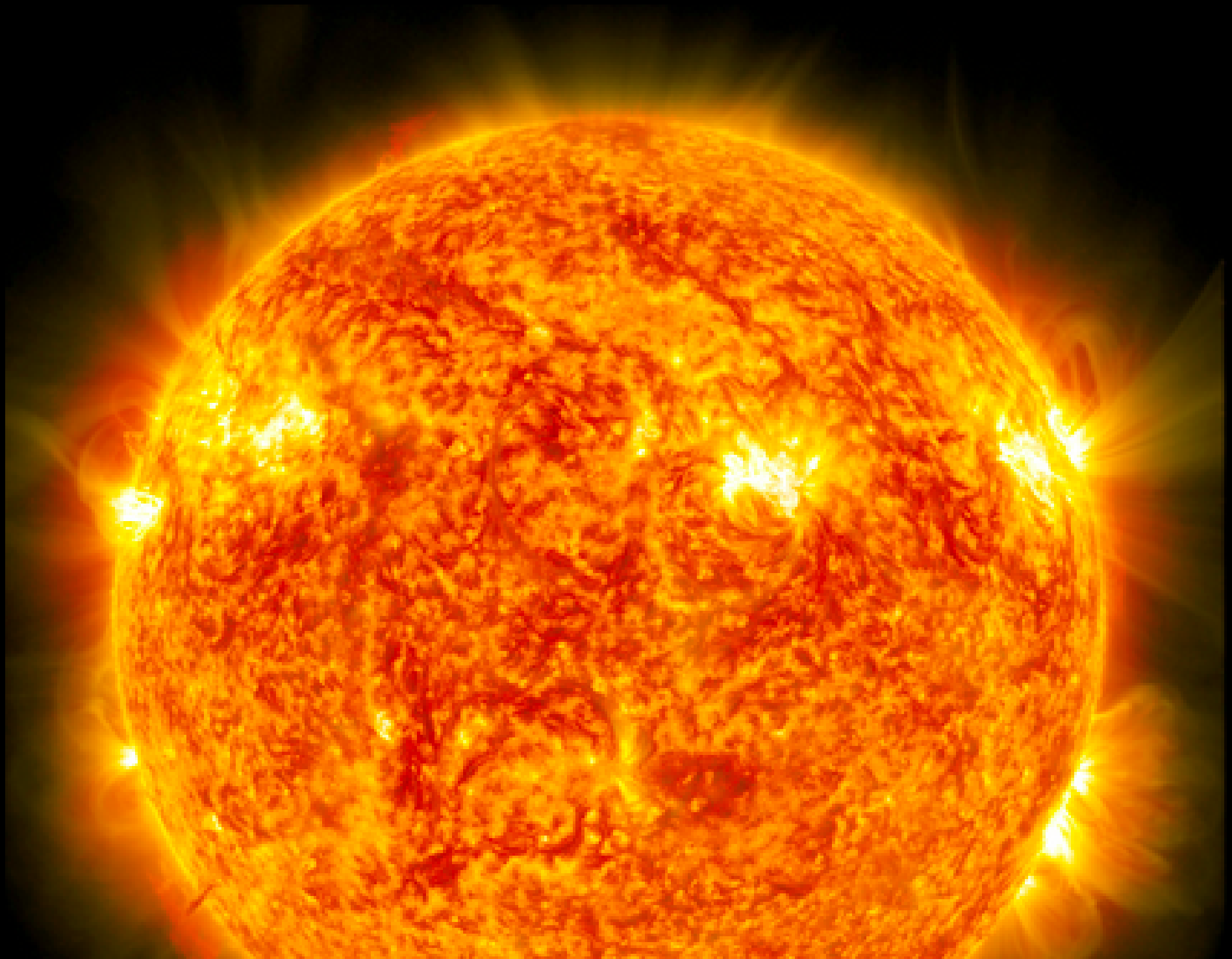

NOVA TOTIUS TERRARUM ORBIS GEOGRAPHICA AC HYDROGRAPHICA TABULA auct: Guilielmo Blaeuw.
AMERICA
Anno Domini 1492 a Christophoro Columbo nomine Regis Castellæ primum detecta, et ab Americo Vesputio nomen sortita 1499
AMERICA SEPTENTRIONALIS
MARE PACIFICUM
MARE ATLANTICUM
MARE DEL NORTE
MARE DEL ZUR
GALLIANICA TERRA AUSTRALIS INCOGNITA
MAGALLANICA TERRA AUSTRALIS INCOGNITA
INDIA
ÆTHIOPIA
OCEANUS
Nova Zemla
Mare Pitzerke
Nieuland
Groenlandia
Nova Guinea
Insulae Salomonis
Ilhas de Ladrones
Tropicus Cancri
Tropicus Capricorni
Circulus Æquinoctialis
Fretum Magallanicum
QUATUOR ELEMENTA
QUATUOR ANNI TEMPESTATES
AER
AQUA
TERRA
VER
AUTUM
HYEM
MURUS BABYLONIS
COLOSSUS
PYRAMIDES
DIANA TEMPLUM
IUPITER OLYMPICUS
PHAROS

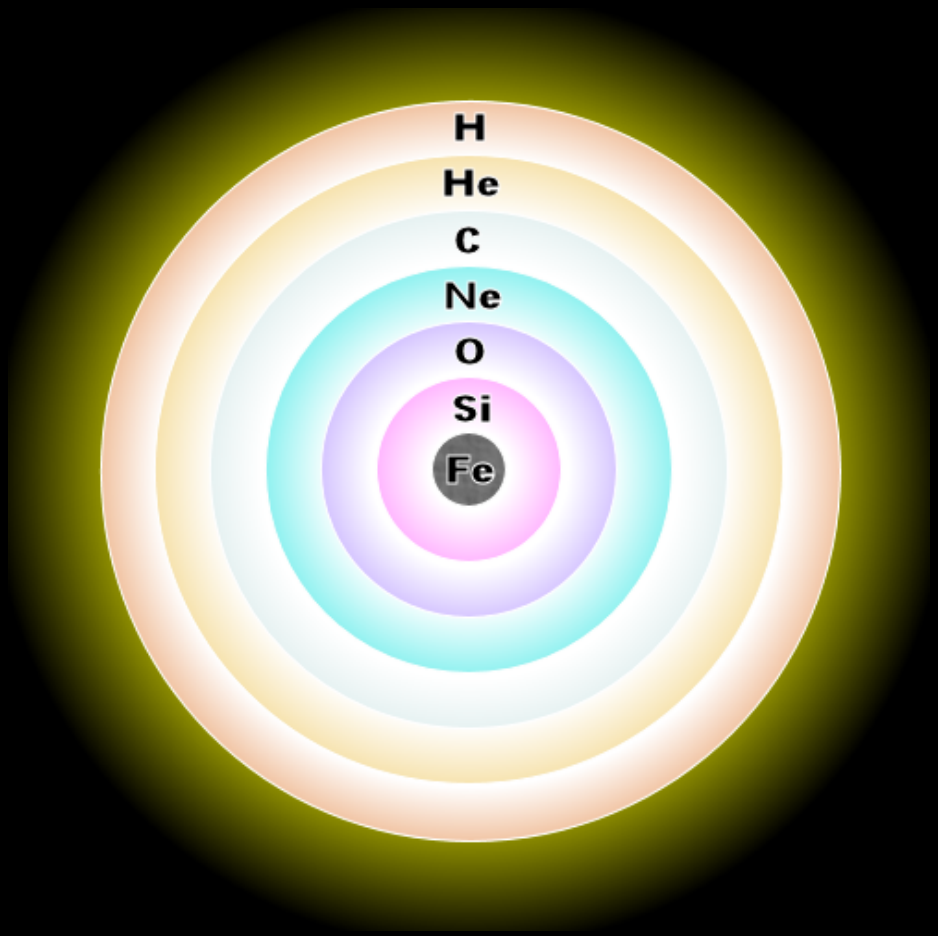

RIA
ANT VROIN
HC SVNT
DRACONES


Stars with Astrospheres
Stars with Planets
10 Light years
Direction of Sun's motion
Local Cloud
Sun
G
Cloud
Alpha Centauri
Sirius


"We" are here

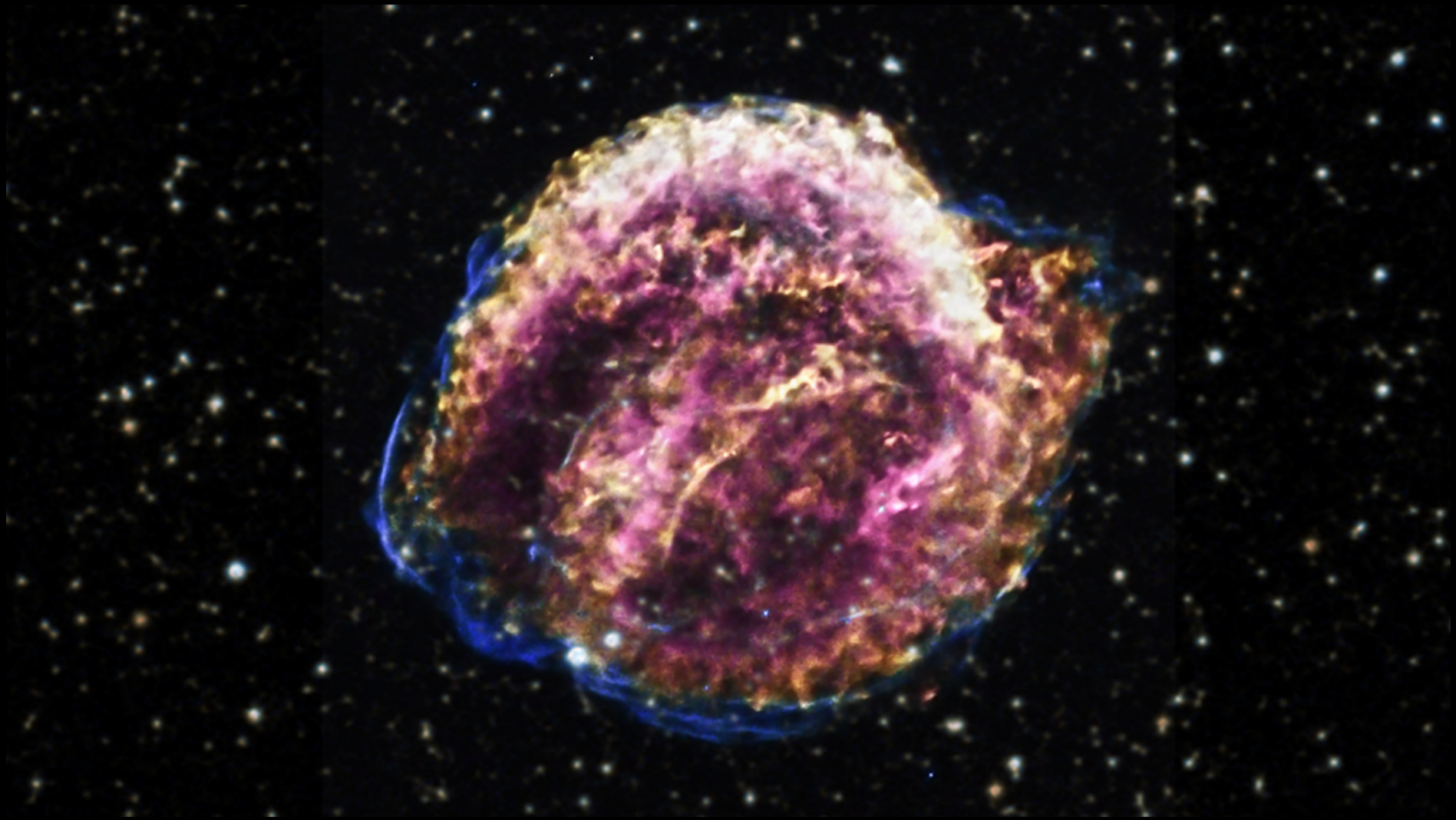
How do Black Holes form?

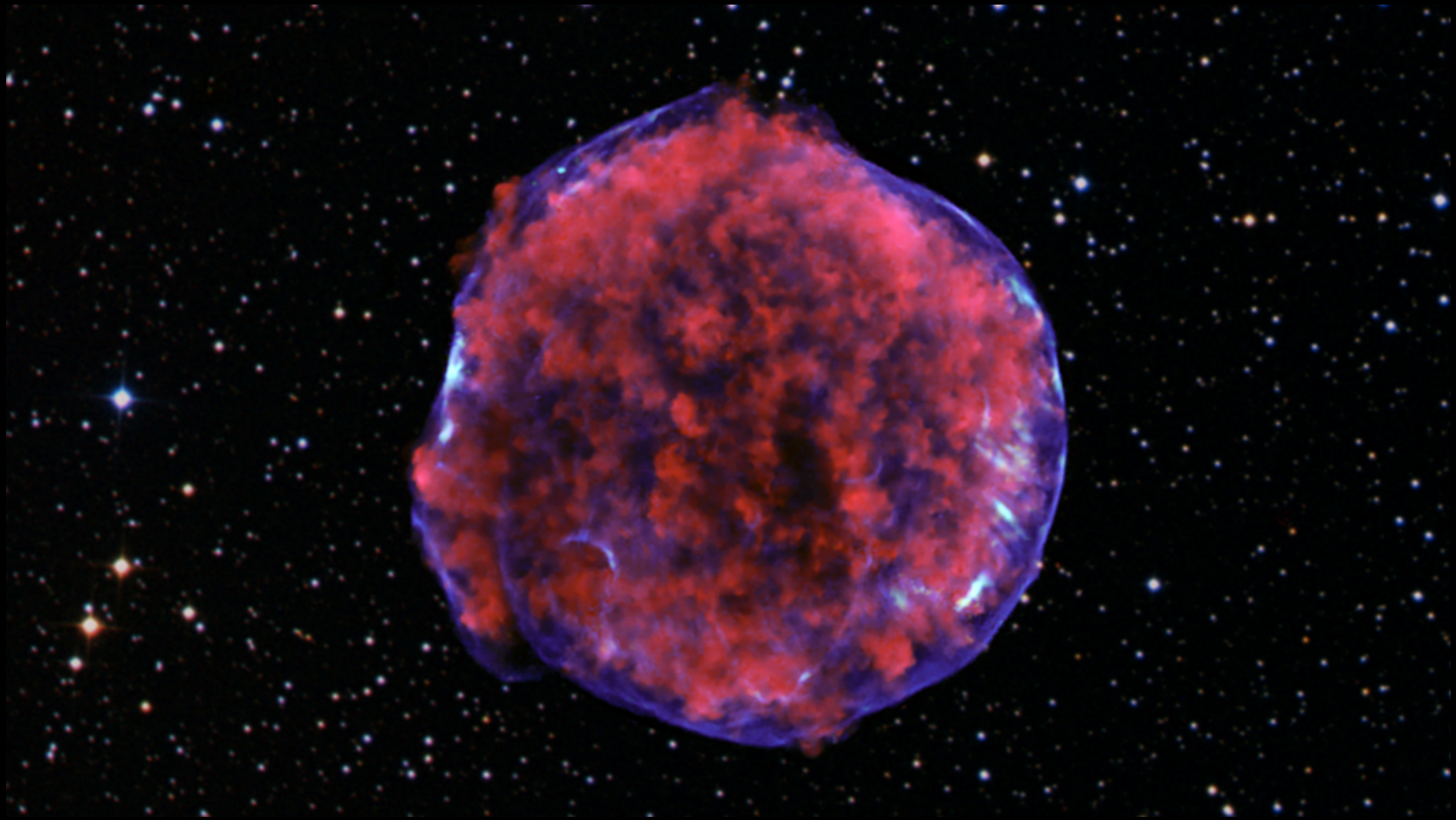


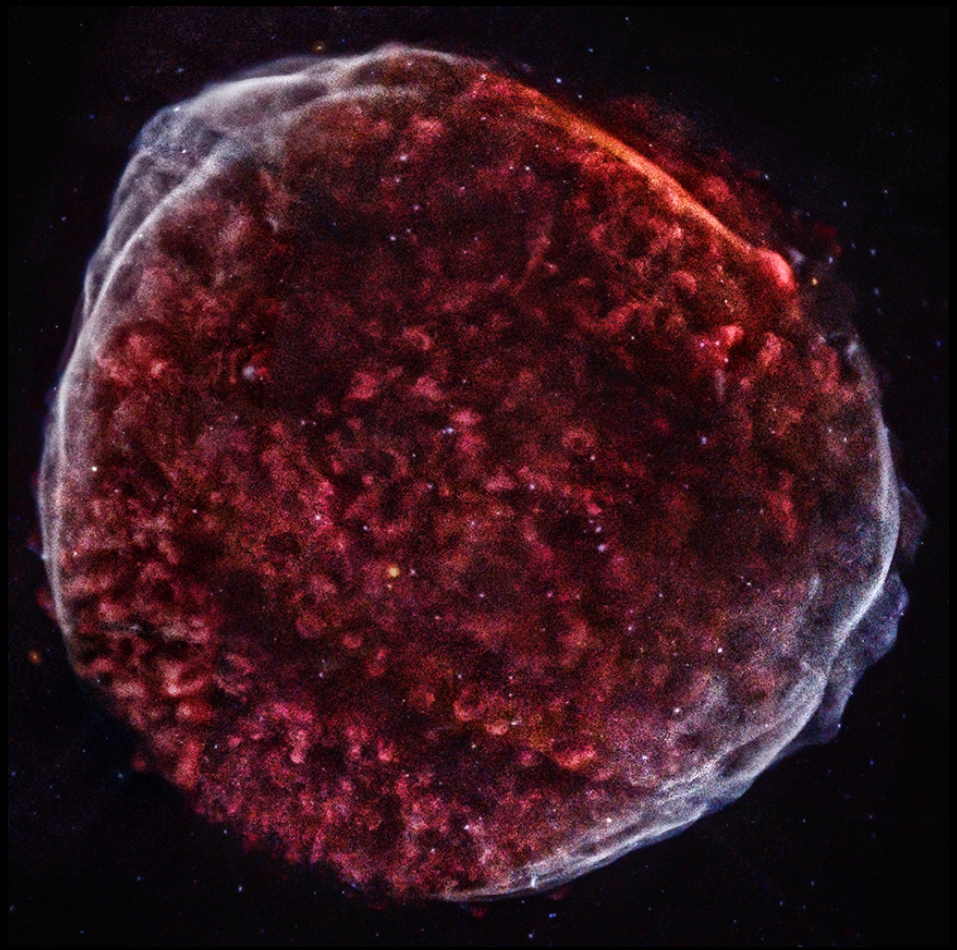


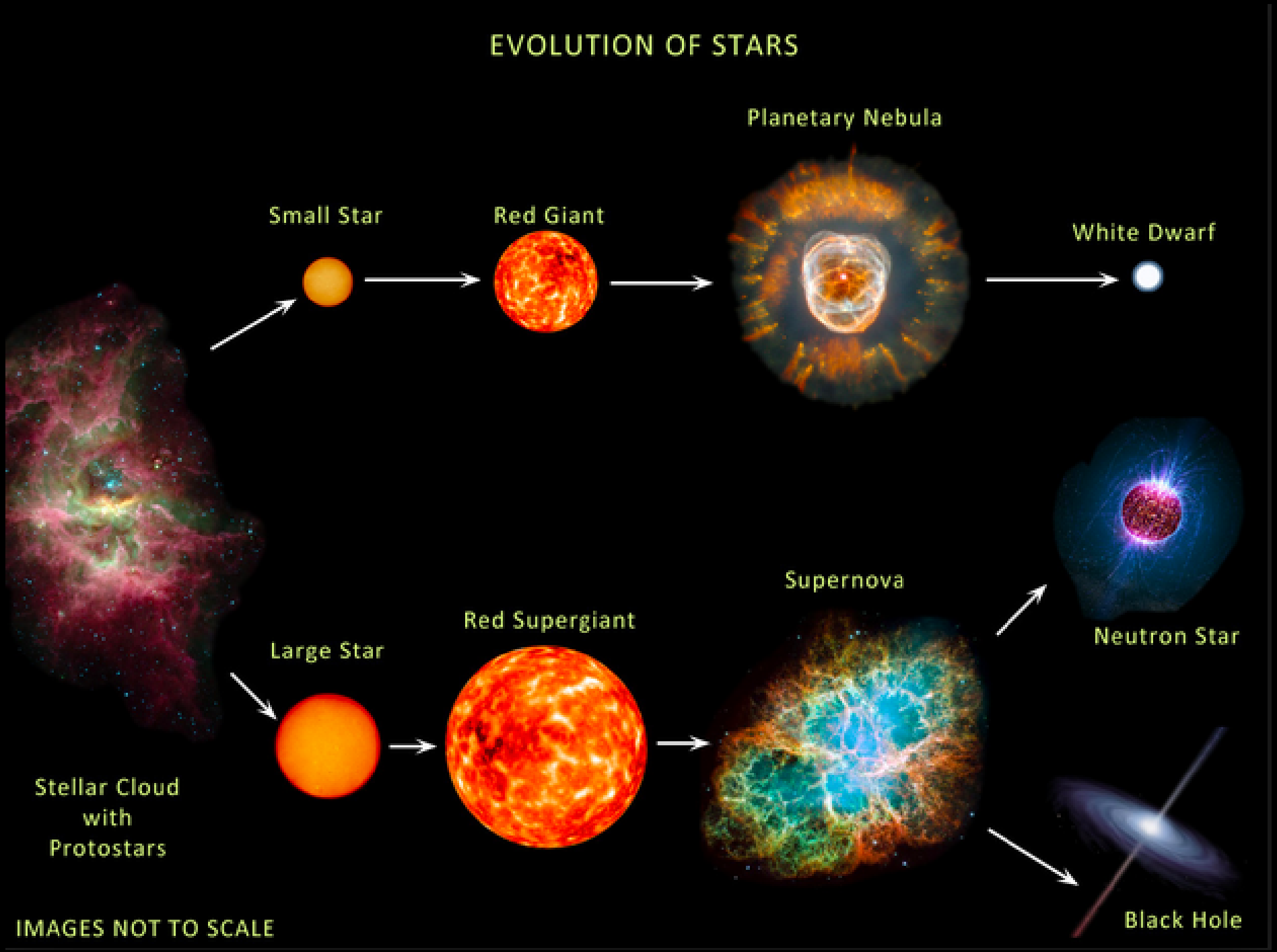
- Fusion ($\mathrm{H} \rightarrow \mathrm{He}$): $\sim$ 1 Gyr
- $\mathrm{He} \rightarrow \mathrm{C}$: 100 Myr
- $\mathrm{C} \rightarrow \mathrm{Ne}$: 1000 yr
- $\mathrm{Ne} \rightarrow \mathrm{O}$: 1 yr
- $\mathrm{O} \rightarrow \mathrm{Si}$: 6 mo
- $\mathrm{Si} \rightarrow \mathrm{Fe}$: 1 day

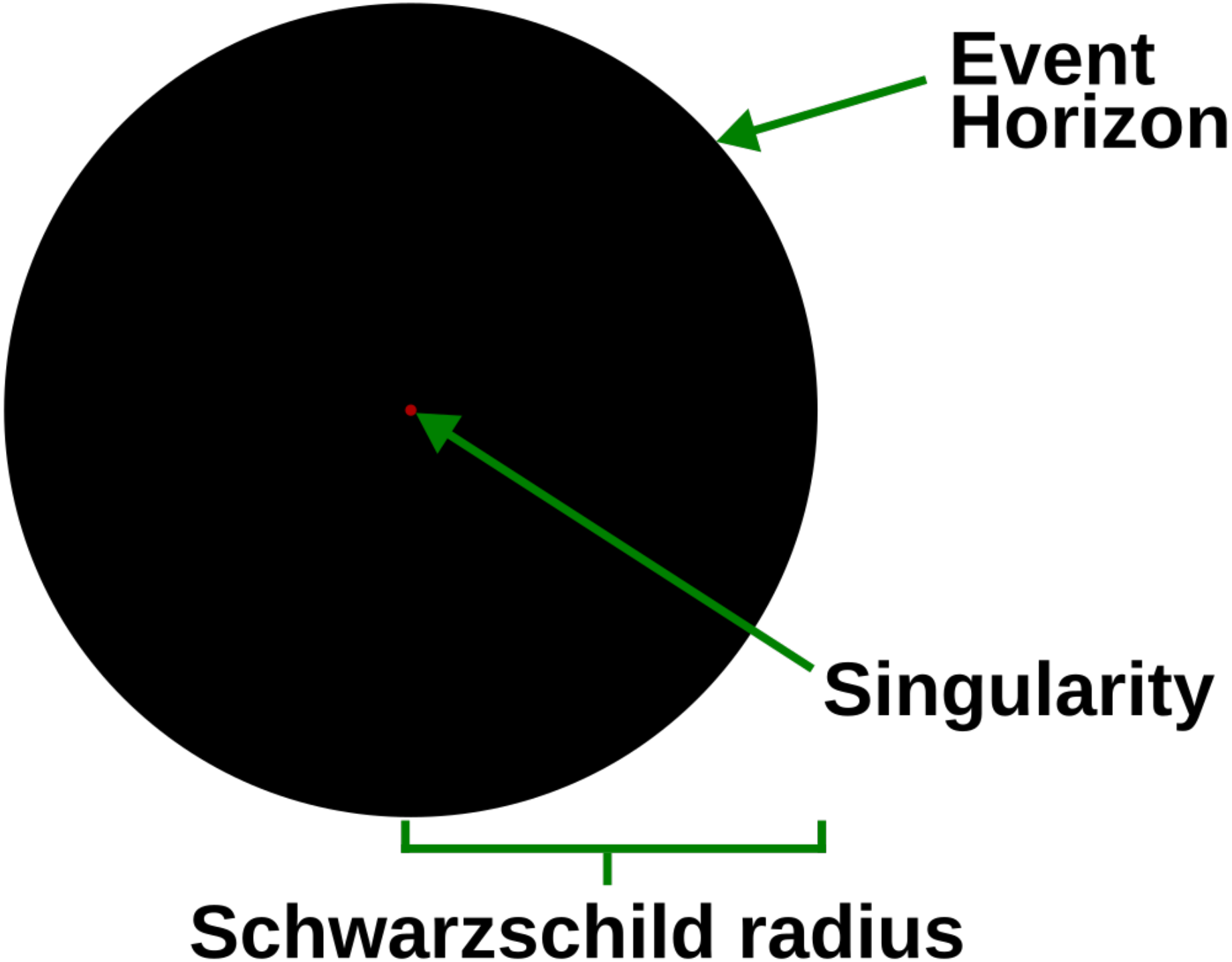
ESA/Hubble (L. Calçada)



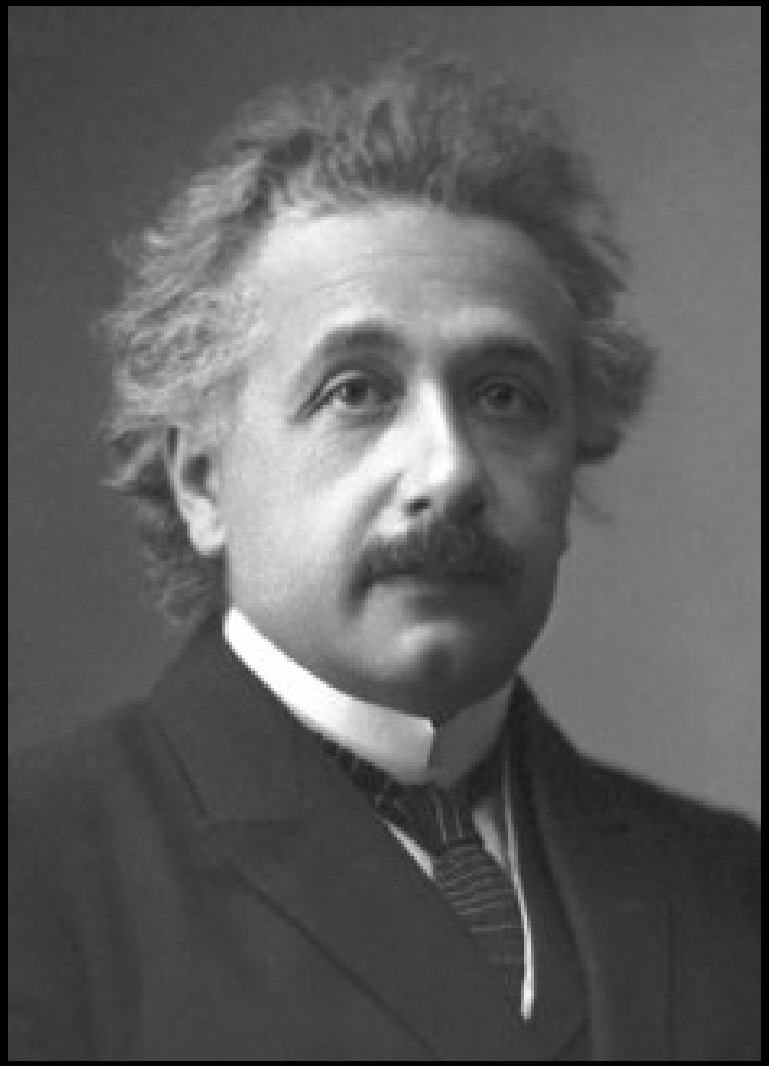





EVOLUTION OF STARS
Planetary Nebula
Small Star
Red Giant
White Dwarf
Supernova
Red Supergiant
Large Star
Neutron Star
Stellar Cloud
with
Protostars
IMAGES NOT TO SCALE
Black Hole


Event
Horizon
Singularity
Schwarzschild radius

Who studies black holes?

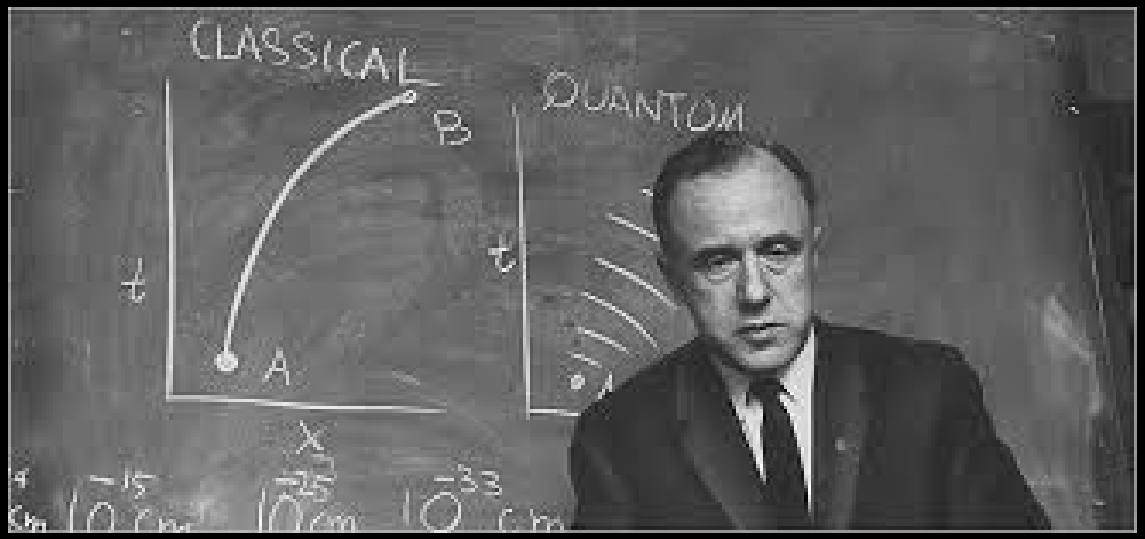


Albert Einstein: Theory of General Relativity (1915)

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 0$$

Karl Schwarzschild: First Solution to GR equations (1916)

Roger Penrose: Black Hole Solutions are real! (1965)
Nobel Prize 2020



John Wheeler: coined the term “Black Hole” (1967)

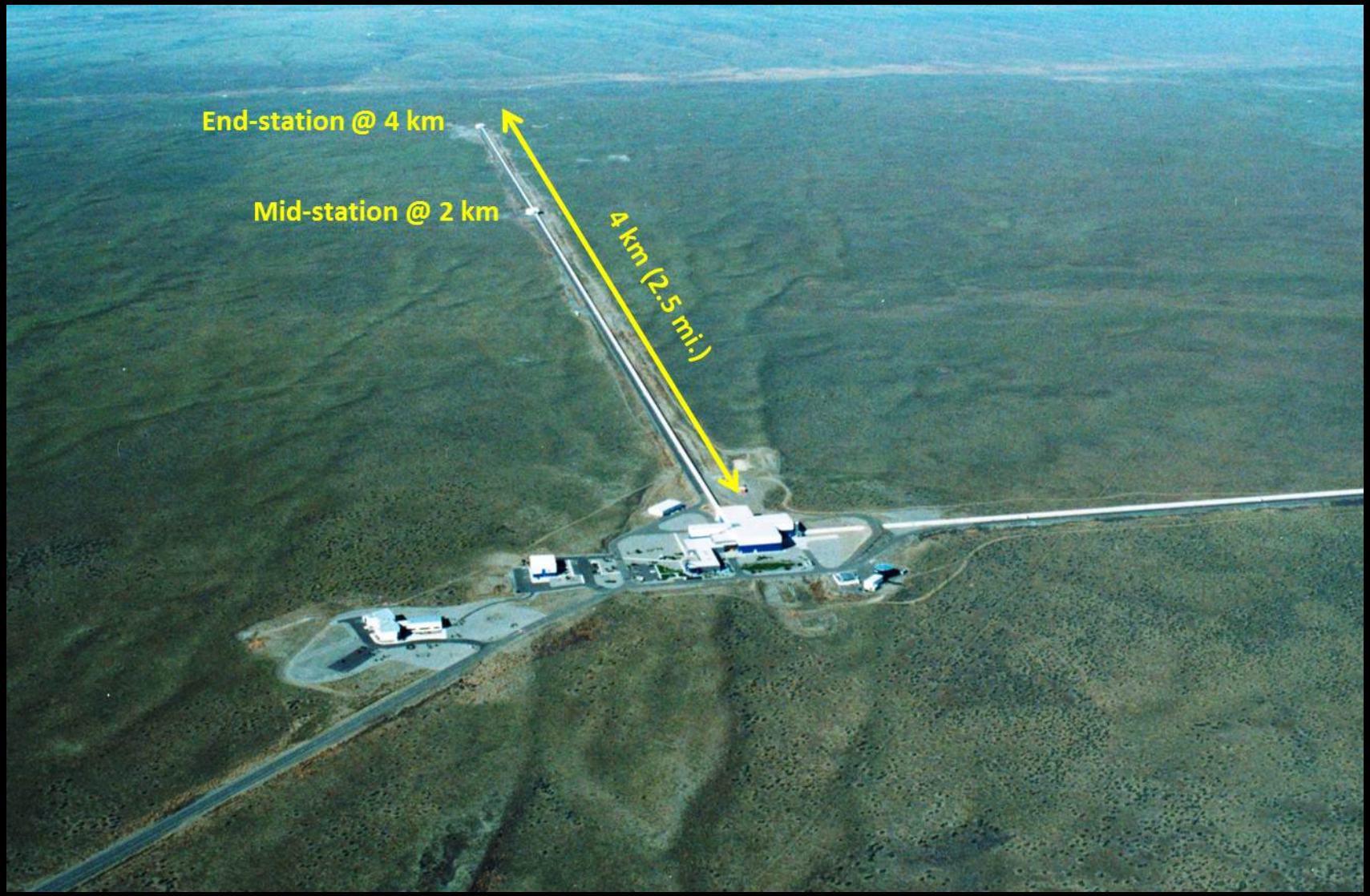
Ann Ewing: coined the term “Black Hole” (1964)

??? : coined the term “Black Hole” (????)

Stephen Hawking: Black Holes are *not really* black (1974)


Andrea Ghez & Reinhard Genzel: Observations of Sg A^* with ESO/Keck (from 1996)

Nobel Prize 2020



LIGO collaboration: Measured gravitational waves from BH-collisions (2016)
(Nobel Prize 2017)

Event Horizon Telescope (EHT): First "Photograph" of a Black Hole (April 19, 2019)