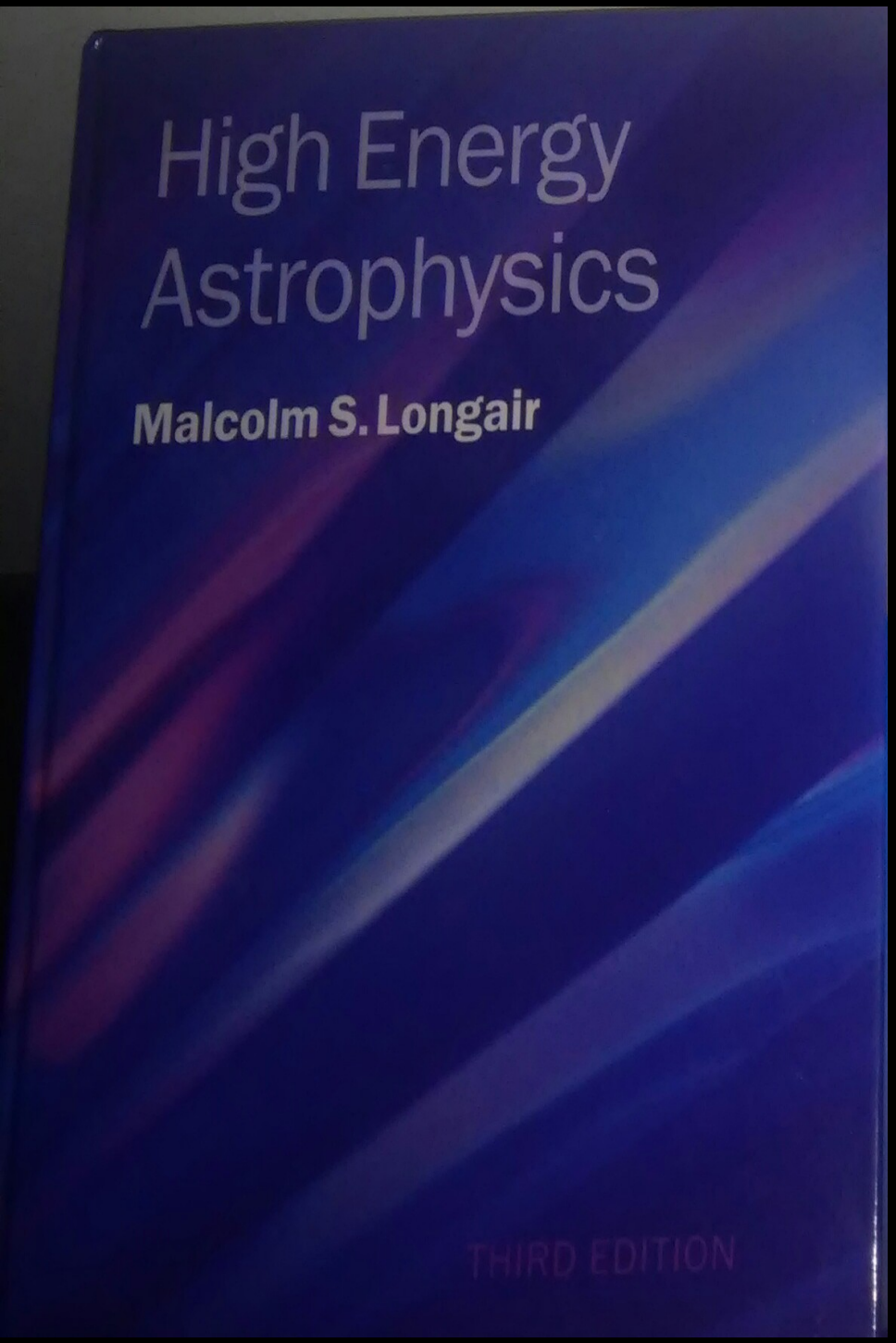
ASTROFISICA

A.Giuliani - INAF / IASF Milano

giuliani@iasf-milano.inaf.it

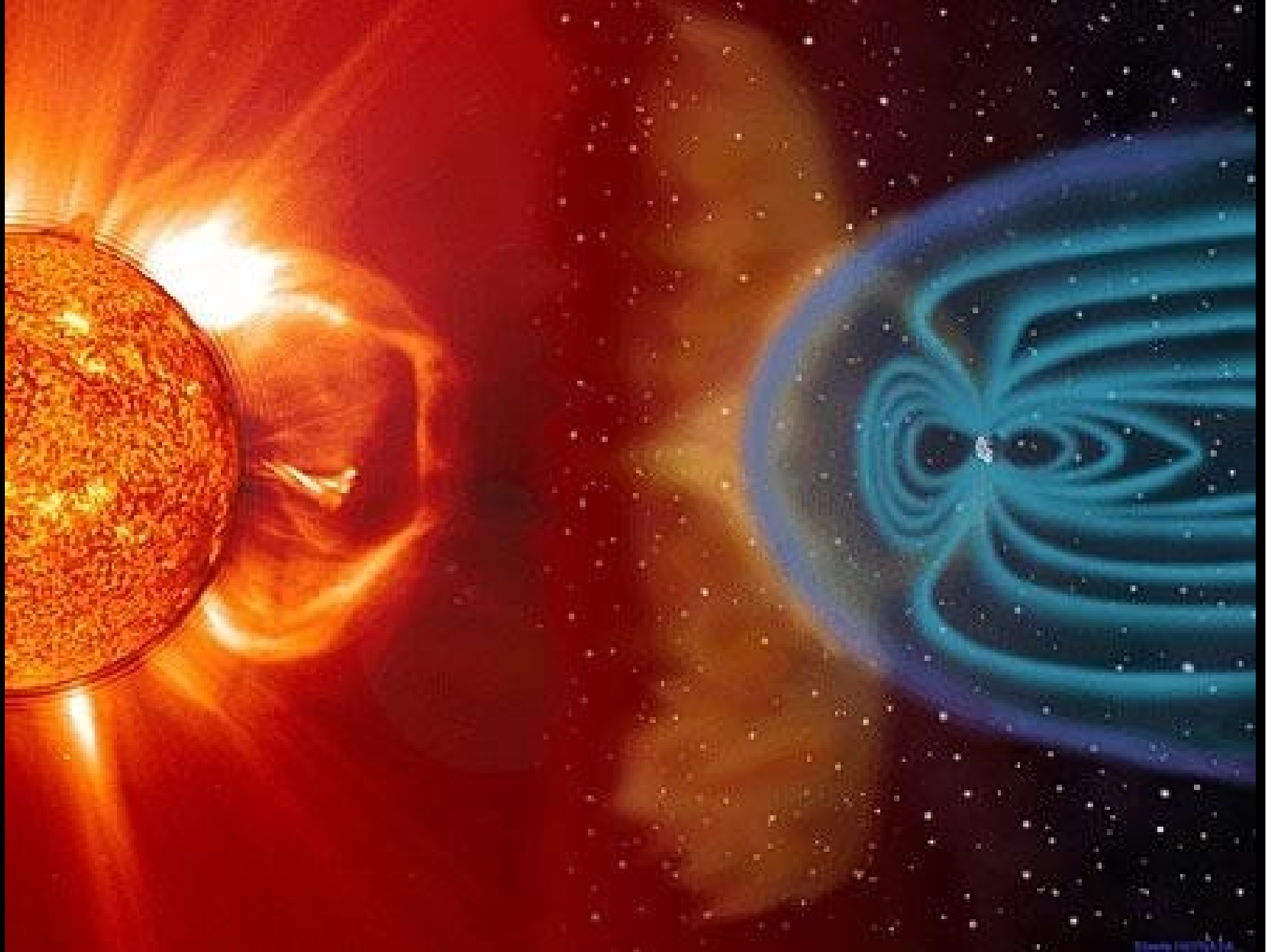
www.iasf-milano.inaf.it/~giuliani/astrofisica2018

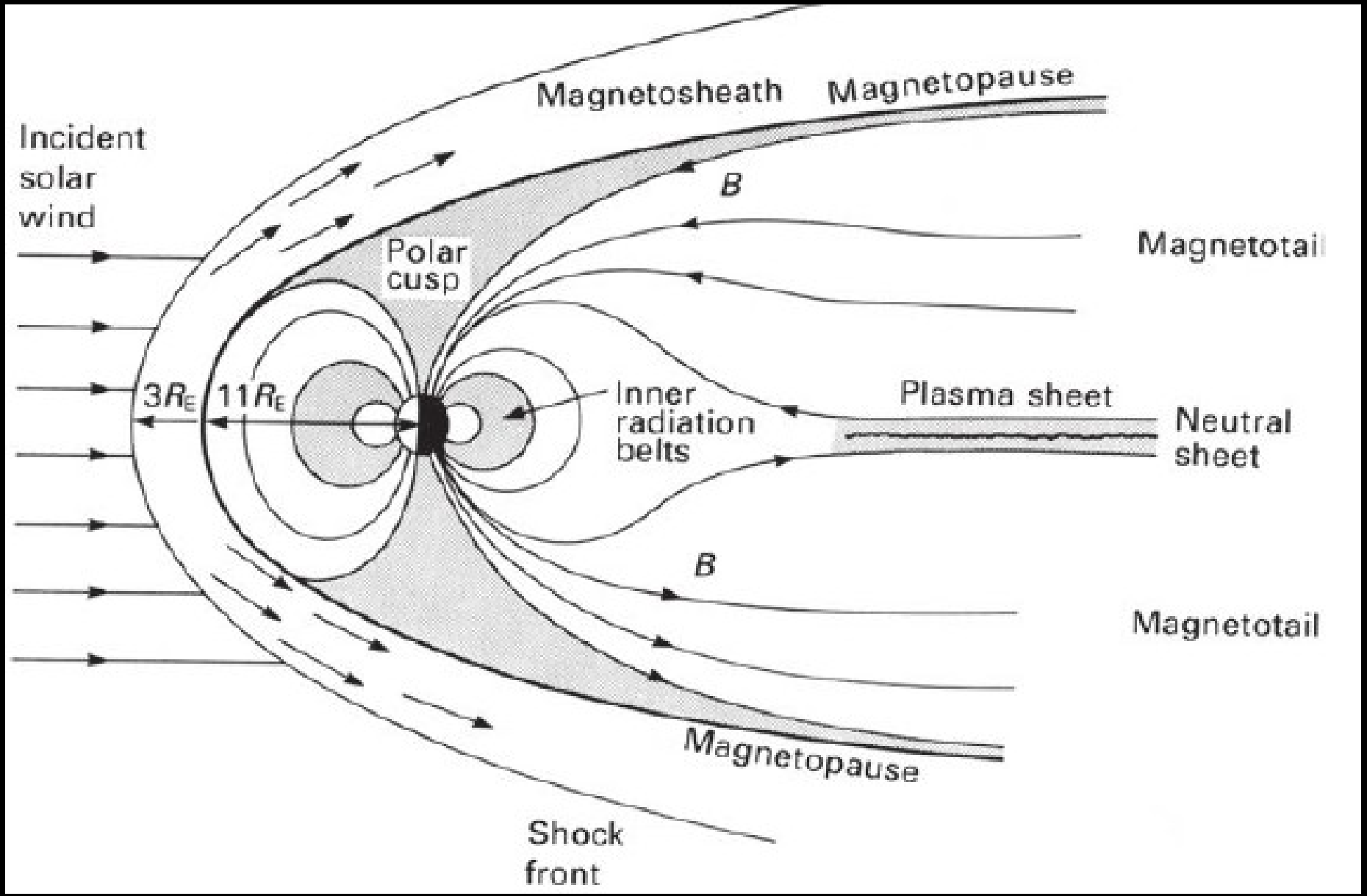


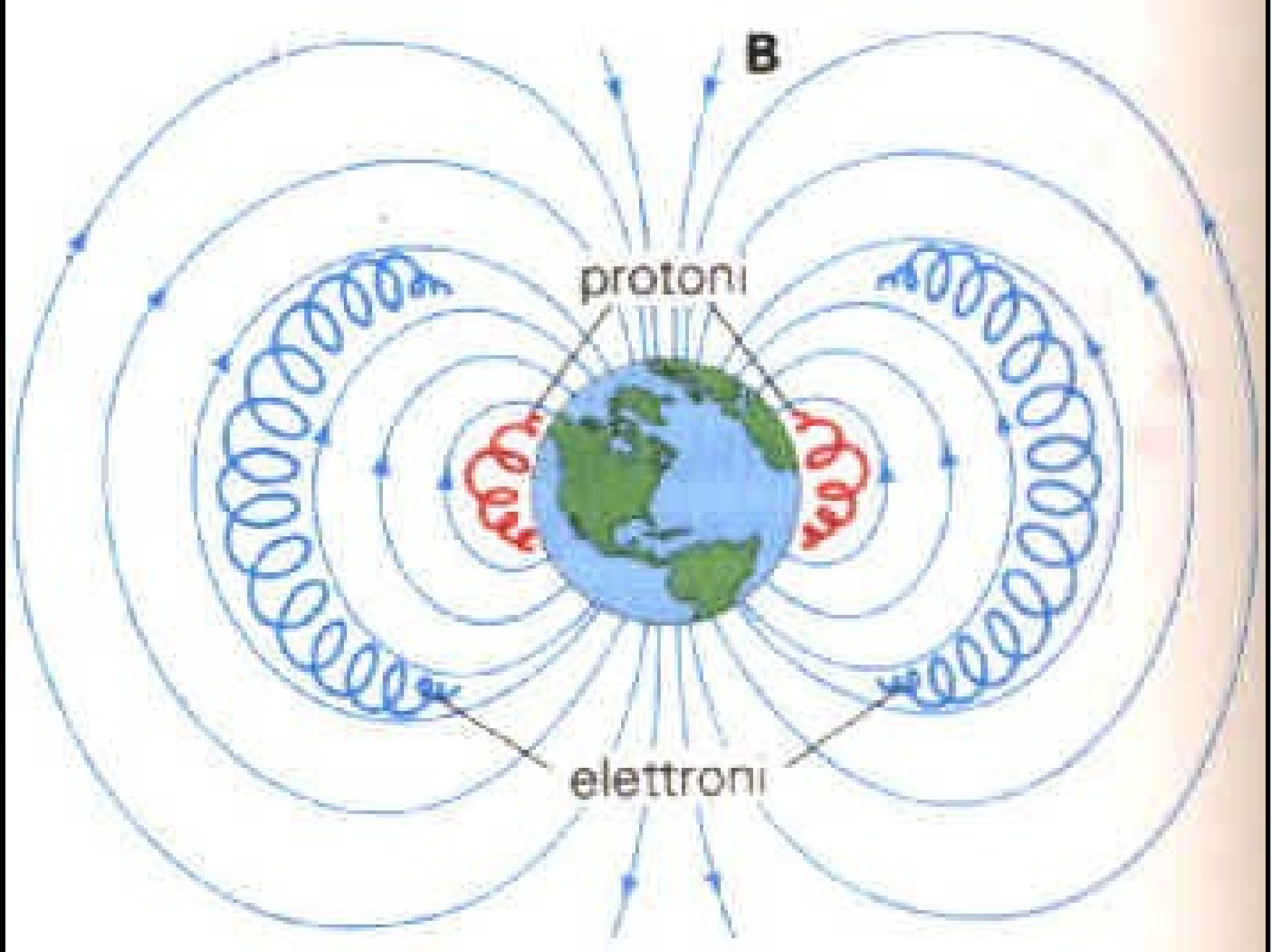
I take this term to mean the astrophysics of high energy processes and their application in astrophysical and cosmological contexts. These processes, their application in astrophysics and how they lead to some of the most challenging problems of contemporary physics, are the subjects of this book.

For example, we need to explain how the massive black holes present in the nuclei of active galaxies can be studied, how charged particles are accelerated to extremely high energies in astronomical environments, the origins of enormous fluxes of high energy particles and magnetic fields in active galaxies, the physical processes in the interiors and environments of neutron stars, the nature of the dark matter, the expected fluxes of gravitational waves in extreme astronomical environments, and so on.

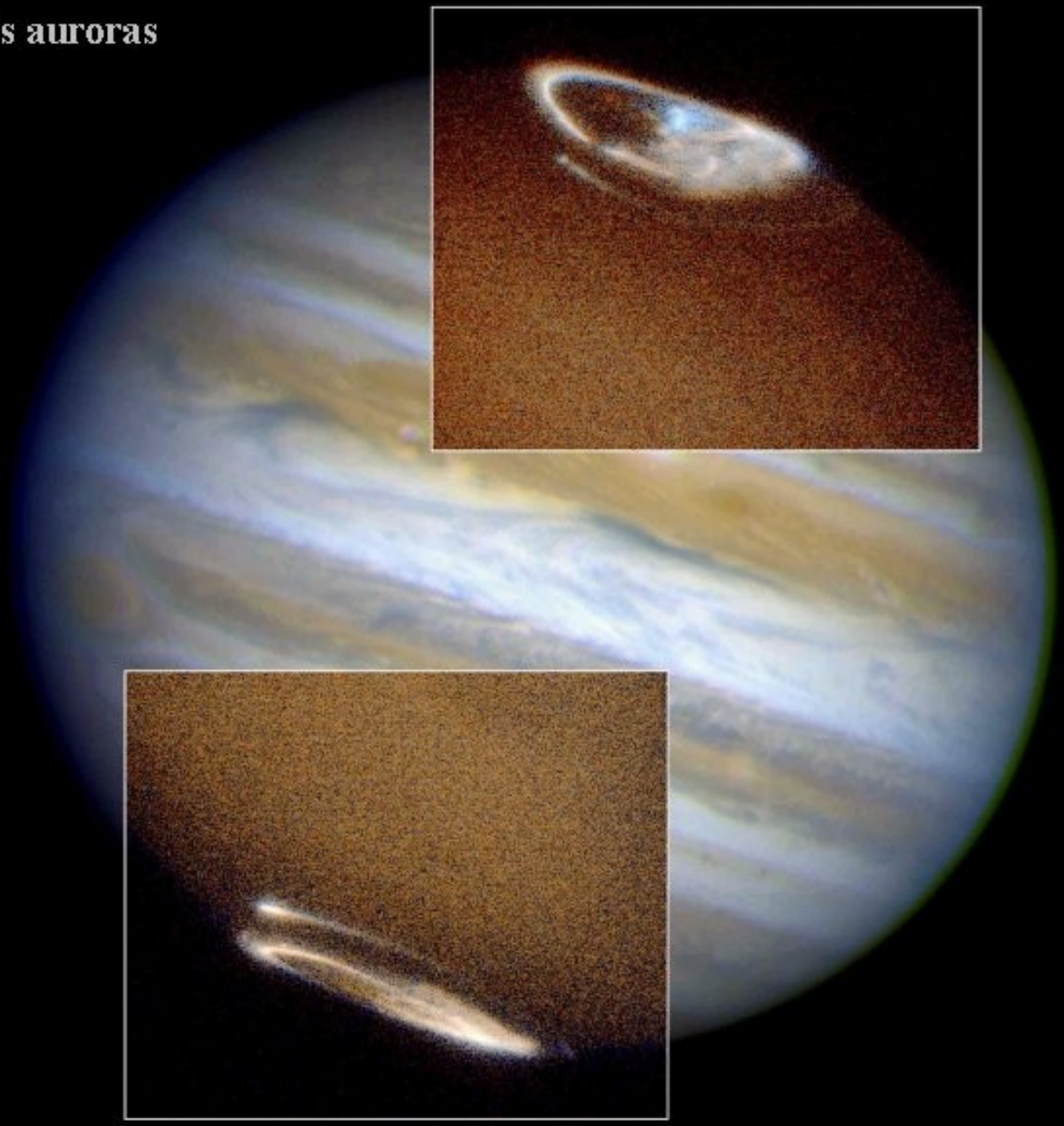
Thus, high energy astrophysics makes feasible the study of the properties of matter under physical conditions which cannot yet be reproduced in the laboratory. Indeed, in many cases, the problems can only be addressed in the astrophysical environment.

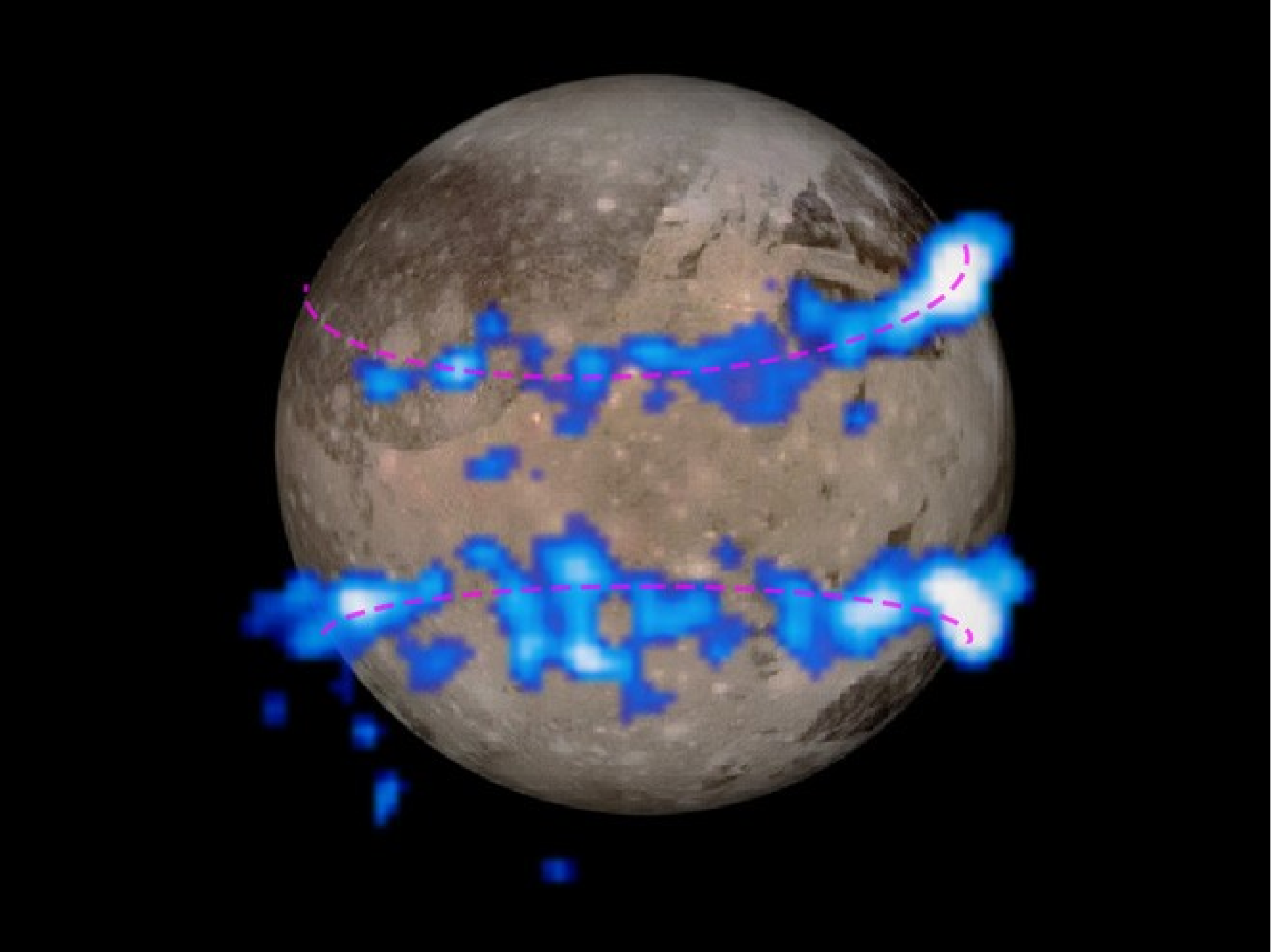


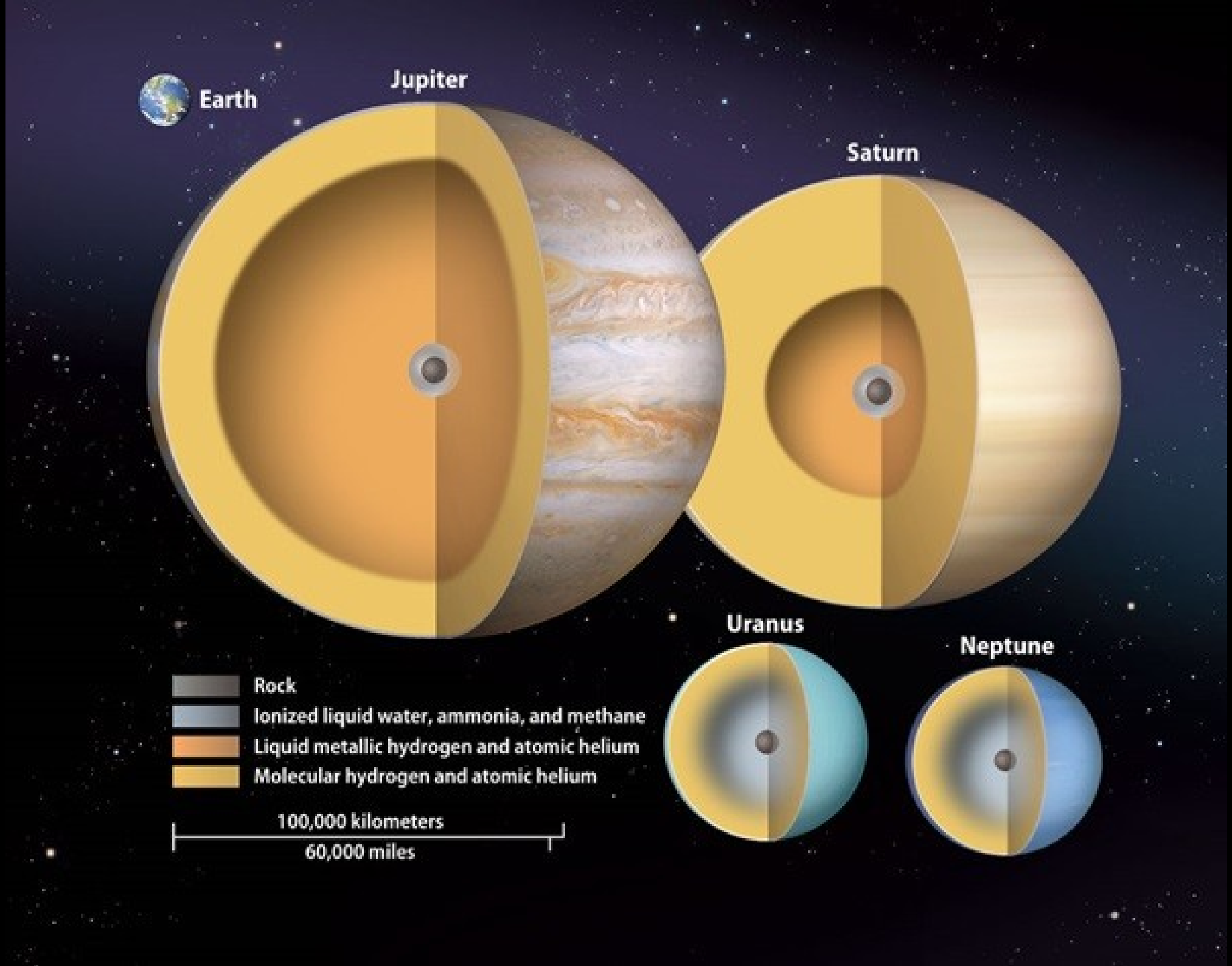

Magnetosheath
Magnetopause
Incident
solar
wind
B
Polar
cusp
Magnetotail
$3R_E$
$11R_E$
Inner
radiation
belts
Plasma sheet
Neutral
sheet
B
Magnetotail
Magnetopause
Shock
front


B
protoni
elettroni

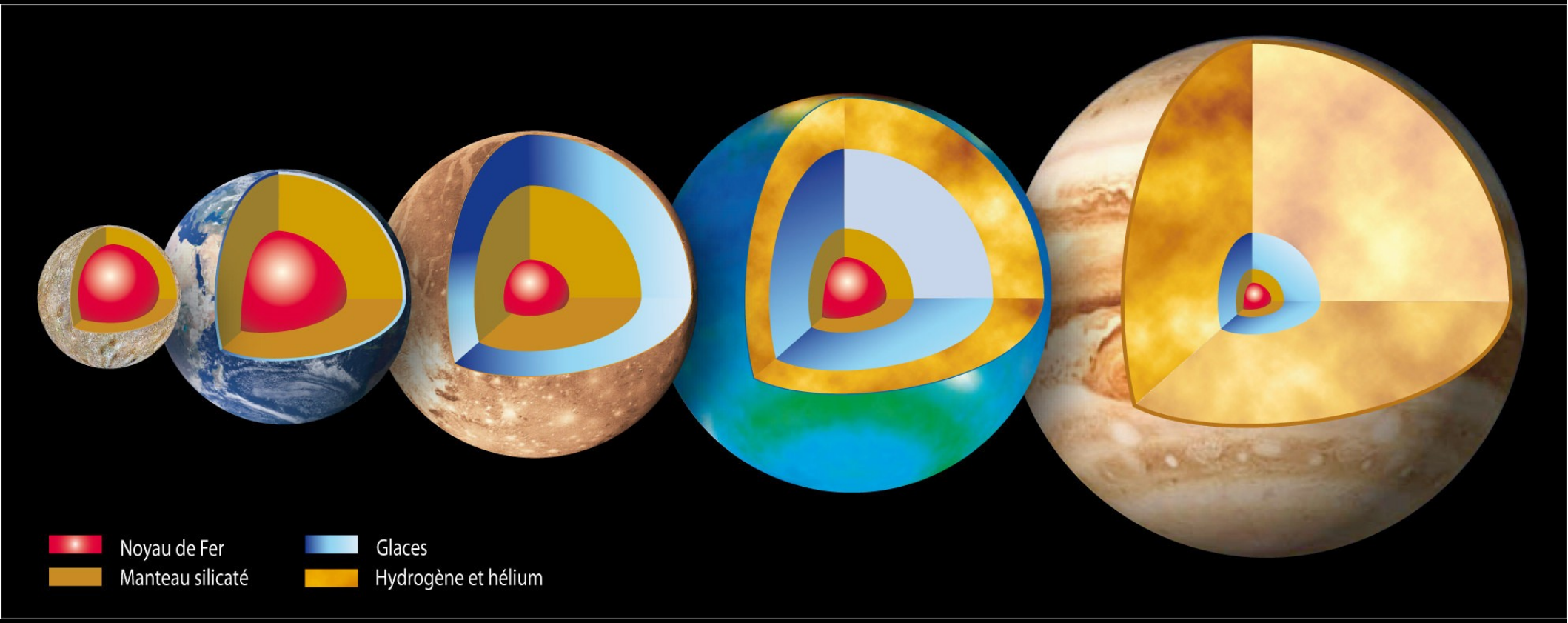
Jupiter's auroras

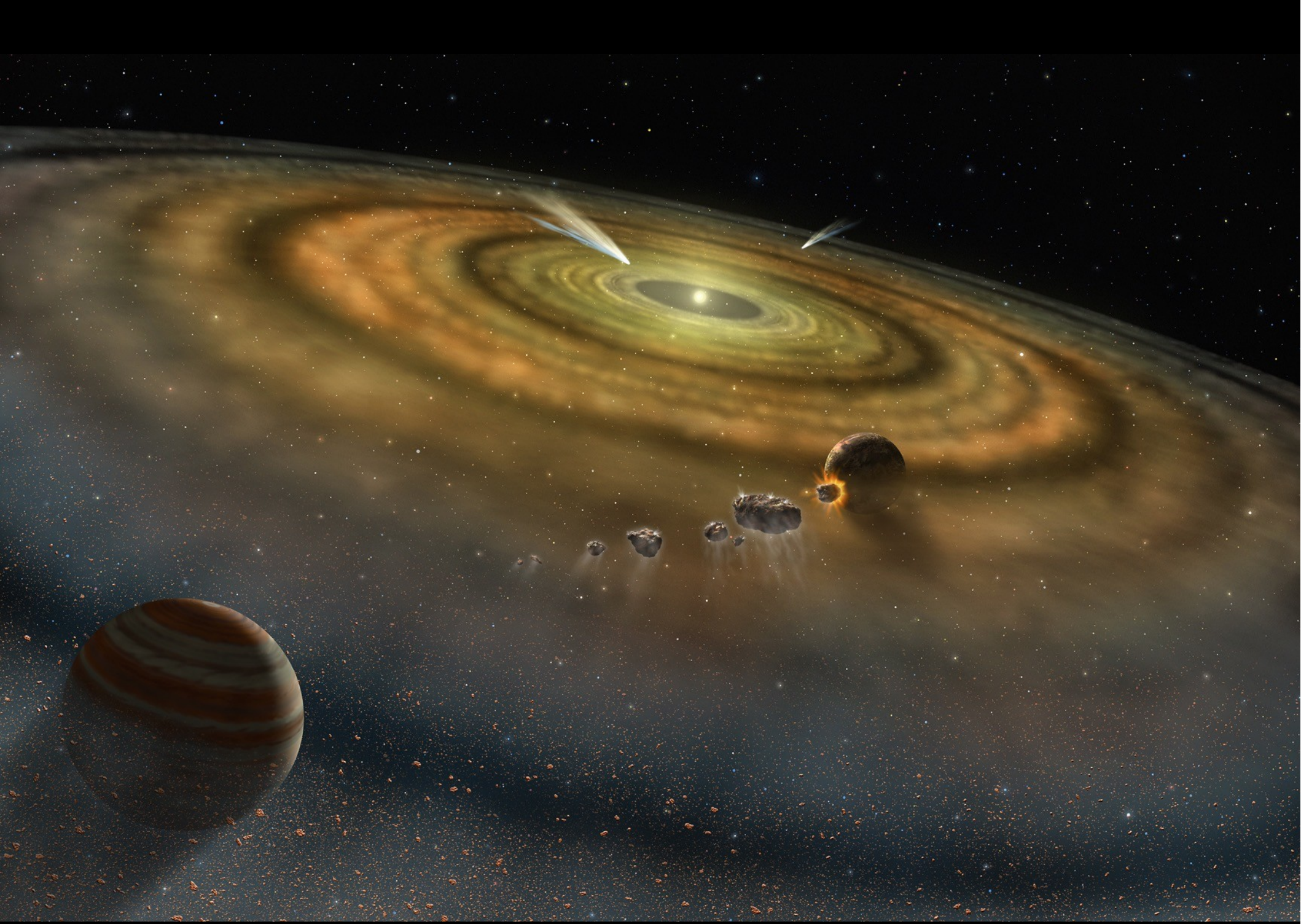


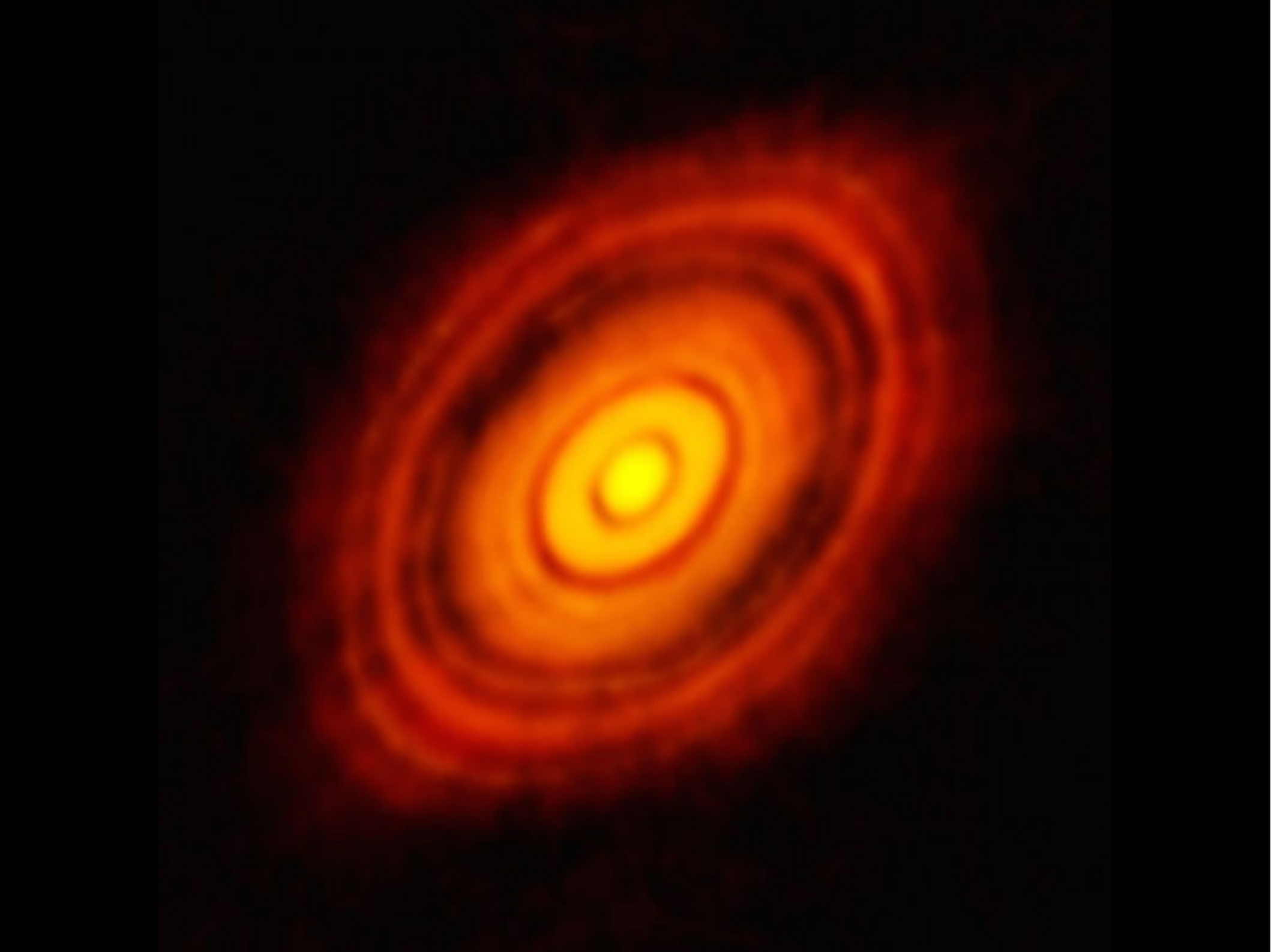


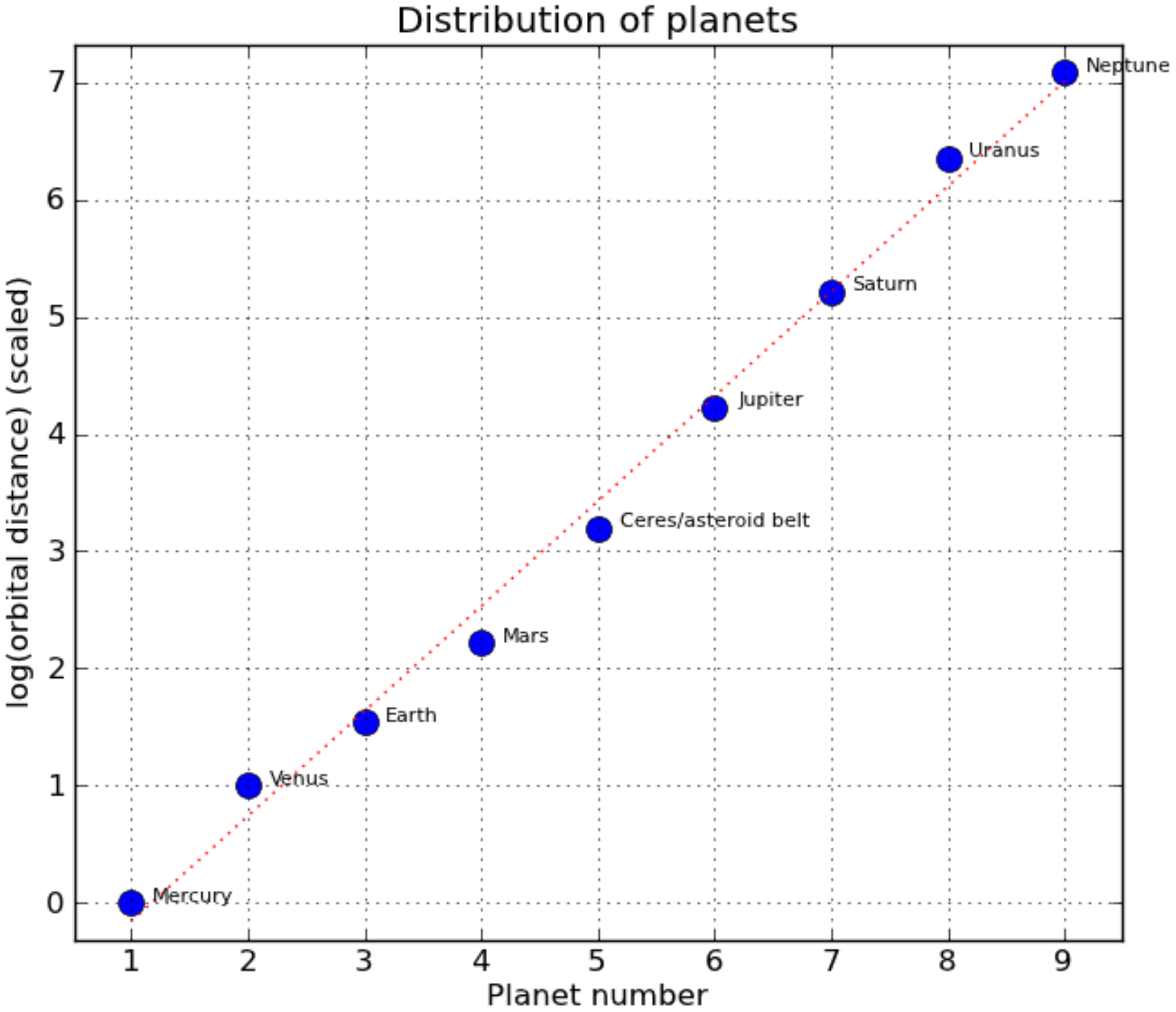

Earth
Jupiter
Saturn
Uranus
Neptune
Rock
Ionized liquid water, ammonia, and methane
Liquid metallic hydrogen and atomic helium
Molecular hydrogen and atomic helium
100,000 kilometers
60,000 miles

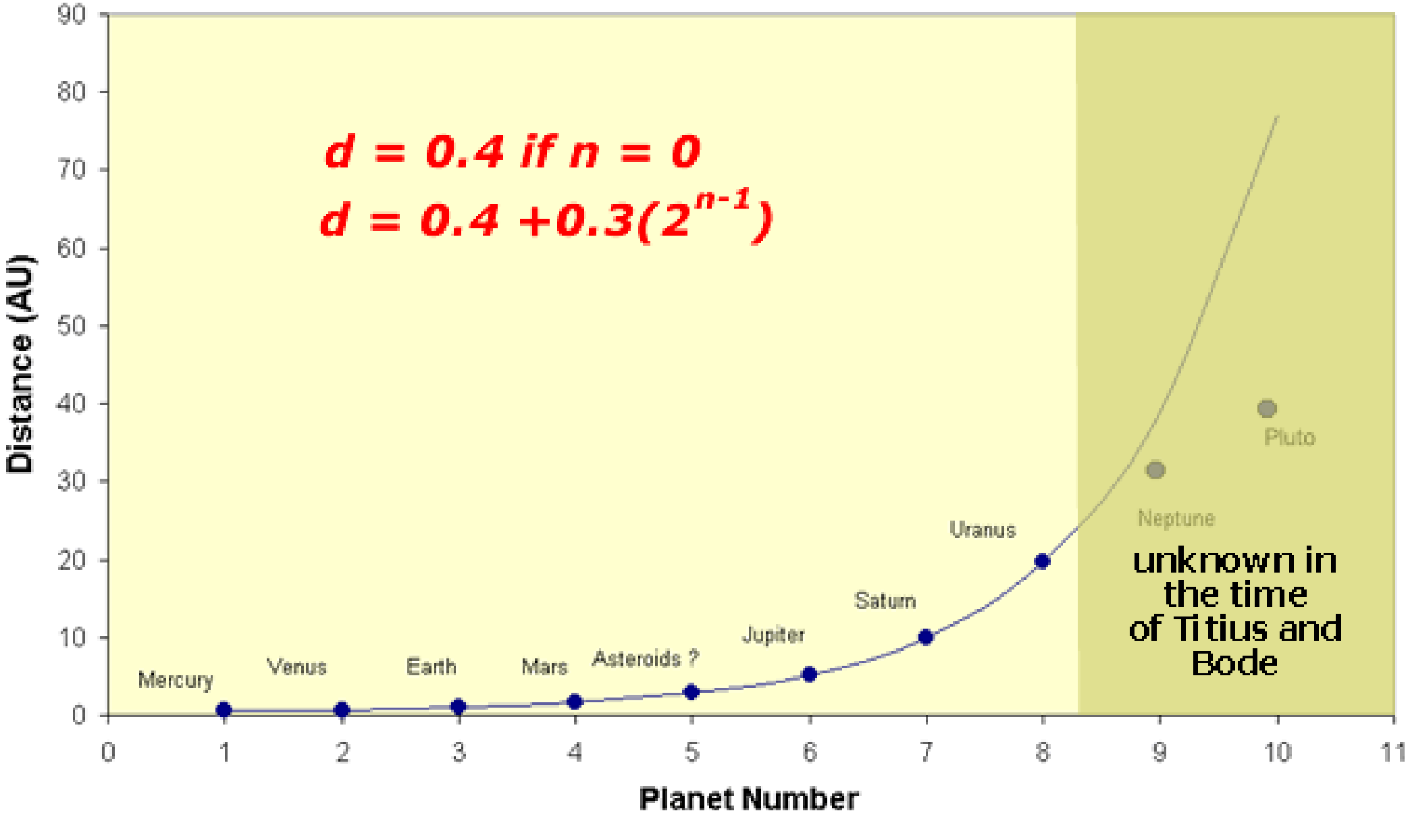

Mars
6804.9 km
Ganymede
5262 km
Titan
5150 km
Mercury
4879.4 km
Callisto
4821 km
Io
3643 km
Moon
3476.2 km
Europa
3122 km
Triton
2706.8 km
Pluto
2390 km
Sedna
~ 1500 km
Titania
1578 km
Rhea
1528 km
Oberon
1523 km
Iapetus
1436 km
Quaoar
1200 km
Charon
1186 km
Umbriel
1169.4 km
Ariel
1158 km
Dione
1118 km
Tethys
1059 km
Earth
12,756.28 km
Diameters of the Terrestrial Bodies
of the Solar System

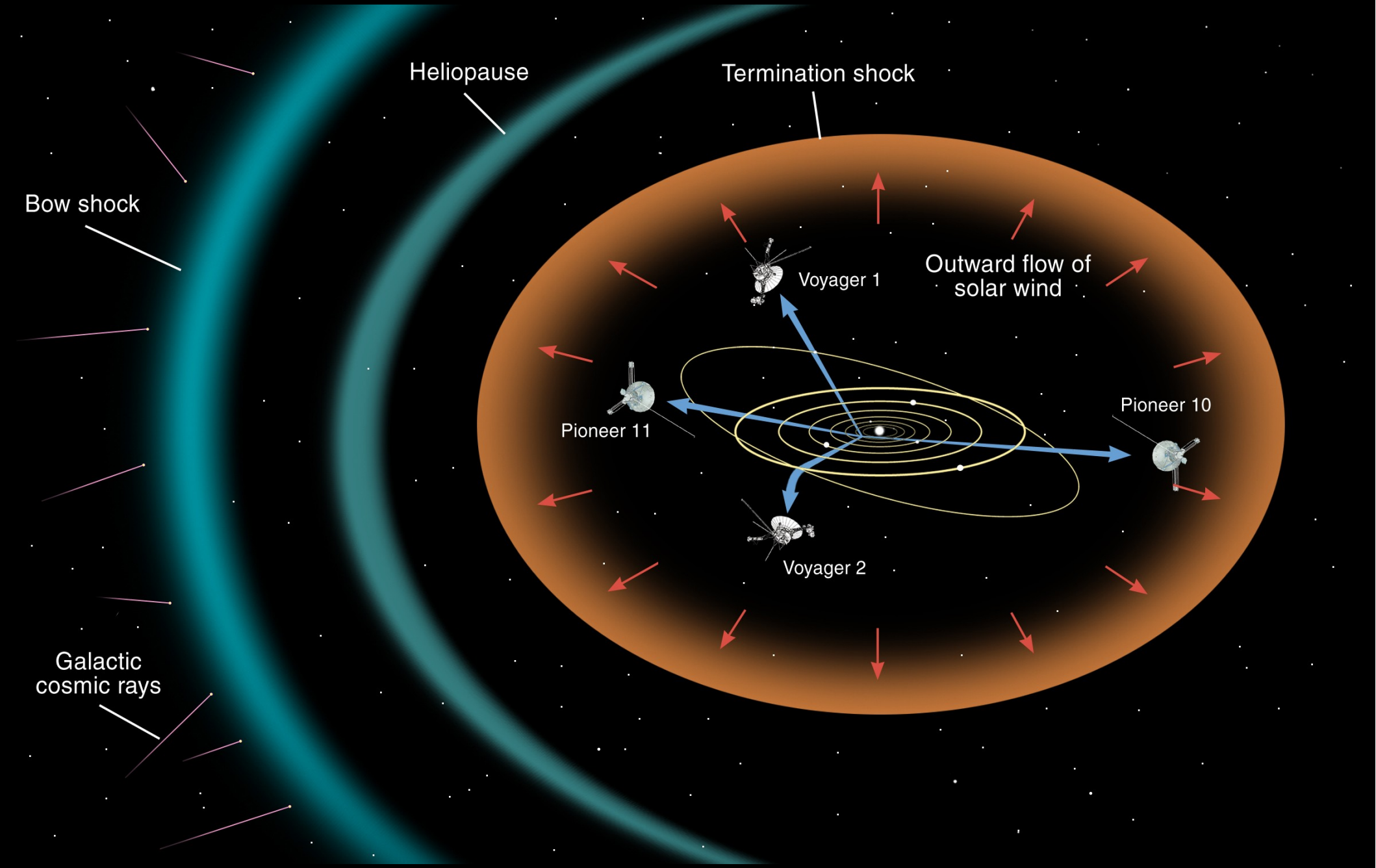

Noyau de Fer
Manteau silicaté
Glaces
Hydrogène et hélium

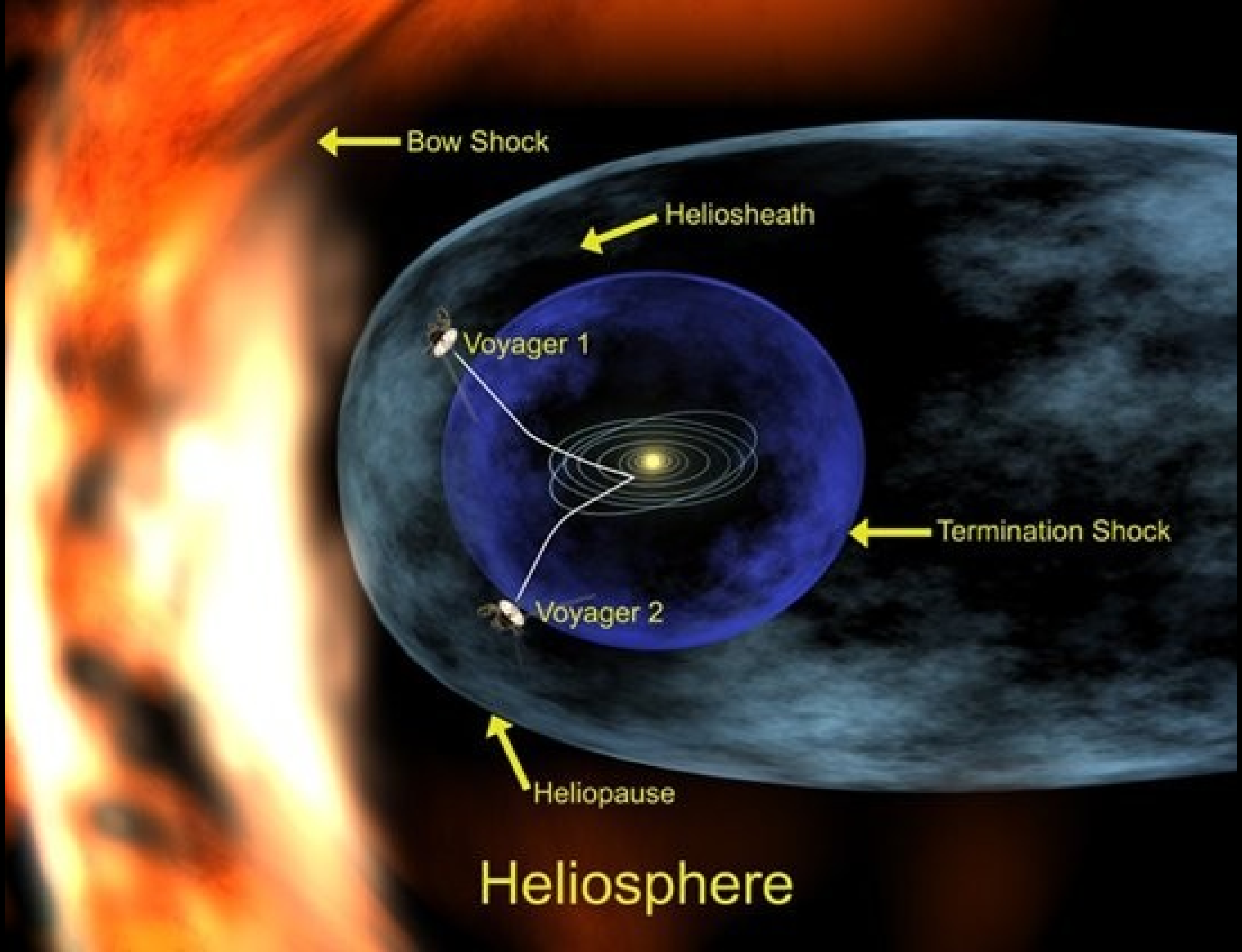


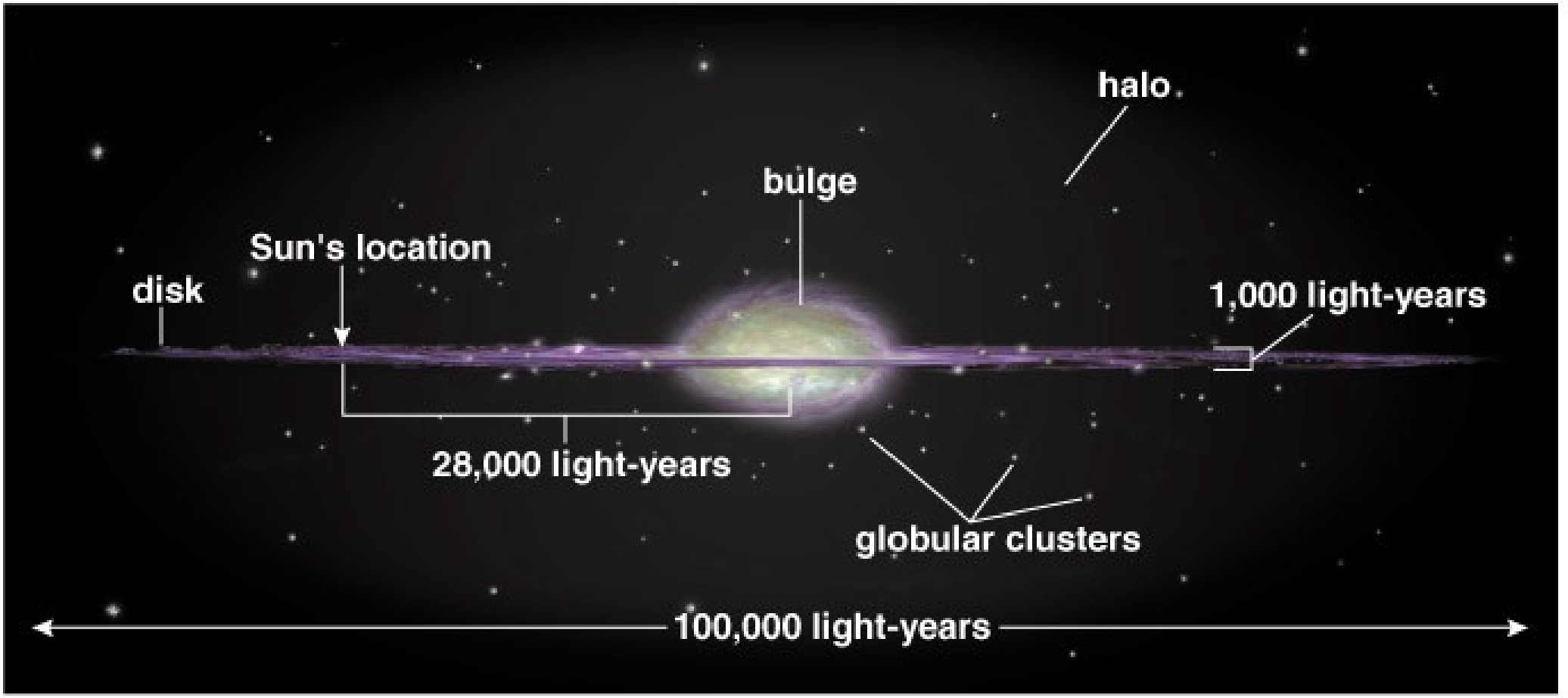



Distribution of planets
log(orbital distance) (scaled)
Planet number
Mercury
Venus
Earth
Mars
Ceres/asteroid belt
Jupiter
Saturn
Uranus
Neptune
0
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9

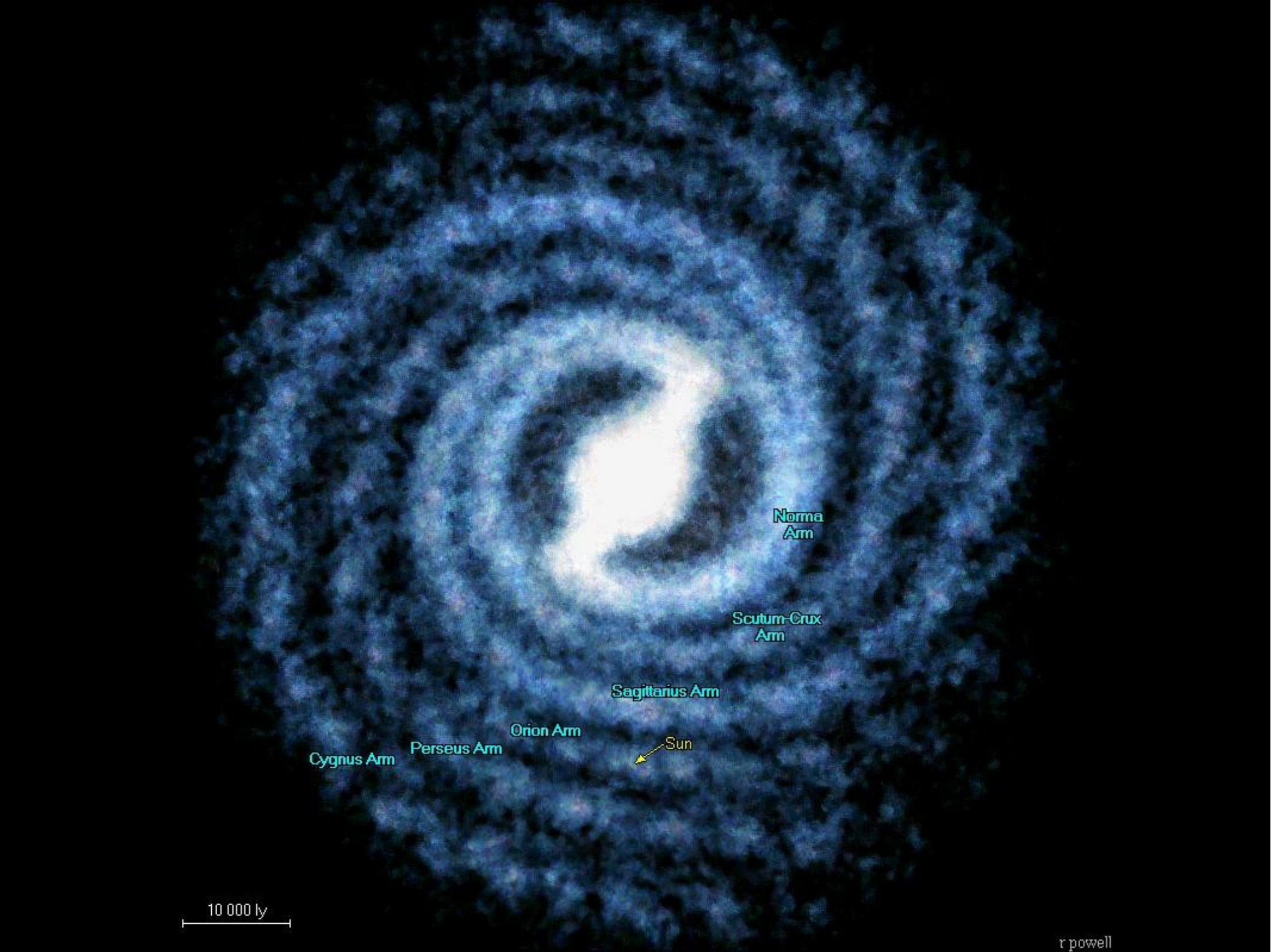

d = 0.4 if n = 0
d = 0.4 +0.3(2^n-1)
Distance (AU)
Planet Number
Mercury
Venus
Earth
Mars
Asteroids ?
Jupiter
Saturn
Uranus
Neptune
Pluto
unknown in the time of Titius and Bode

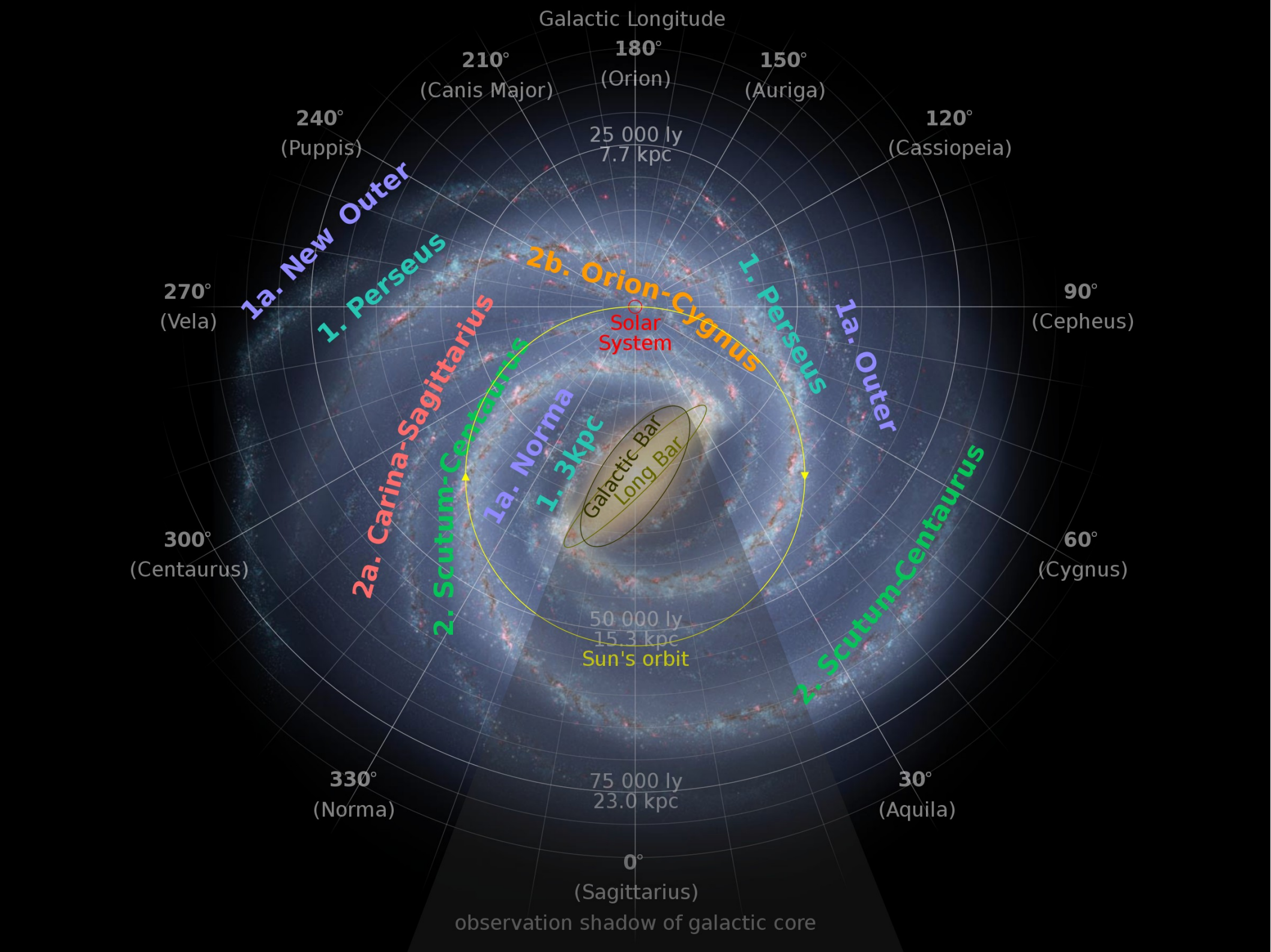

Heliopause
Termination shock
Bow shock
Outward flow of
solar wind
Voyager 1
Pioneer 11
Pioneer 10
Voyager 2
Galactic
cosmic rays


Bow Shock
Heliosheath
Voyager 1
Termination Shock
Voyager 2
Heliopause
Heliosphere

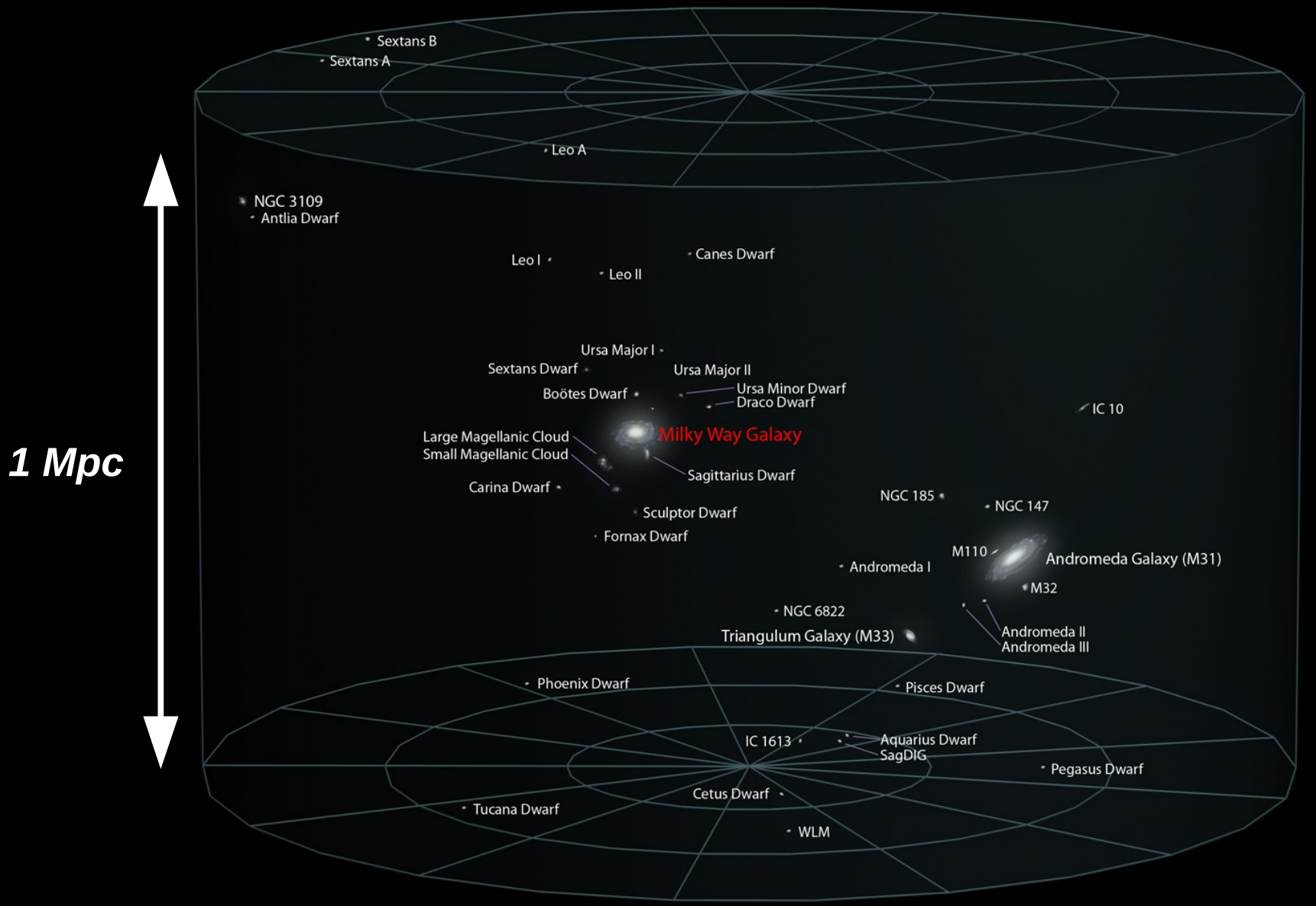


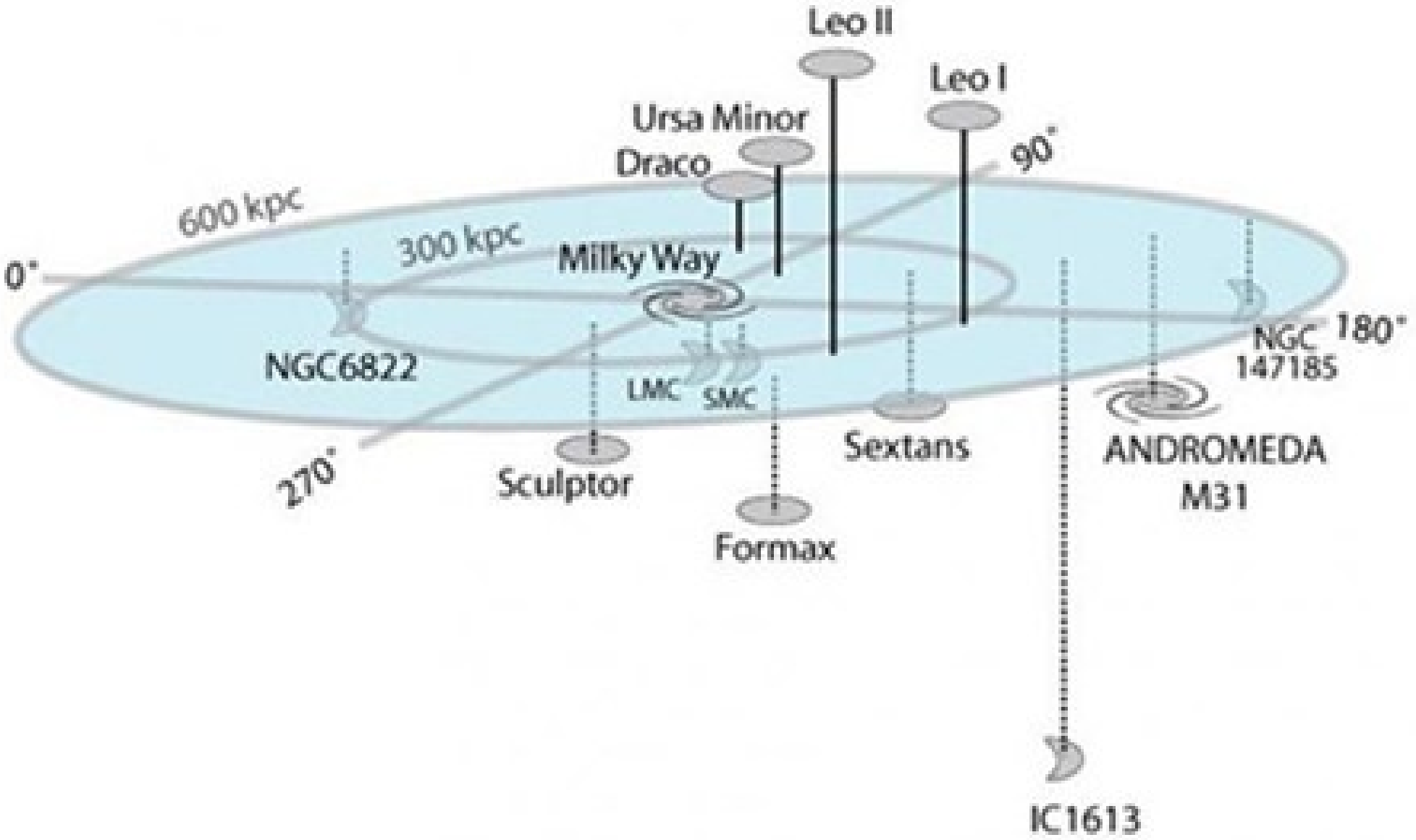
(b)


Norma
Arm
Scutum-Crux
Arm
Sagittarius Arm
Orion Arm
Sun
Perseus Arm
Cygnus Arm
10 000 ly
r powell


Galactic Longitude
180°
(Orion)
210°
(Canis Major)
150°
(Auriga)
240°
(Puppis)
120°
(Cassiopeia)
25 000 ly
7.7 kpc
270°
(Vela)
90°
(Cepheus)
300°
(Centaurus)
60°
(Cygnus)
330°
(Norma)
30°
(Aquila)
0°
(Sagittarius)
1a. New Outer
1. Perseus
2b. Orion-Cygnus
1. Perseus
1a. Outer
2a. Carina-Sagittarius
2. Scutum-Centaurus
1a. Norma
1. 3kpc
Solar System
Galactic Bar
Long Bar
2. Scutum-Centaurus
50 000 ly
15.3 kpc
Sun's orbit
75 000 ly
23.0 kpc
observation shadow of galactic core

LOCAL GALACTIC GROUP

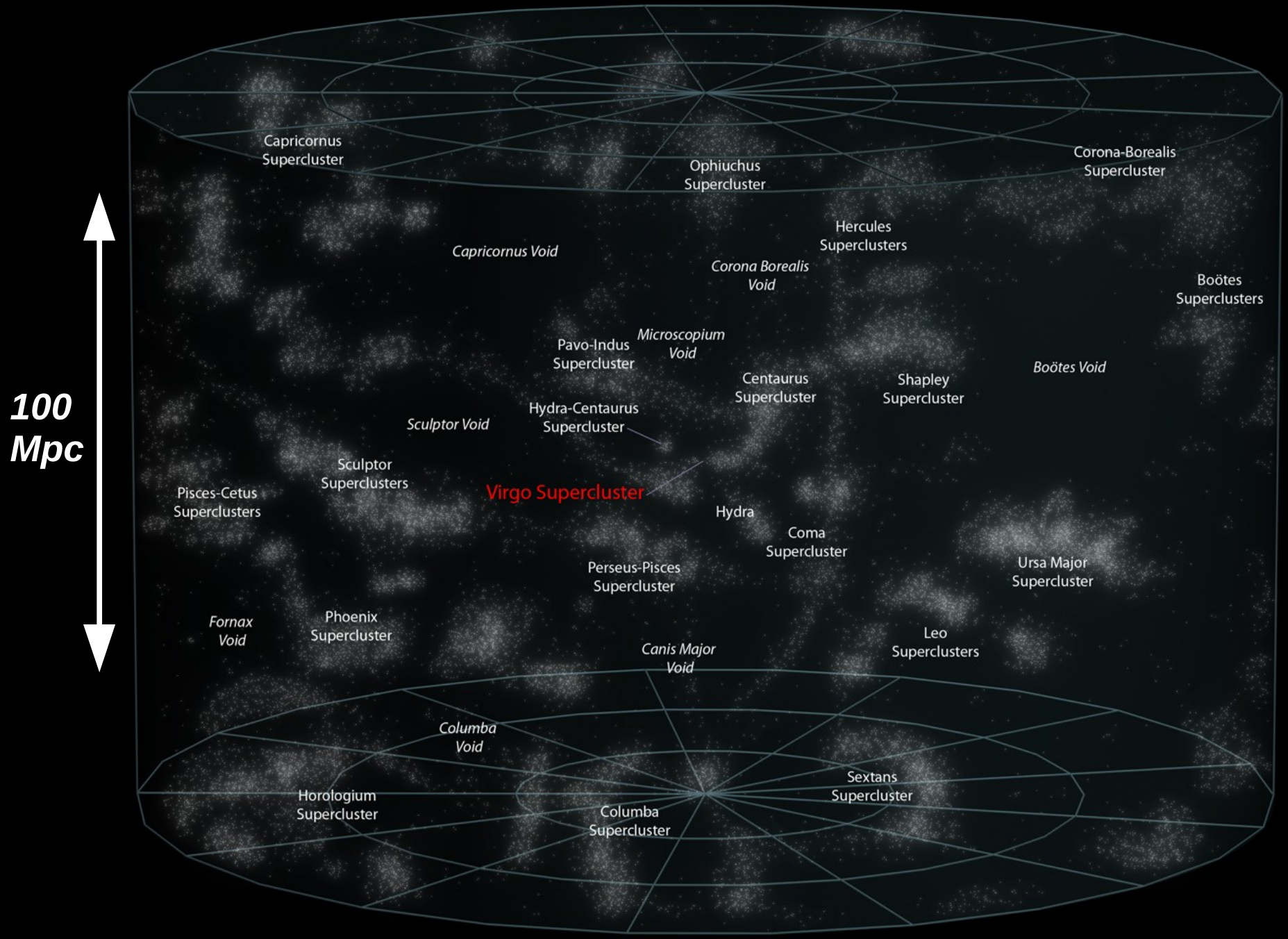


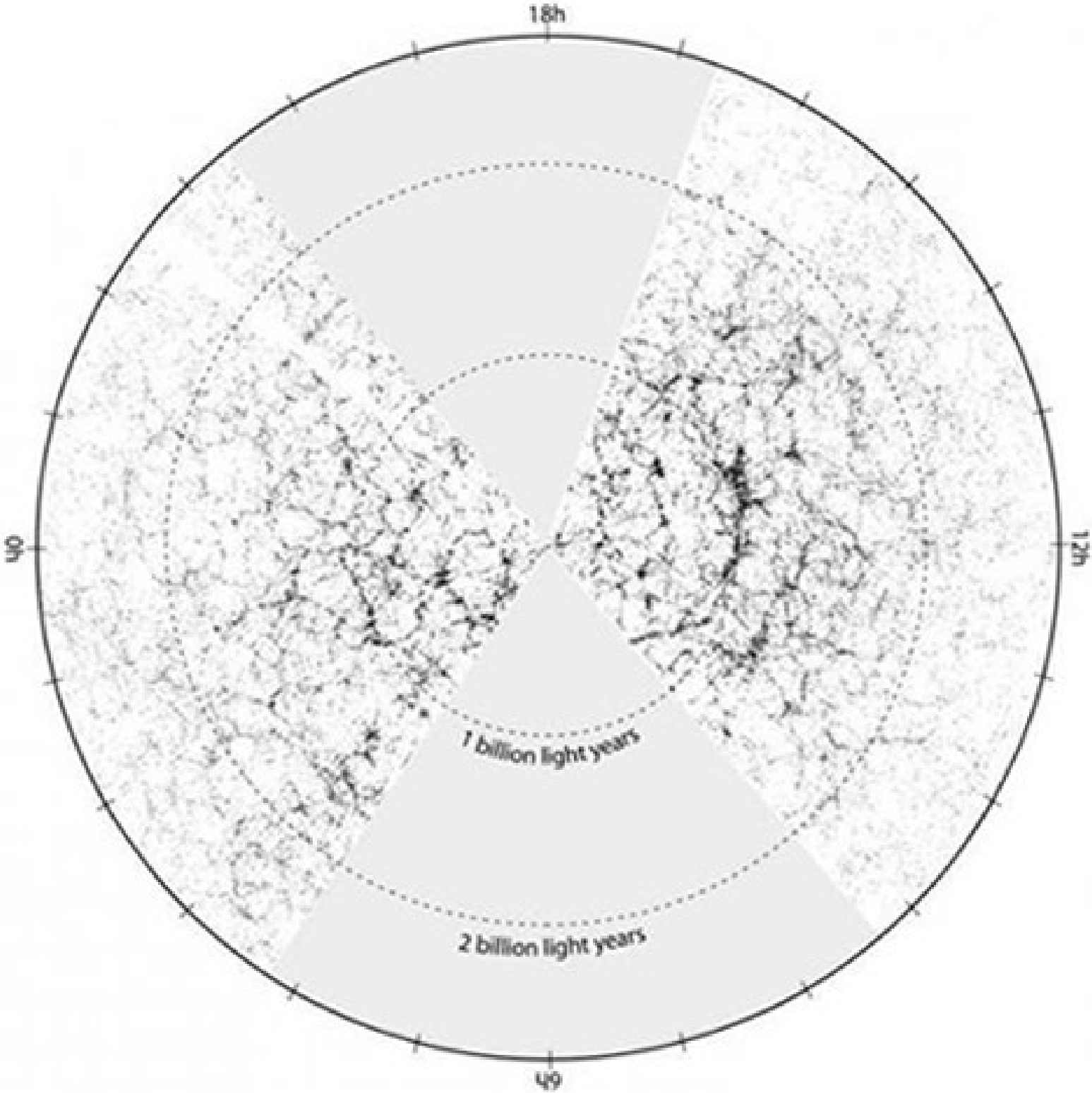

Leo II
Leo I
Ursa Minor
Draco
90°
600 kpc
300 kpc
0°
Milky Way
NGC6822
LMC
SMC
NGC 147185
180°
270°
Sculptor
Sextans
ANDROMEDA
M31
Formax
IC1613

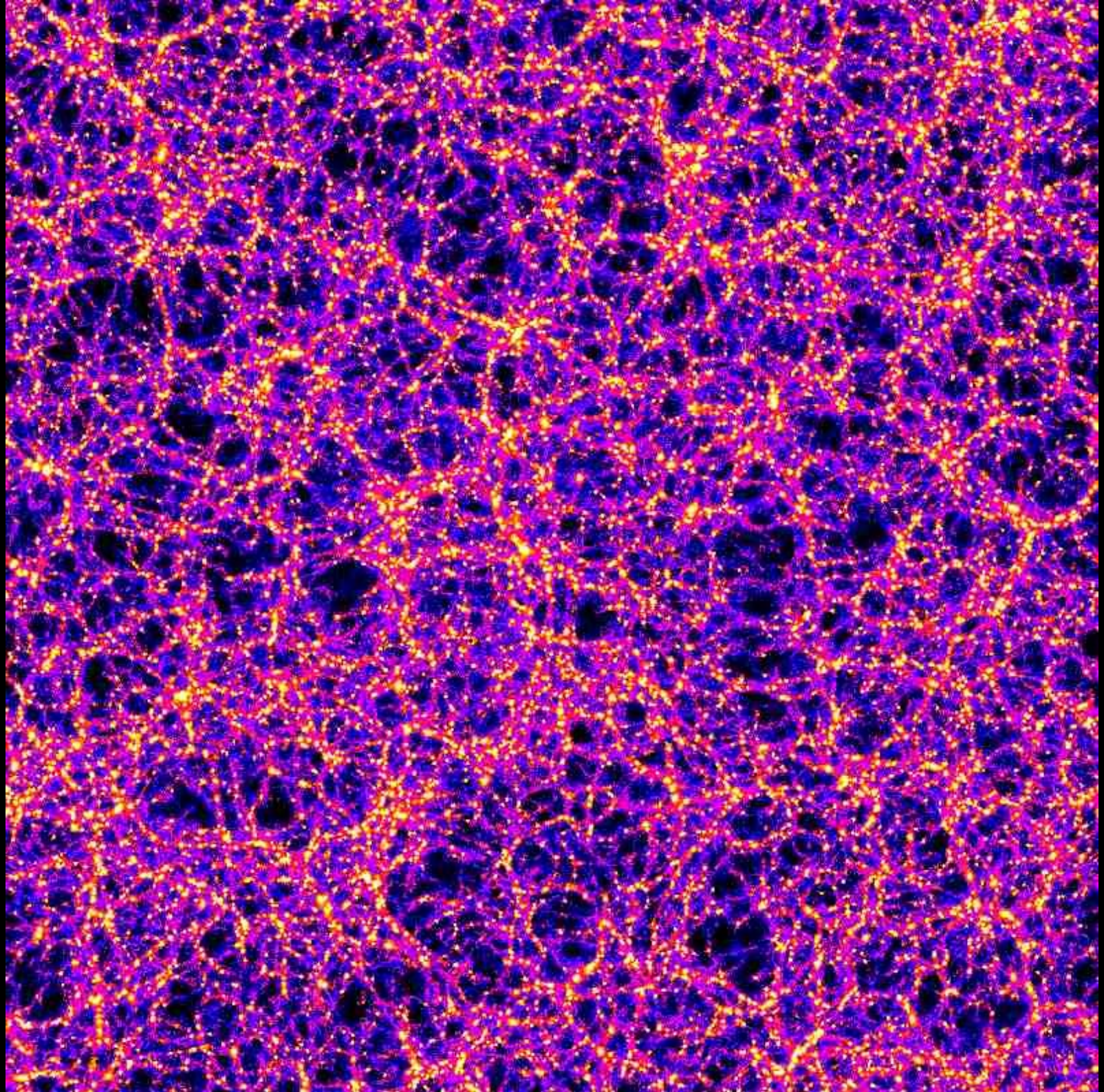
VIRGO SUPERCLUSTER

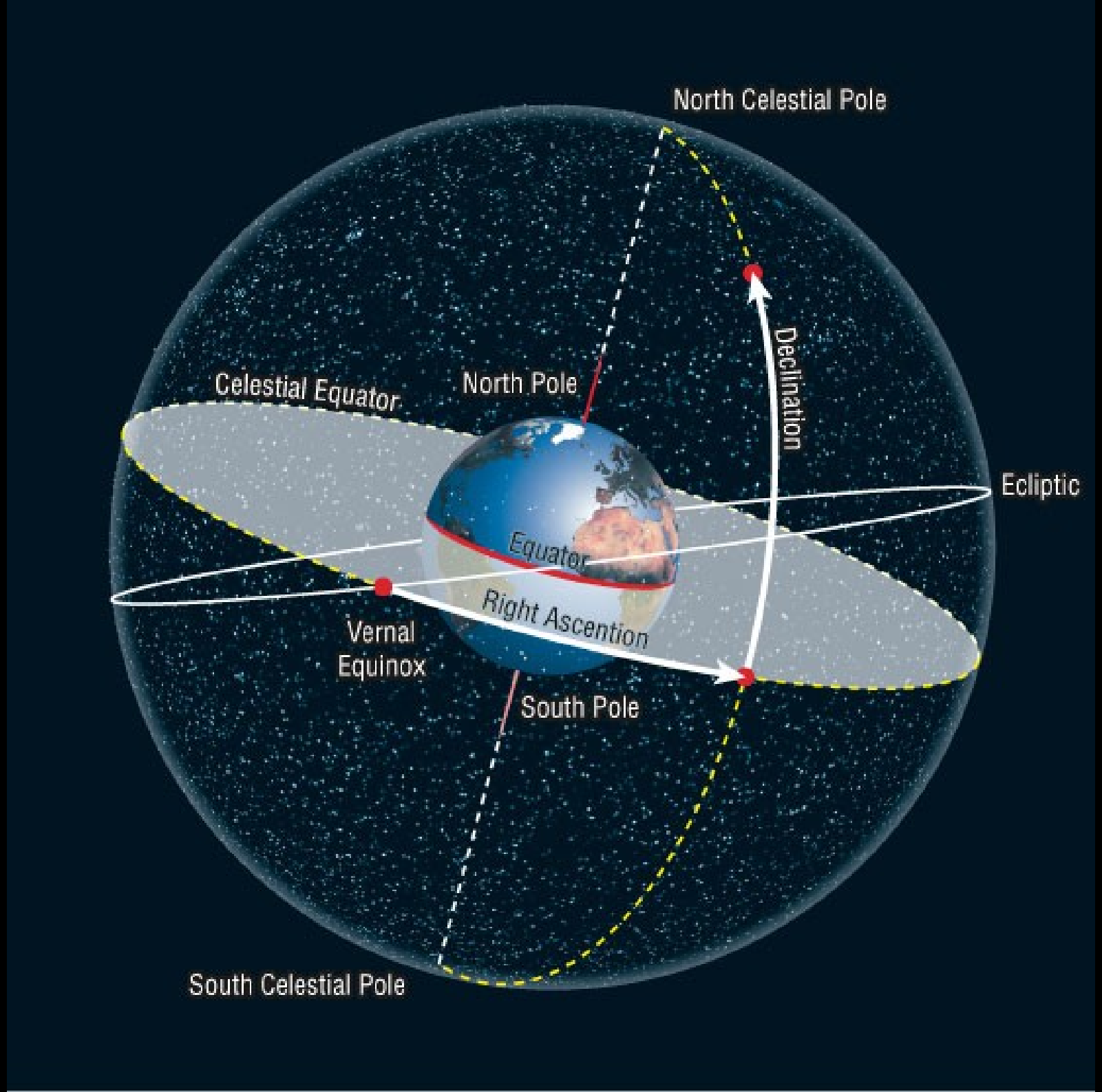
Virgo Cluster

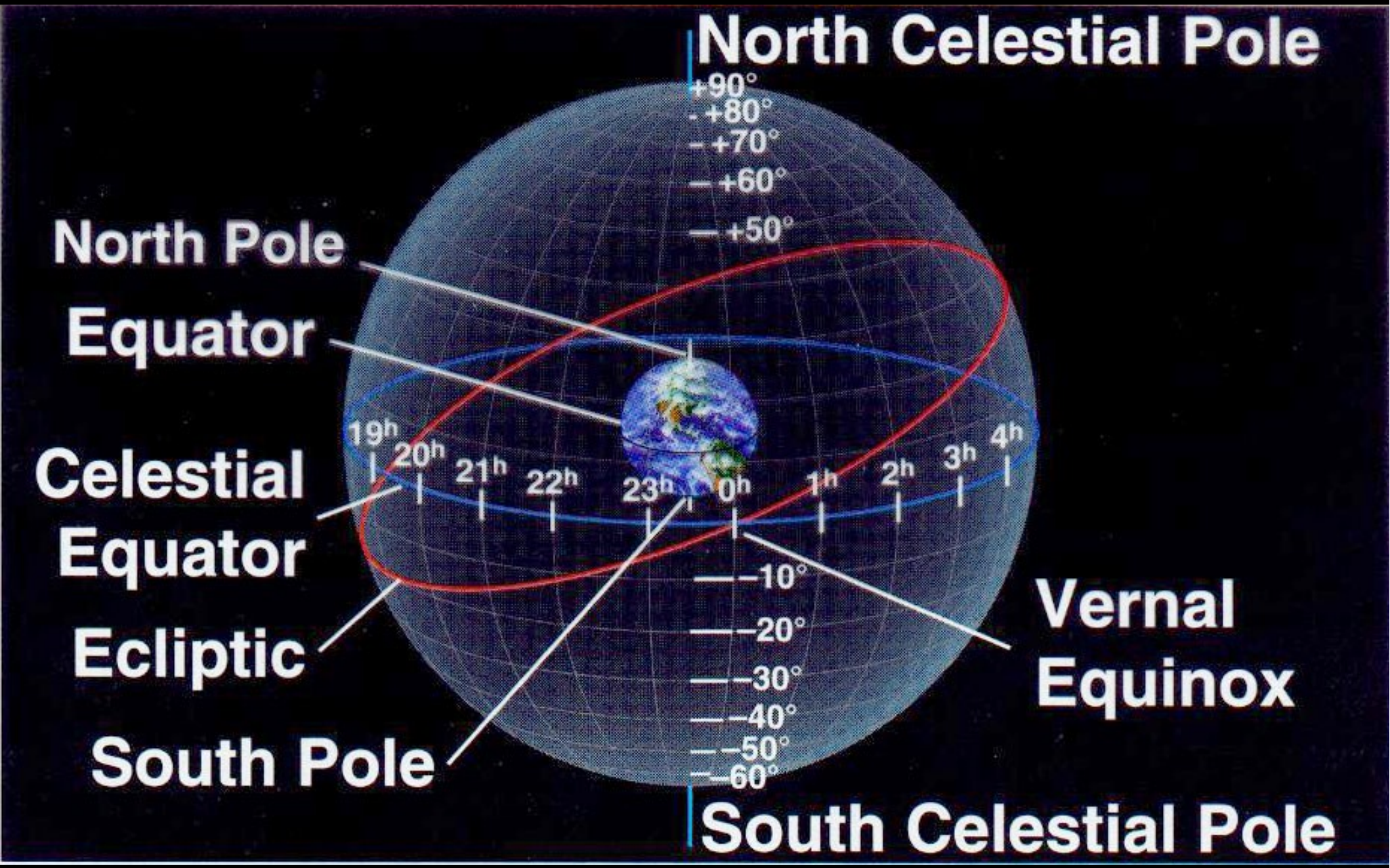
LOCAL SUPERCLUSTERS

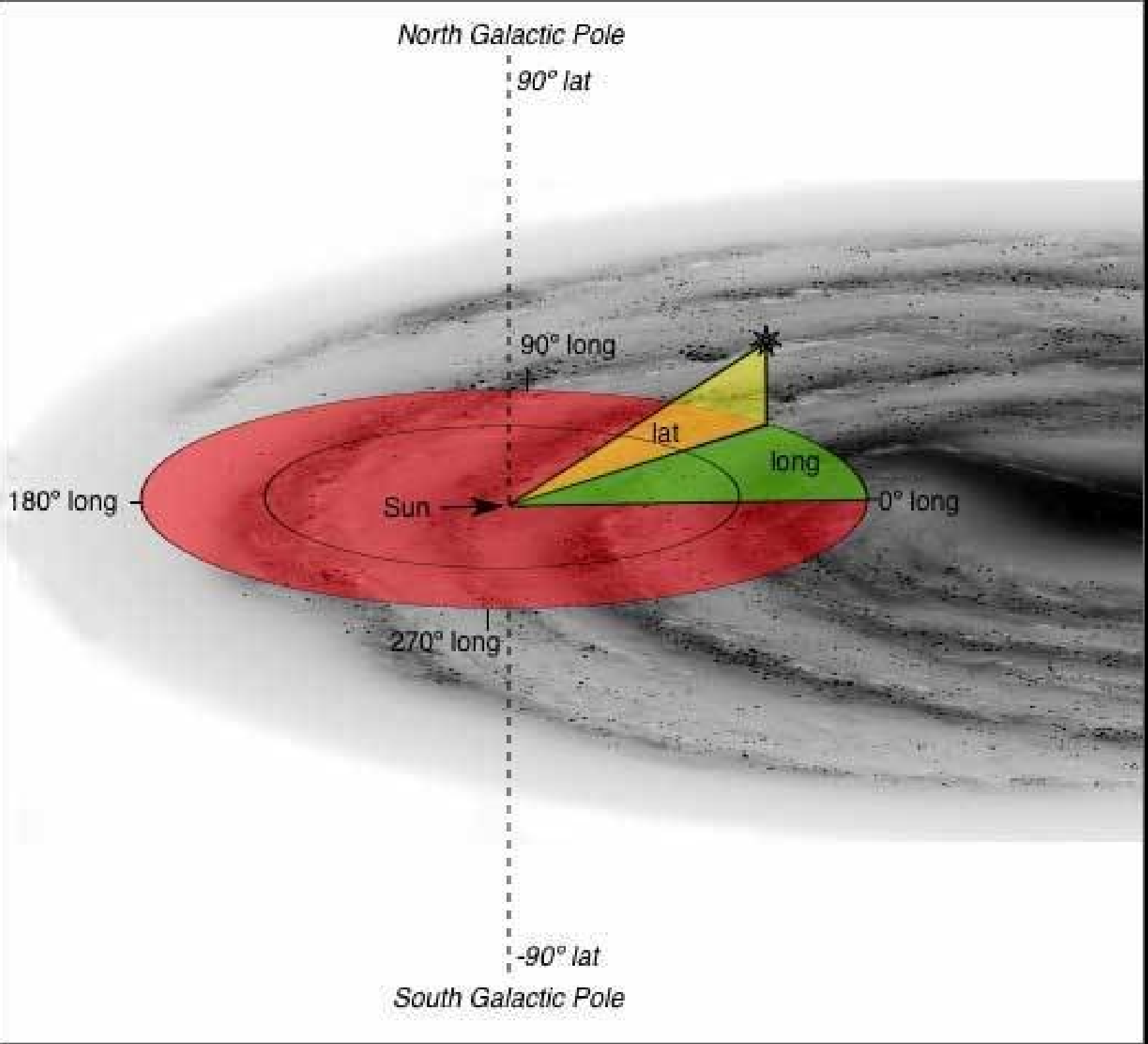


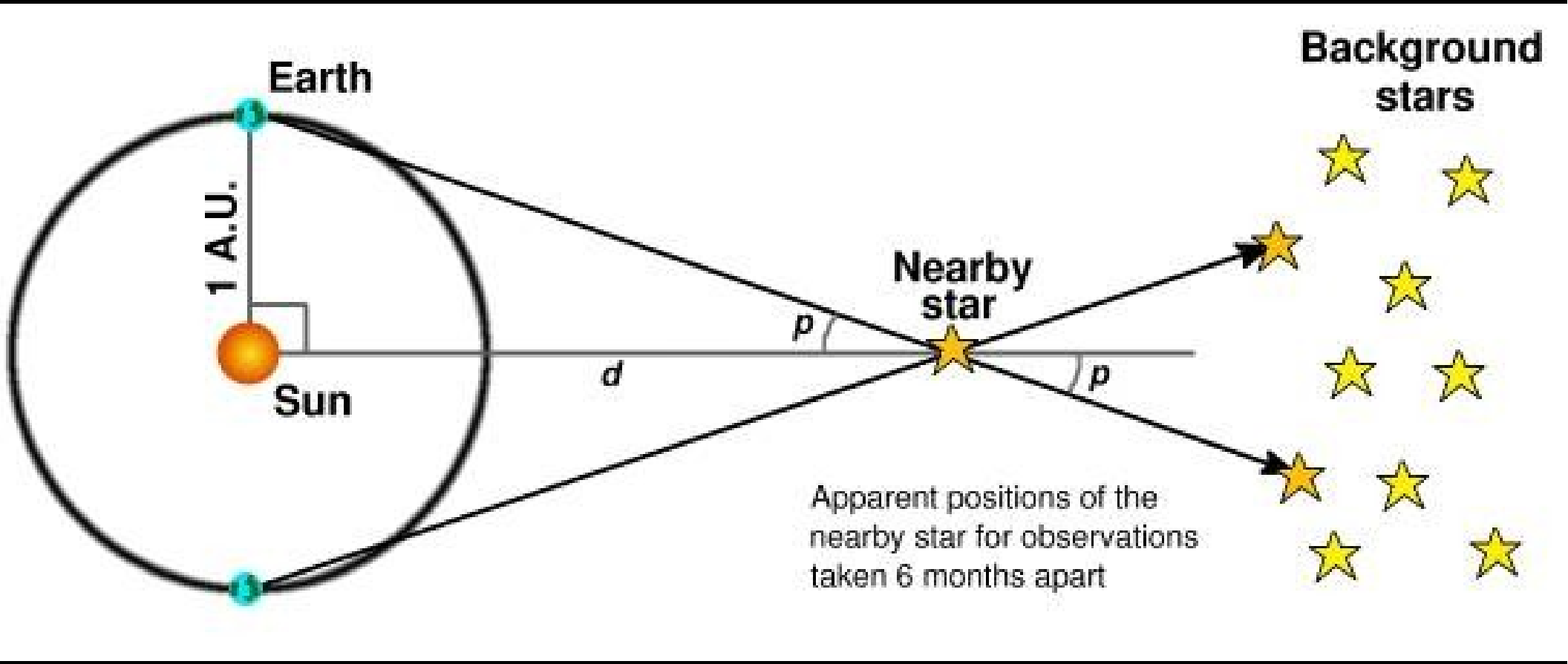

18h
0h
12h
6h
1 billion light years
2 billion light years

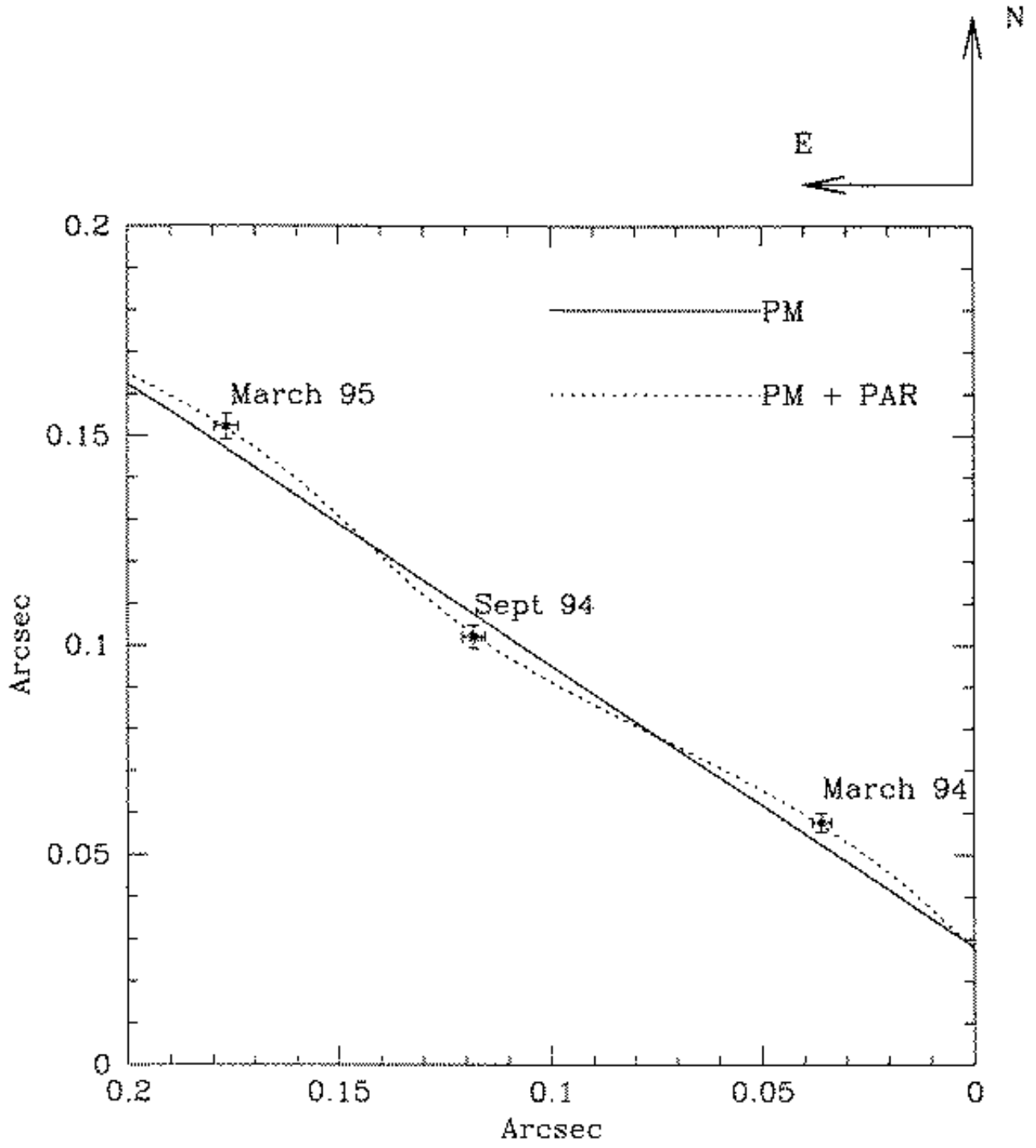



North Celestial Pole
Declination
Celestial Equator
North Pole
Ecliptic
Equator
Right Ascention
Vernal
Equinox
South Pole
South Celestial Pole


North Celestial Pole
+90°
+80°
+70°
+60°
+50°
North Pole
Equator
19h
20h
21h
22h
23h
0h
1h
2h
3h
4h
Celestial Equator
Ecliptic
South Pole
−10°
−20°
−30°
−40°
−50°
−60°
Vernal Equinox
South Celestial Pole


North Galactic Pole
90° lat
90° long
lat
long
180° long
Sun
0° long
270° long
-90° lat
South Galactic Pole


Earth
1 A.U.
Sun
Nearby star
p
d
p
Background stars
Apparent positions of the nearby star for observations taken 6 months apart


Geminga's Parallax
N
E
PM
PM + PAR
March 95
Sept 94
March 94
Arcsec
Arcsec
0.2
0.15
0.1
0.05
0

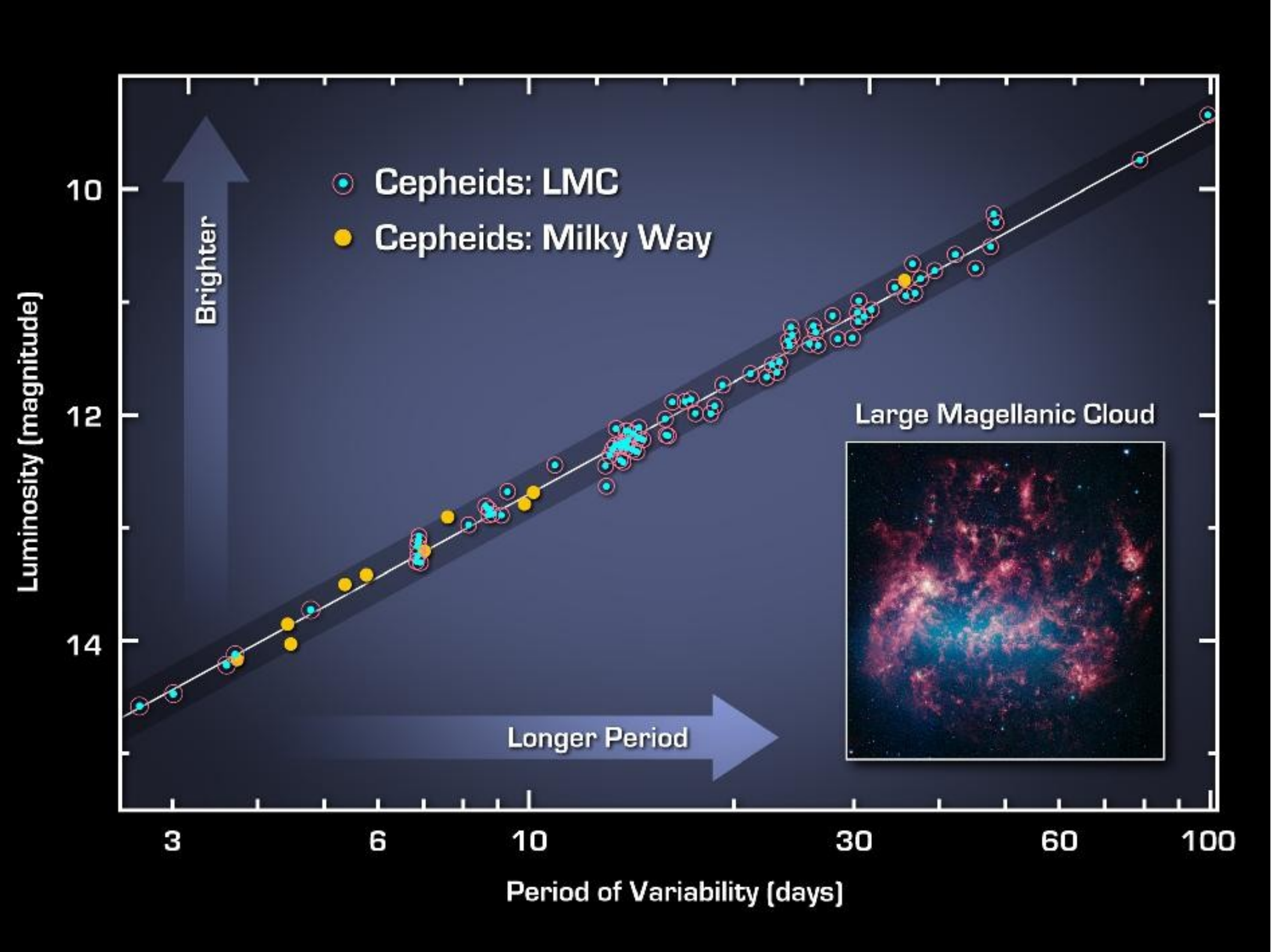

Cepheids: LMC
Cepheids: Milky Way
Brighter
Longer Period
Large Magellanic Cloud
Luminosity (magnitude)
10
12
14
3
6
10
30
60
100
Period of Variability (days)

Figure 14.2 Henrietta Swan Leavitt (1868–1921). (Courtesy of Harvard College Observatory.)

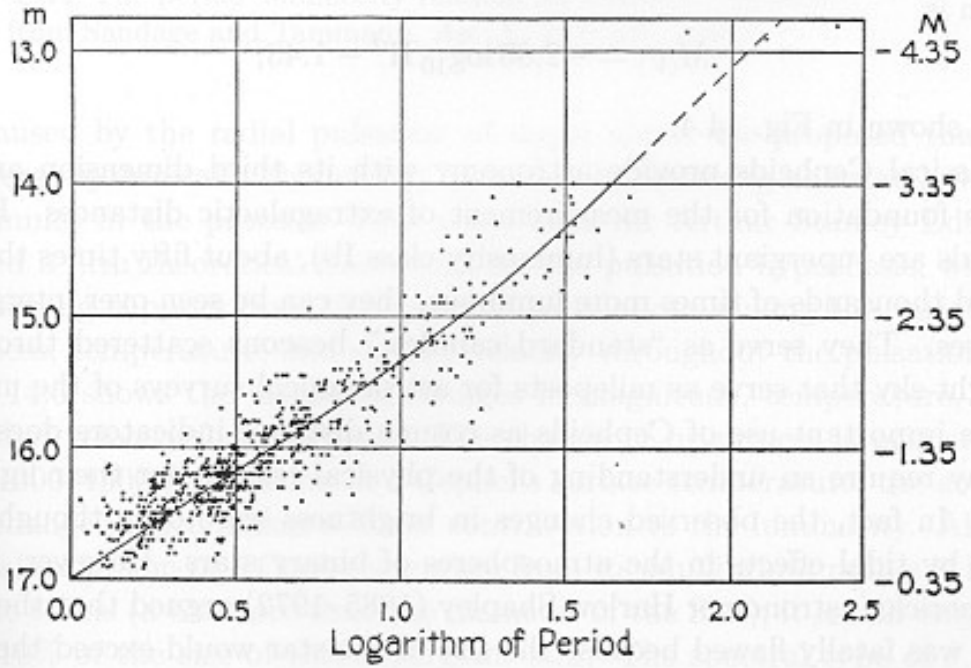


Figure 14.3 Classical Cepheids in the Small Magellanic Cloud, with the period in units of days. (Figure from Shapley, *Galaxies*, Harvard University Press, Cambridge, MA, 1961.)

Hubble Law

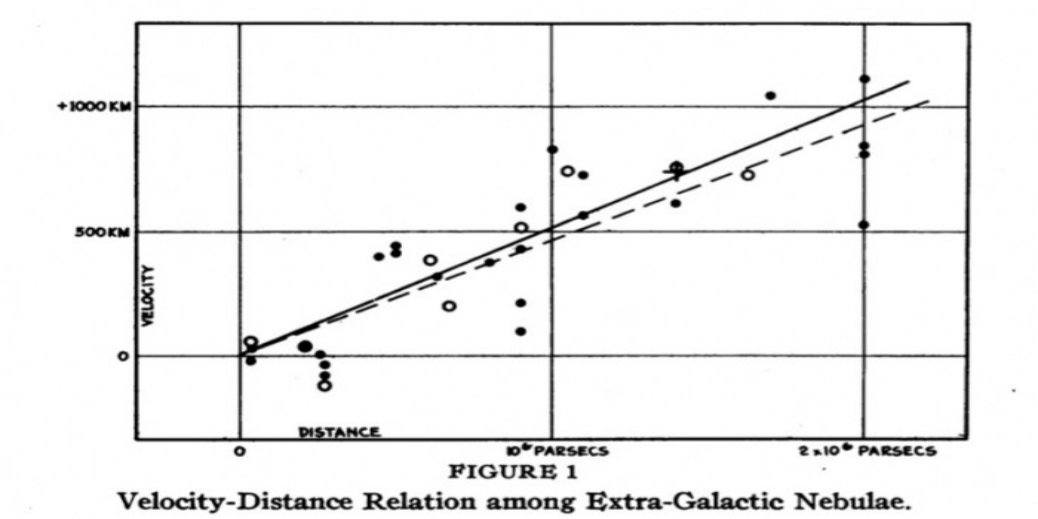
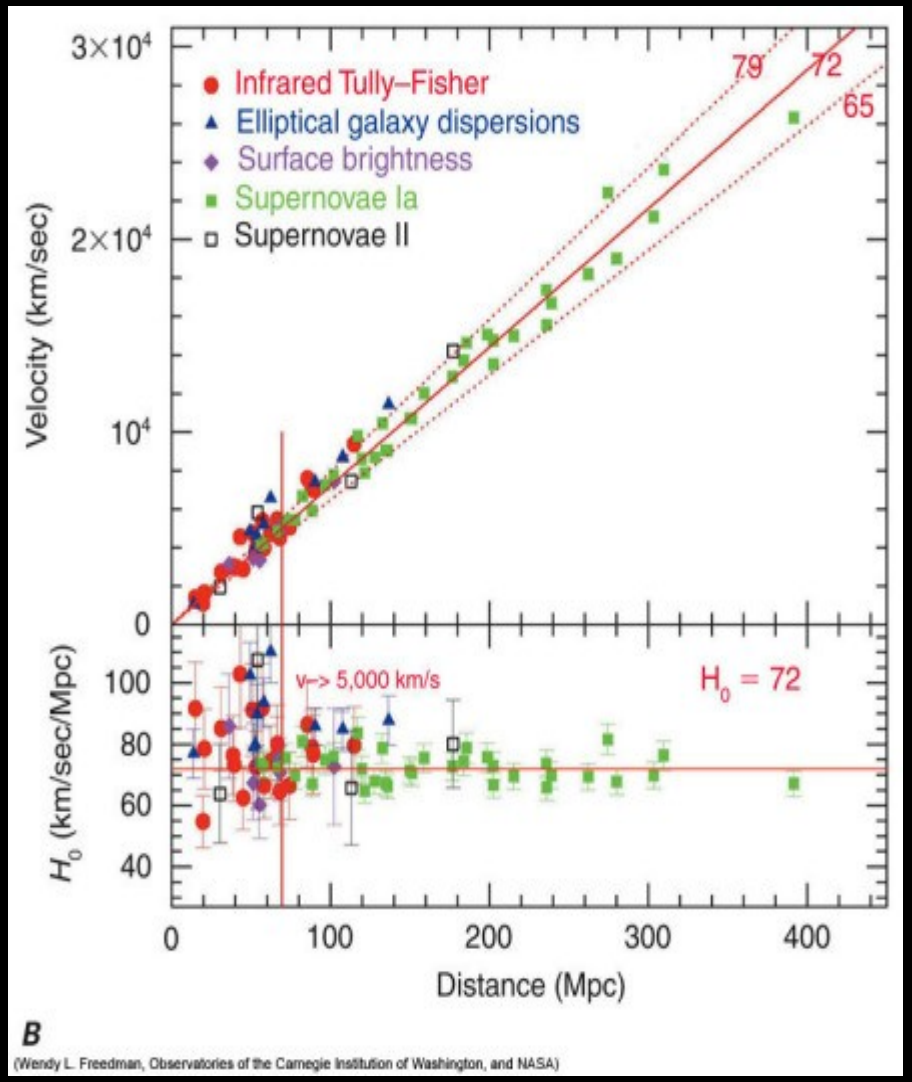


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

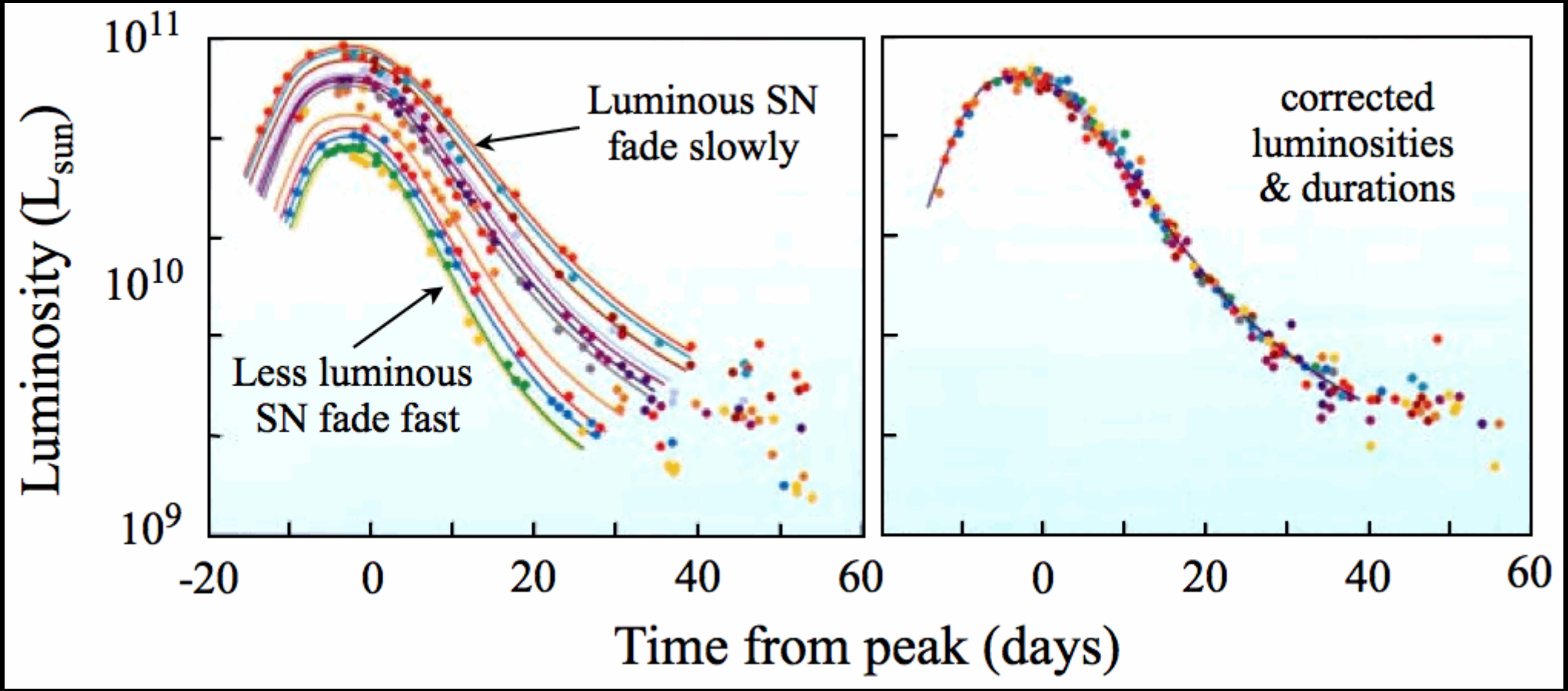
Edwin Hubble, Proceedings of the National Academy of Sciences, vol. 15 no. 3, pp.168-173

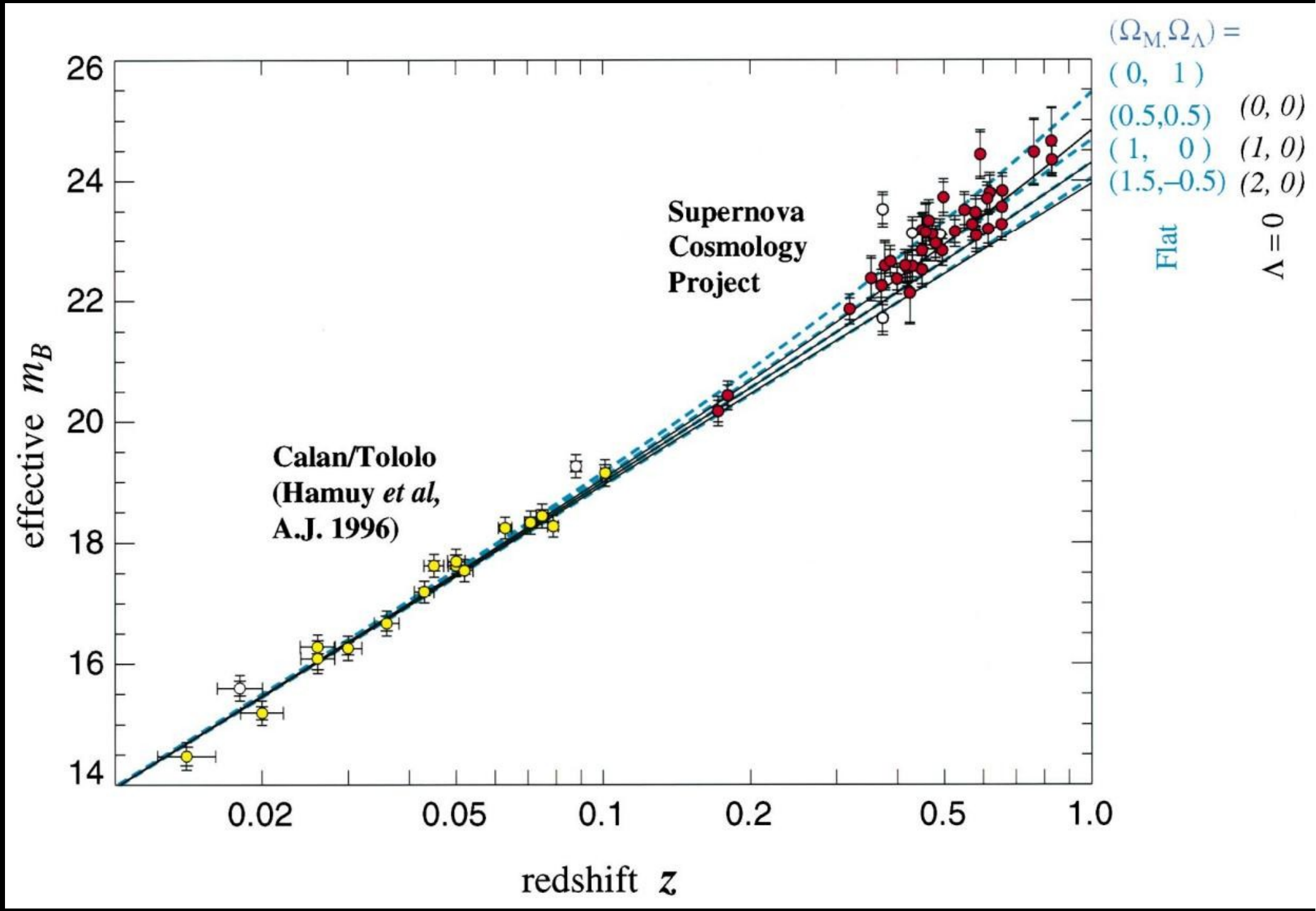
$$v = H_0 \; d$$

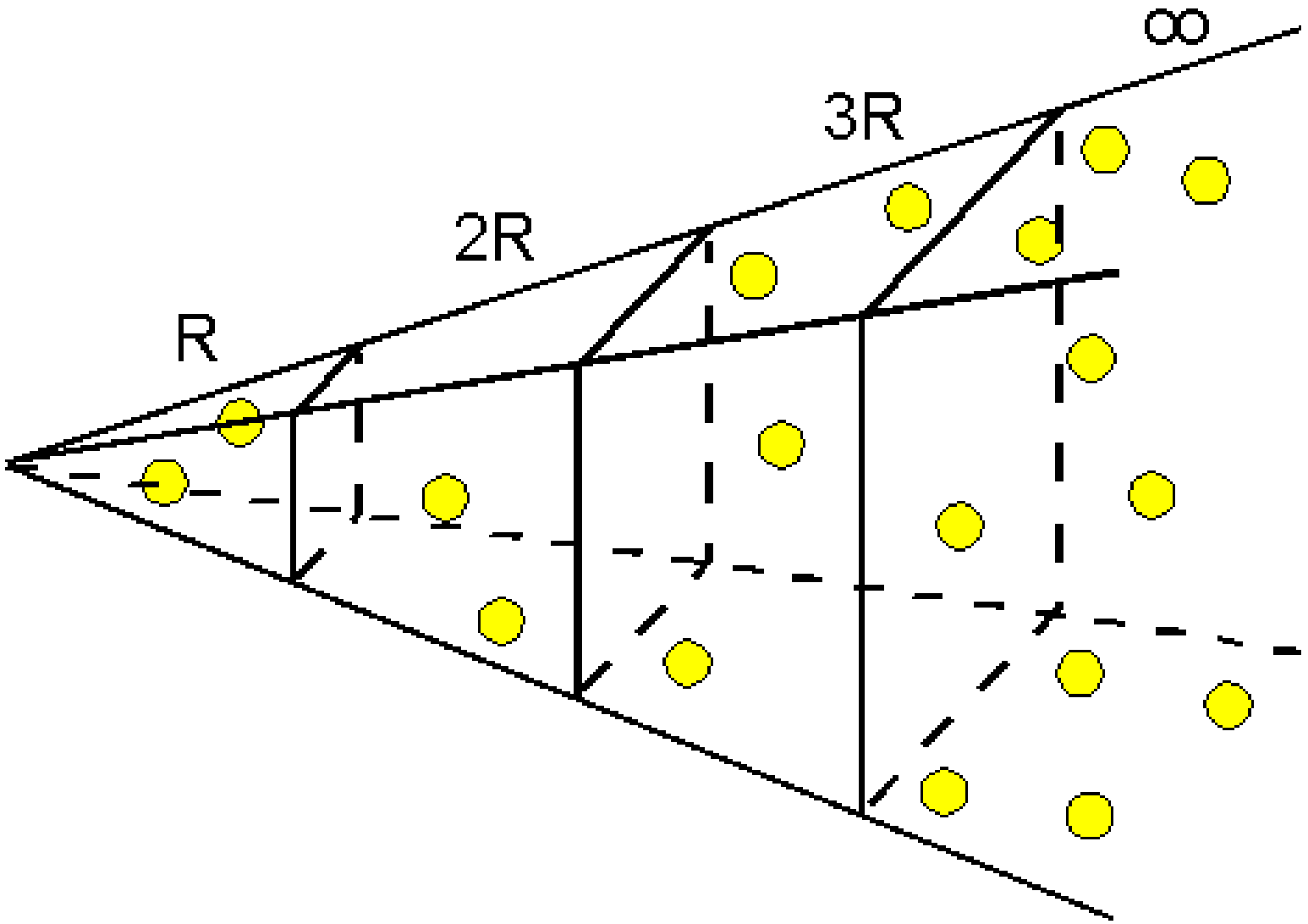
$$H_0 \sim 72 \; km/s \; / Mpc$$

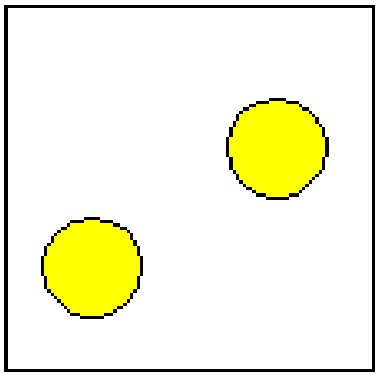


SN Ia as standard candles

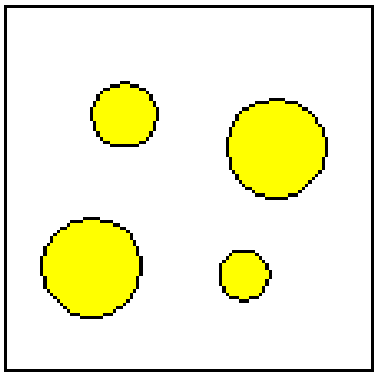



$(\Omega_M, \Omega_\Lambda)$ =
(0, 1)
(0.5,0.5) (0, 0)
(1, 0) (1, 0)
(1.5,–0.5) (2, 0)
Flat
$\Lambda = 0$
Supernova
Cosmology
Project
Calan/Tololo
(Hamuy *et al*,
A.J. 1996)
effective m_B
redshift z
26
24
22
20
18
16
14
0.02
0.05
0.1
0.2
0.5
1.0

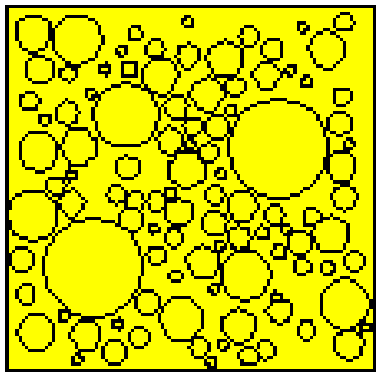




R



2R



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