
SIZE AND SCALE
OF THE
UNIVERSE

# WHAT IS YOUR COSMIC ADDRESS?

| | |
|---|---|
| # Street | Planet |
| City | Orbit |
| State | Star? |
| Country | …? |
| Continent | … |
| Hemisphere | … |
| | … |
| | … |

# REALMS OF THE UNIVERSE

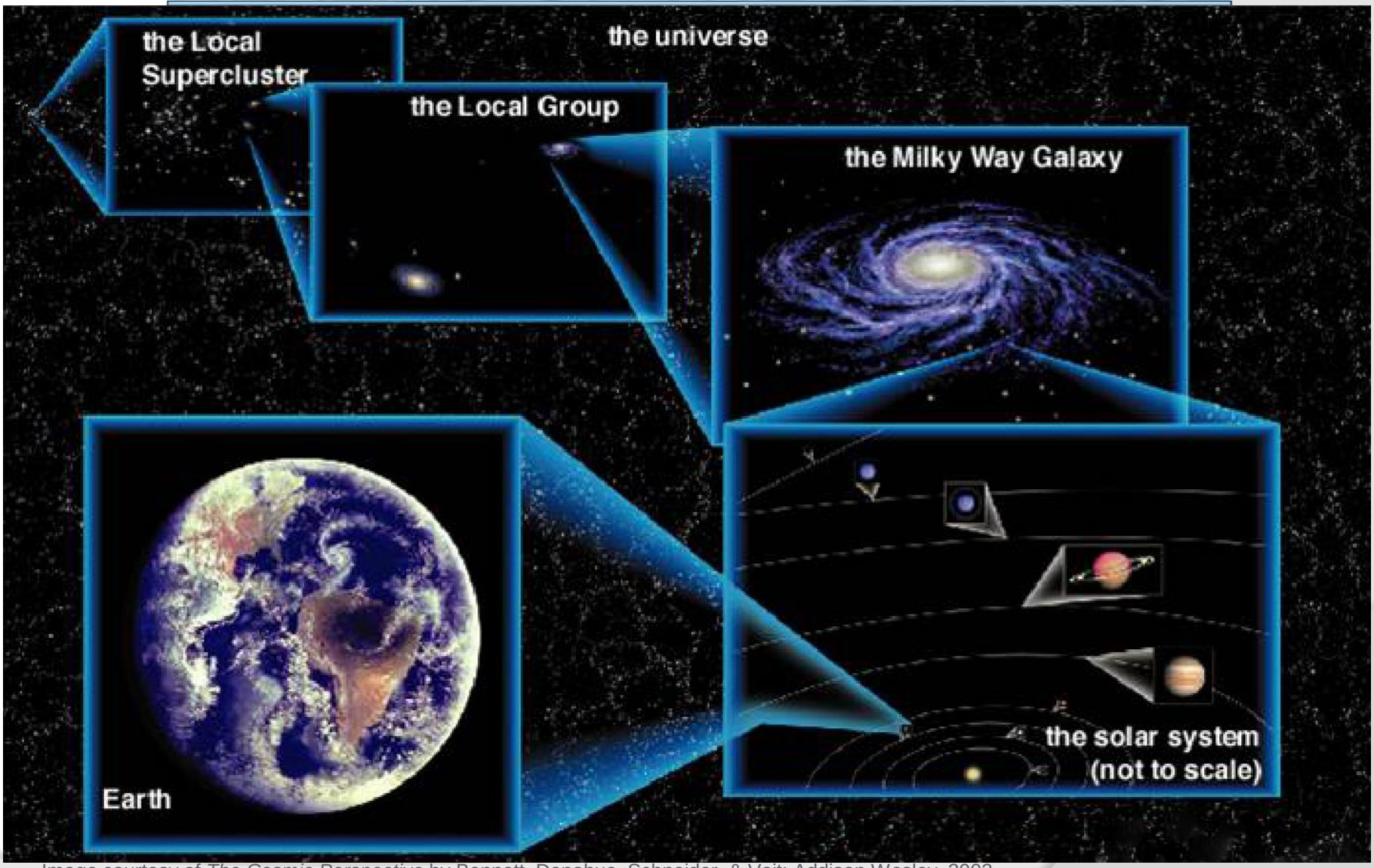



Image courtesy of *The Cosmic Perspective* by Bennett, Donahue, Schneider, & Voit; Addison Wesley, 2002

# Speed of Light

The speed of light in a vacuum, c, is a physical constant.

- meters per second: **299,792,458** m/s (exact)
- kilometers per second: 300,000 km/s (rounded)
- miles per second: 186,000 mi/s (rounded)
- miles per hour: 671,000,000 mph (rounded)

https://www.youtube.com/watch?v=uCIWL7xILos

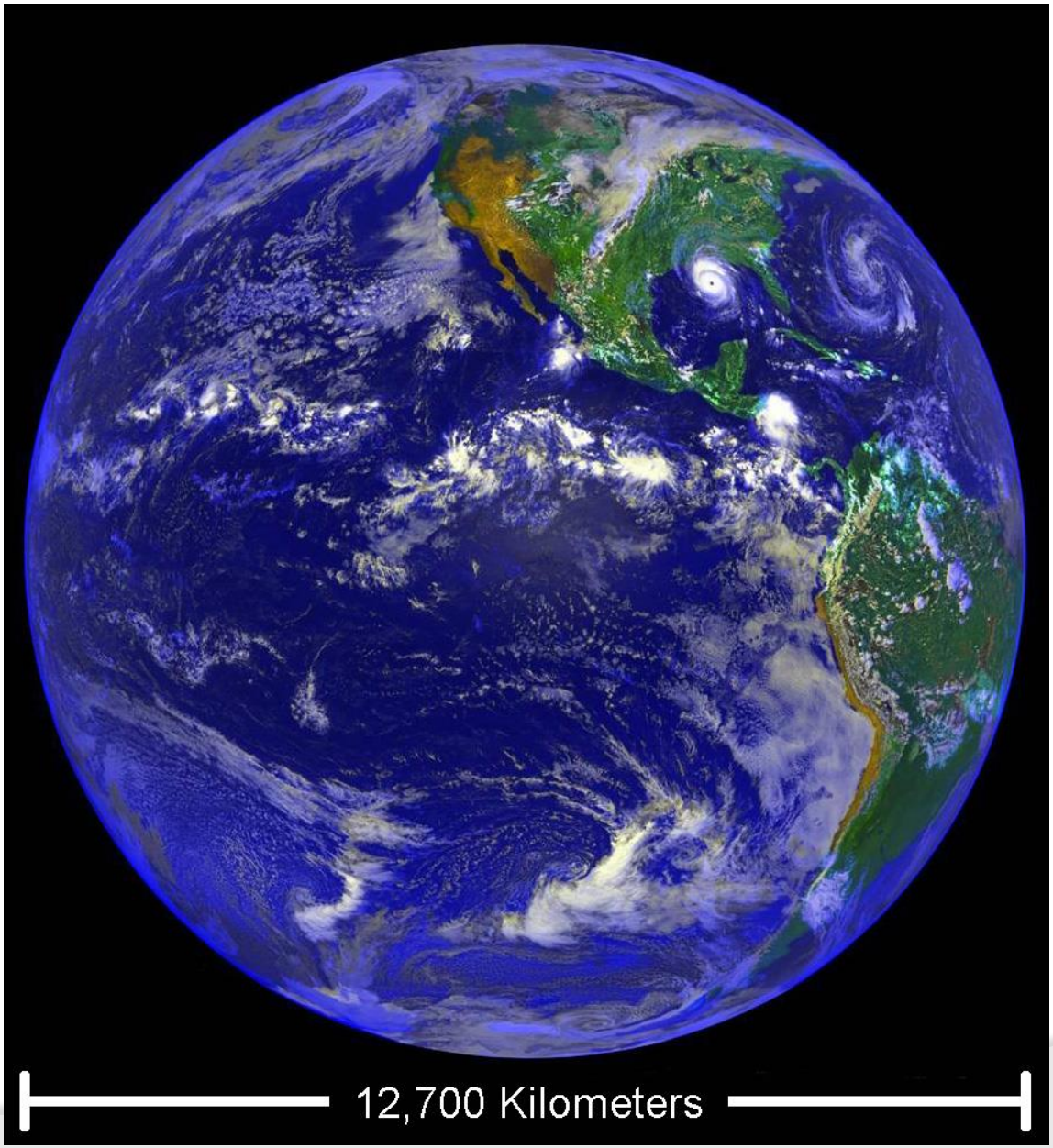



Image Credit: NASA/JPL/GSFC

# EARTH

- Planet where we all live
- Spherical in shape
- 12,700 km in diameter
- It would take 17 days to circumnavigate the globe driving a car at 100 km/hr (62 mph)
- At the speed of light, it would take 0.13 seconds to go all the way around Earth

# SUN

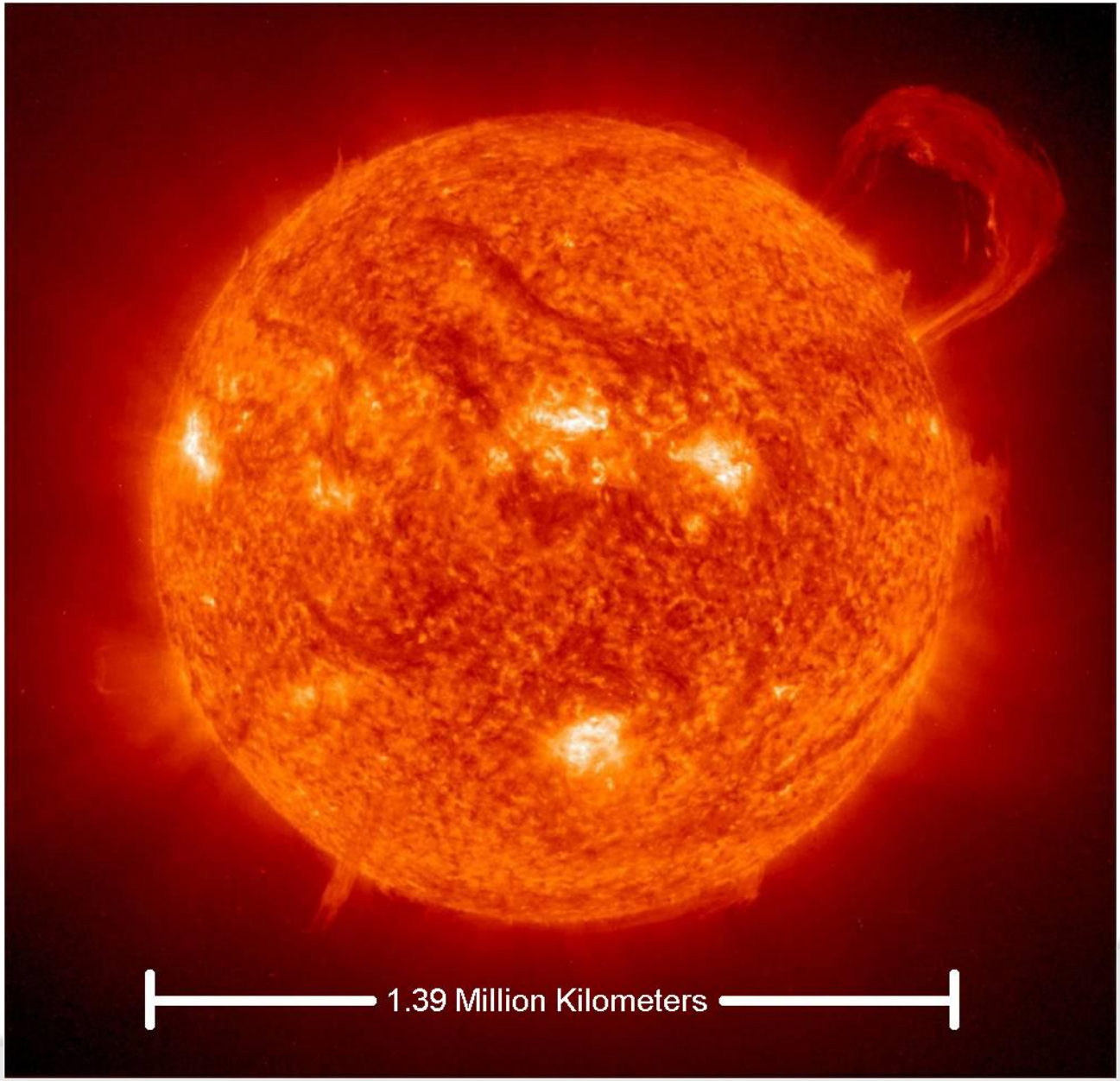



Image Credit: SOHO/NASA/ESA

- The star that Earth orbits
- Composed primarily of hydrogen and helium gas
- Uses nuclear fusion in its core to generate heat and light to allow itself to resist the crushing weight of its own mass
- Spherical in shape
- 1.39 Million km in diameter

# SUN & EARTH

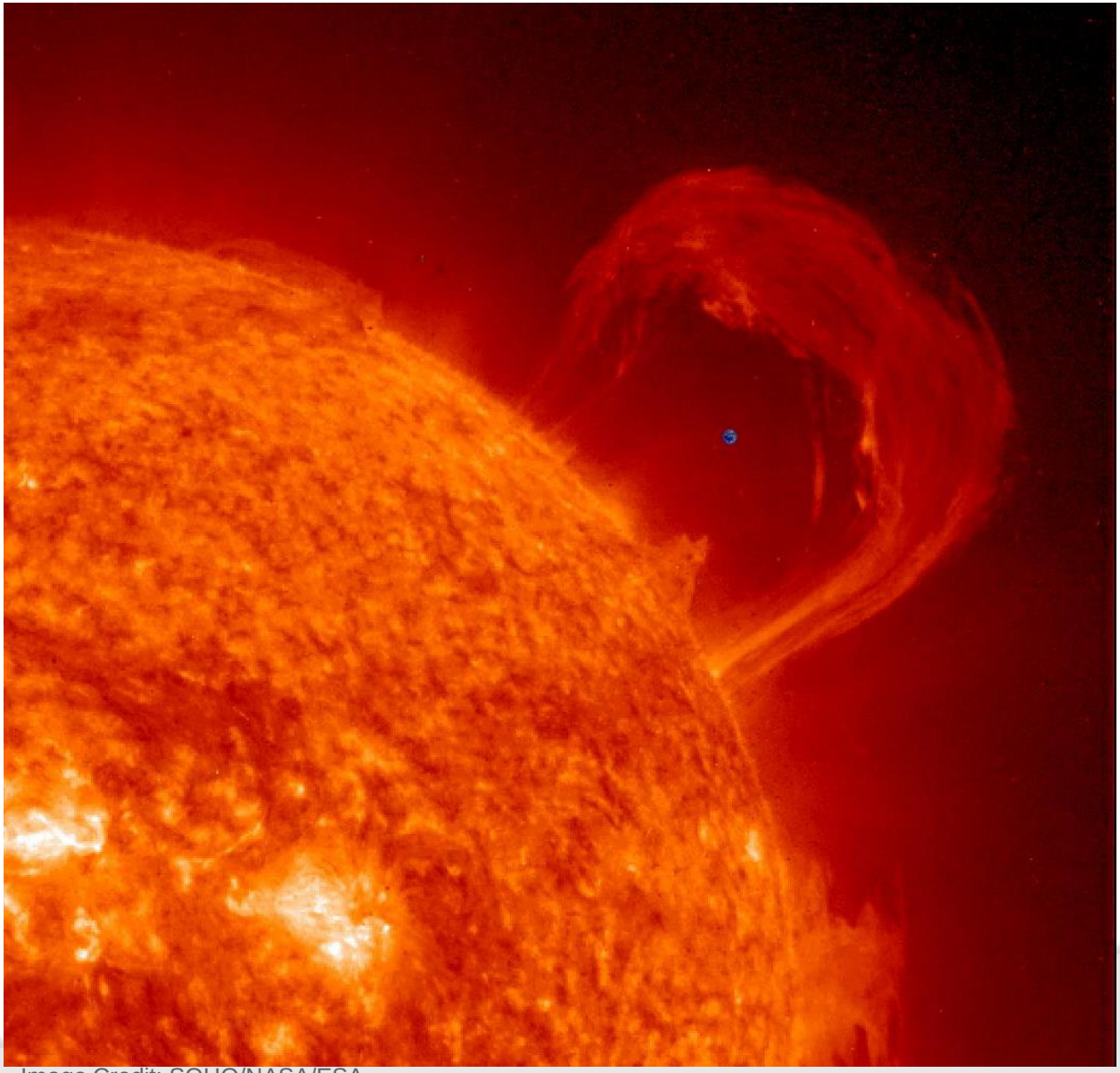


Image Credit: SOHO/NASA/ESA

- The Sun's diameter is 109 times greater than that of Earth
- Over 1 million Earths would fit inside the Sun's volume
- The average distance between the Earth and the Sun is called an Astronomical Unit (AU) - it is about150 million kilometers
- It would take 11,780 Earths lined up side to side to bridge the gap between Earth and Sun (or 107 Suns)

# THE SOLAR SYSTEM

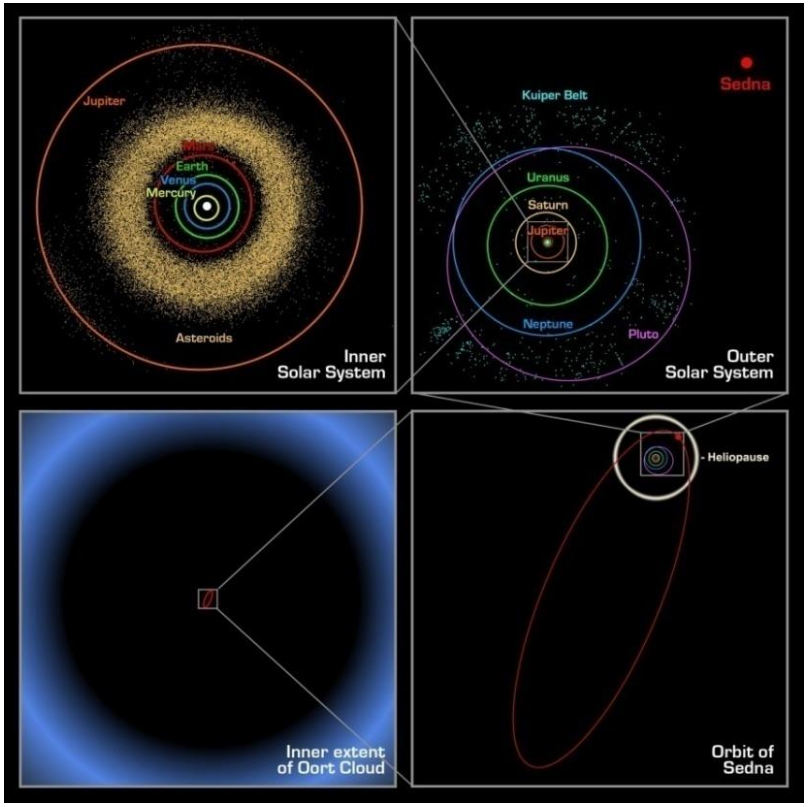


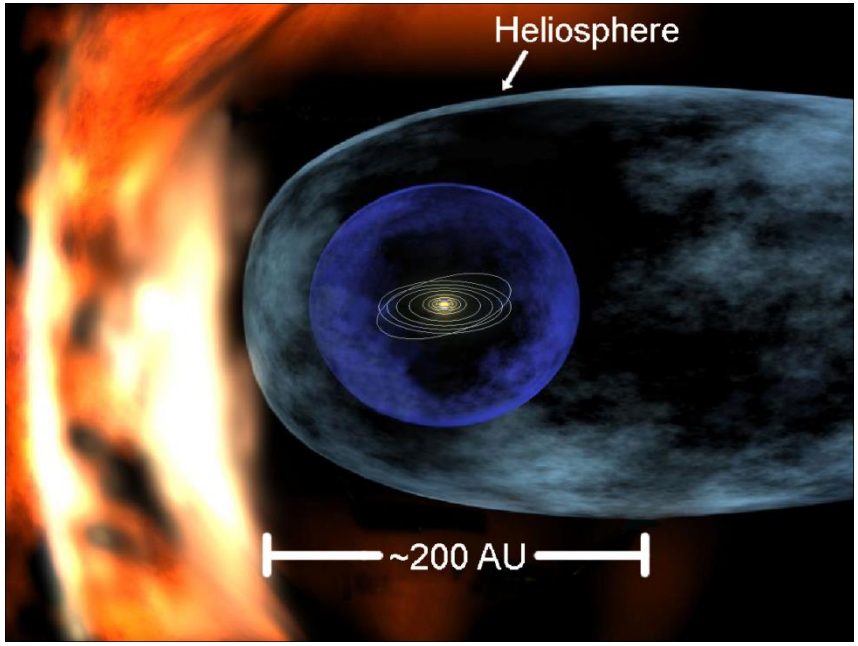

Image credit: NASA/JPL-Caltech/R. Hurt

Image credit: NASA

- The Sun blows a constant wind of charged gas into interstellar space, called the Solar Wind
- The boundary between the Solar Wind and interstellar space (the ***Heliosphere***) is around 100 AU from the Sun (200 AU diameter)

Image credit: NASA

# THE SOLAR SYSTEM



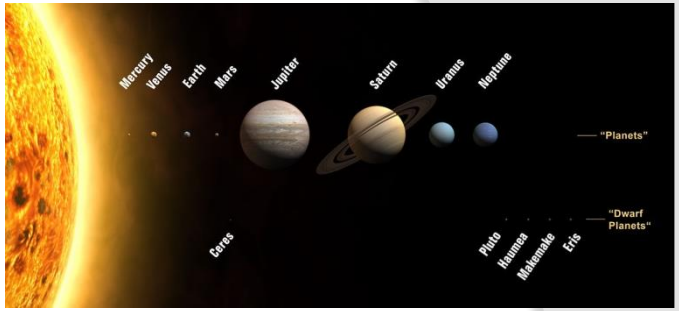




Image credit: NASA

- 8 planets, several dwarf planets, thousands of asteroids, and trillions of comets and meteoroids
- Mostly distributed in a flat disk
- Pluto orbits ~40 AU from Sun

Image credit: NASA

# THE SOLAR NEIGHBORHOOD

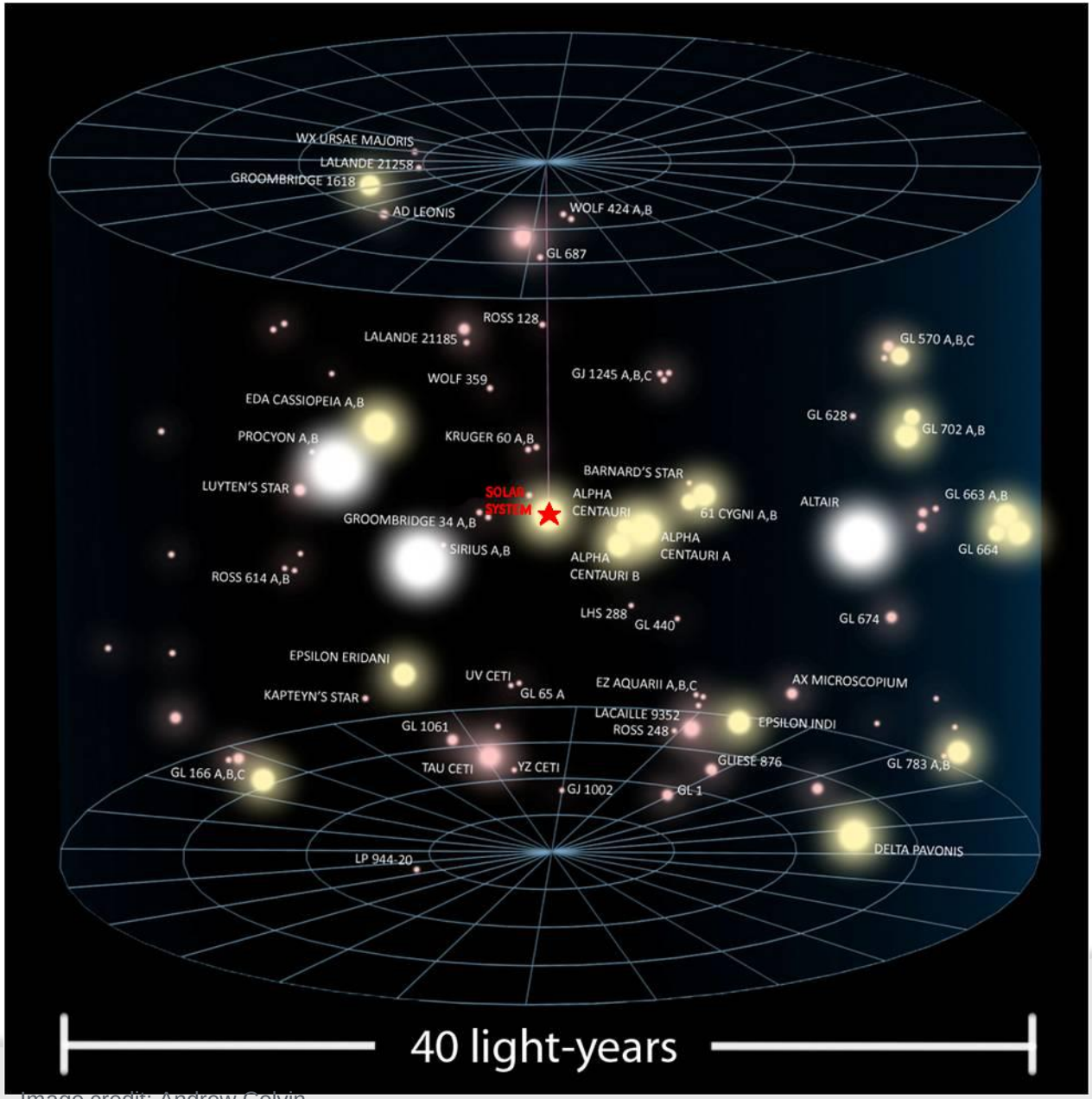



Image credit: Andrew Colvin

- The region of the Galaxy within about 20 light-years of the Sun (40 light-years diameter)
- A light-year is the ***distance*** that light travels in one year (~10 trillion kilometers or 63,000 AU)

*Note: the size of the stars in this image represents their brightness, they would actually all be specks at this distance*

# THE SOLAR NEIGHBORHOOD

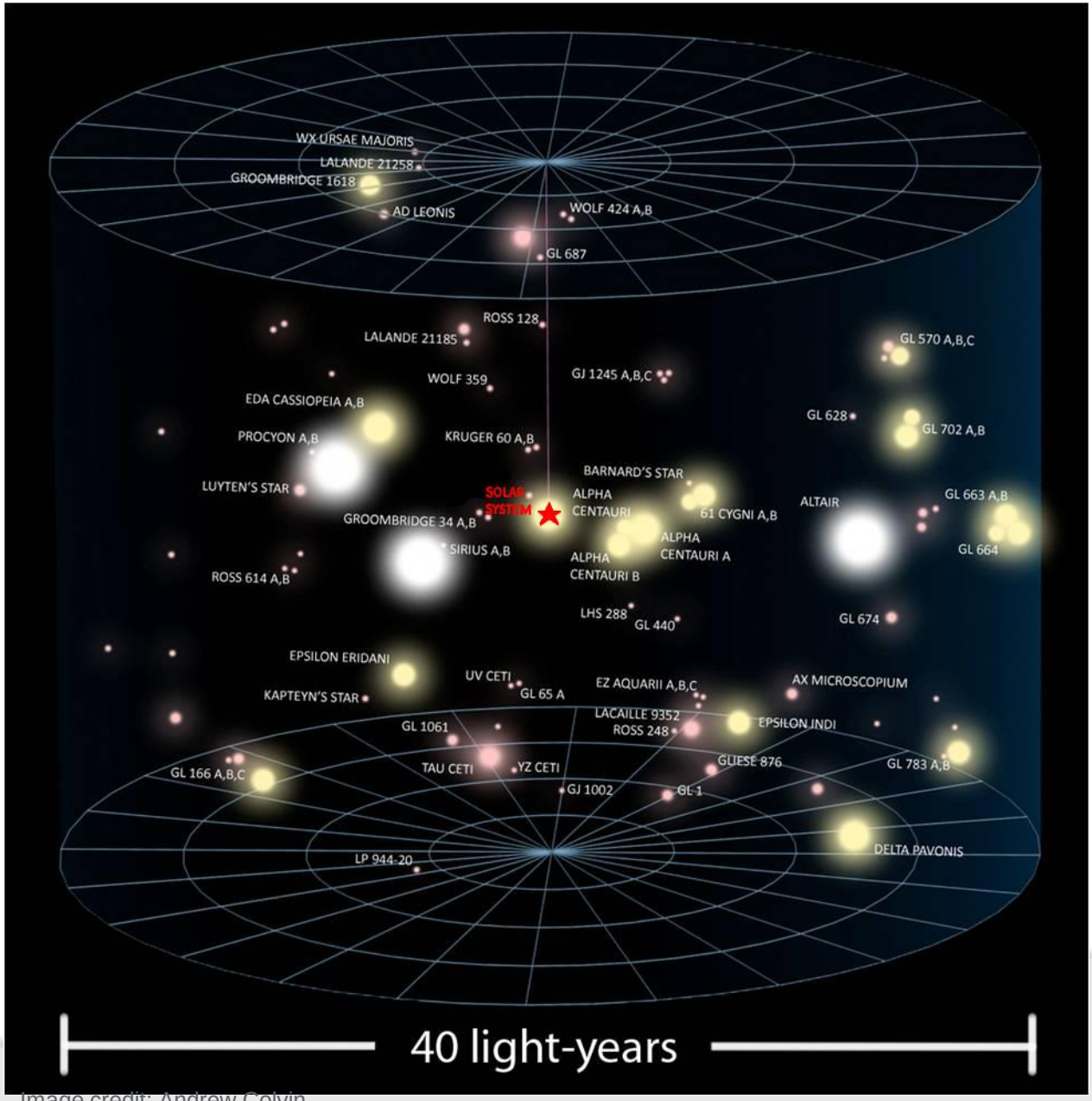



Image credit: Andrew Colvin

- The neighborhood stars generally move with the Sun in its orbit around the center of the Galaxy
- The 'Solar Neighborhood' is a vague term not scientifically defined

*Note: the size of the stars in this image represents their brightness, they would actually all be specks at this distance*

# THE MILKY WAY GALAXY

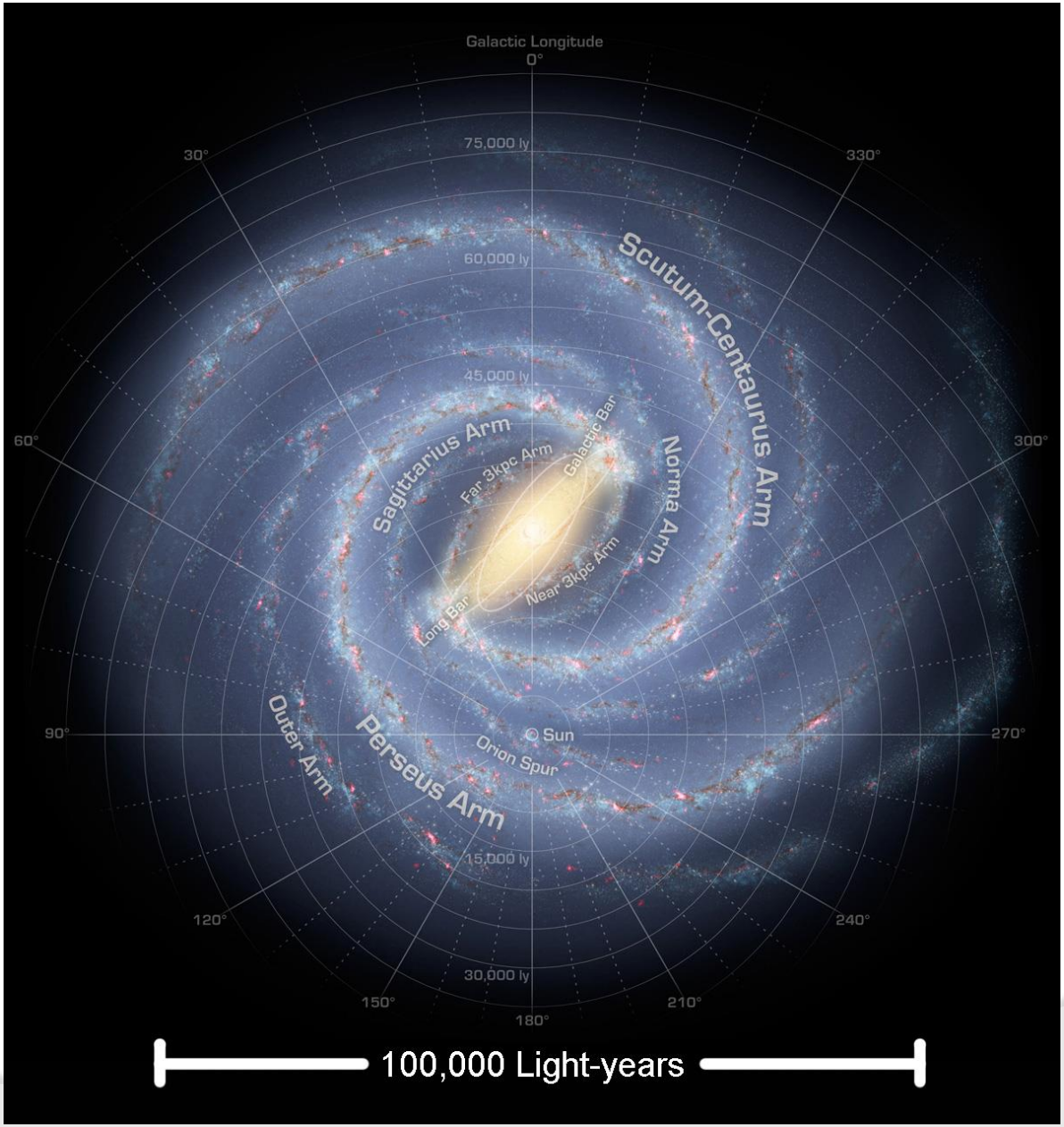



Image credit: R. Hurt (SSC), JPL-Caltech, NASA

- The Milky Way Galaxy is a giant disk of stars 100,000 light-years across and 1,000 light-years thick
- The Sun is located at the edge of a spiral arm, 30,000 light-years from the center

# THE MILKY WAY GALAXY

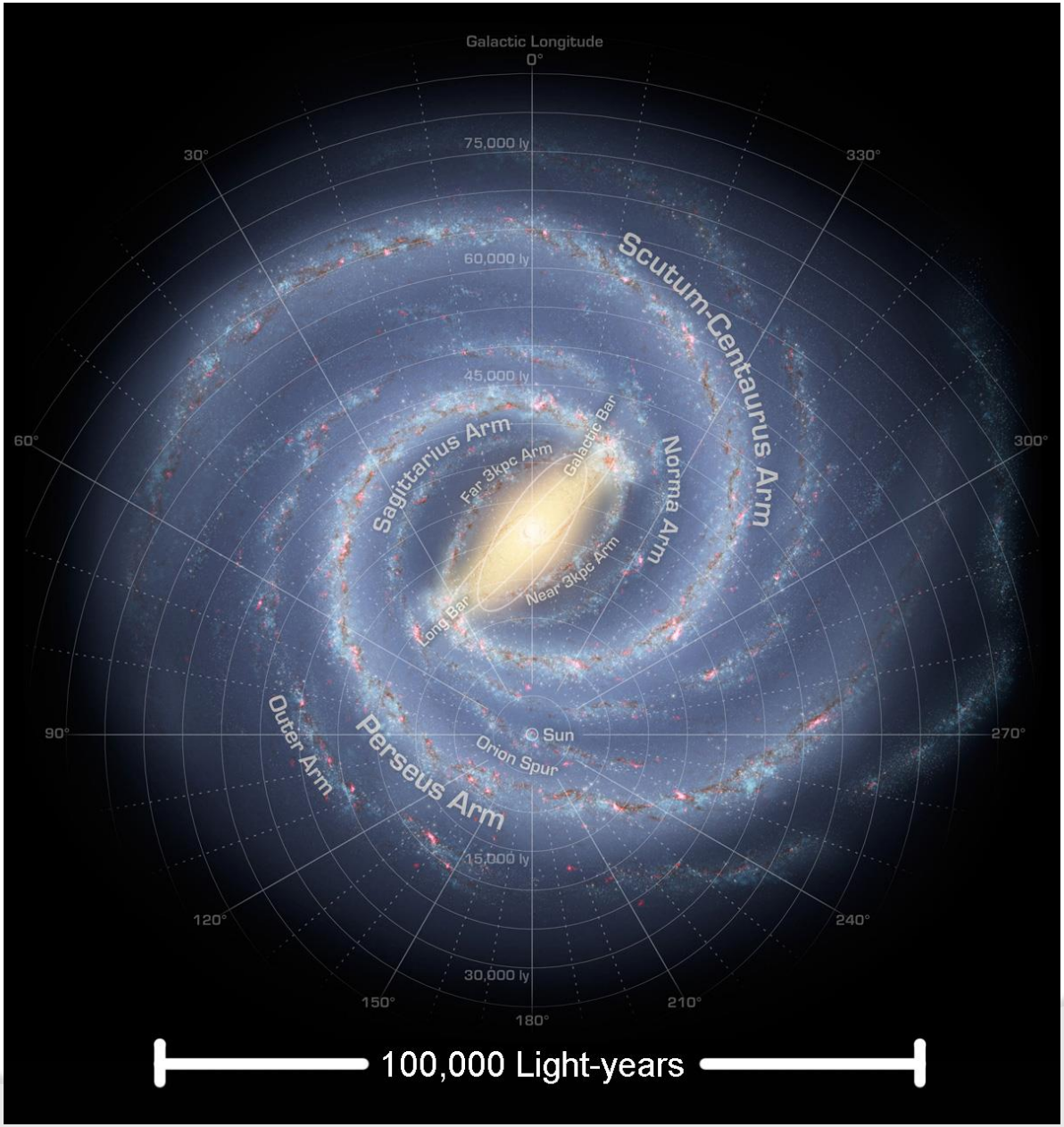



Image credit: R. Hurt (SSC), JPL-Caltech, NASA

- It takes about 250 million years for the Sun to complete one orbit
- There are over 200 billion stars in the Milky Way

# 200 BILLION Stars!!!

# Fill with bird seed
# 4 feet deep on a football field

# Milky Way Video

- https://www.youtube.com/watch?v=KsRQHIt3BkI

# THE LOCAL GROUP

## (OF GALAXIES)

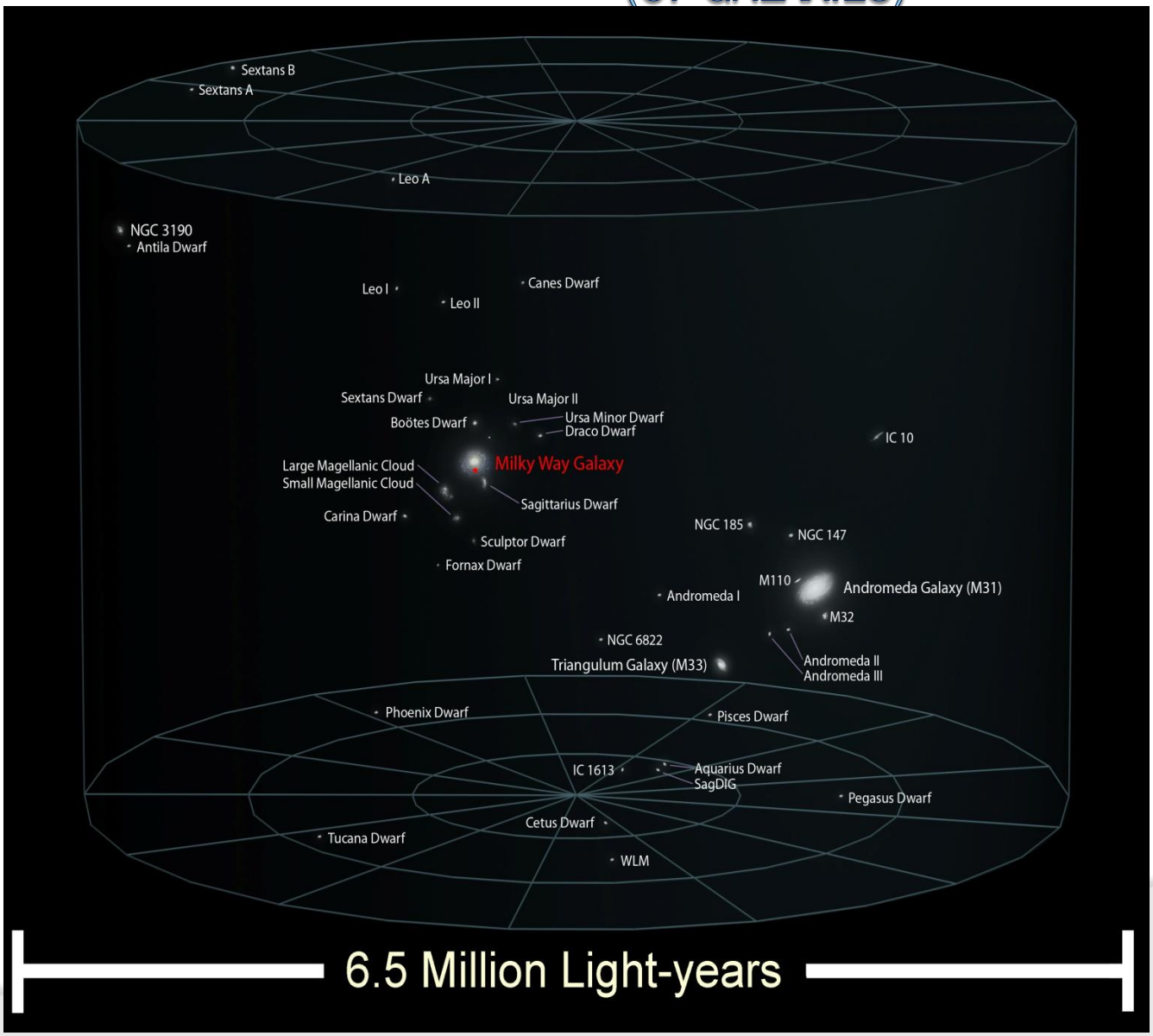
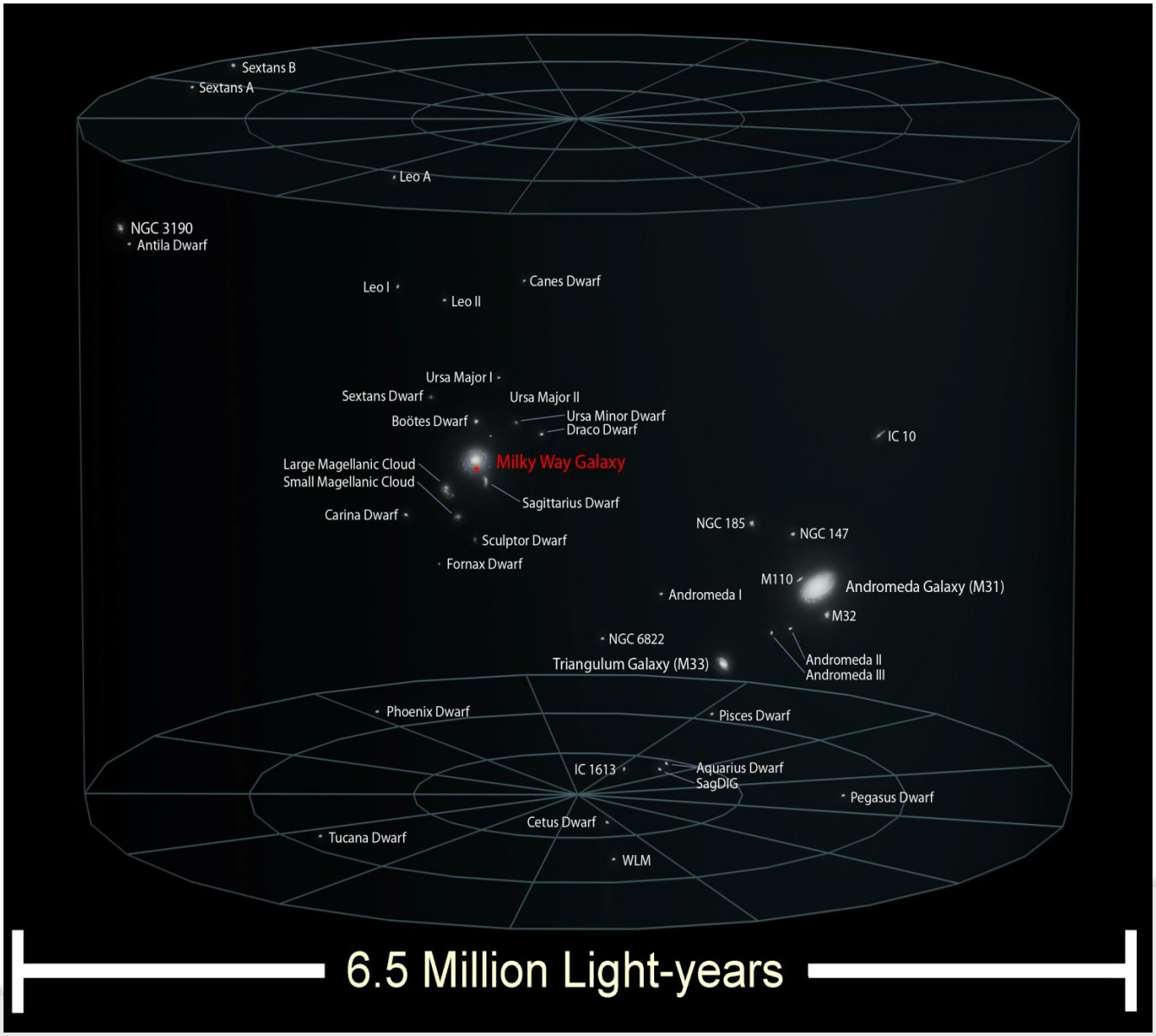



Image Credit: Andrew Colvin

- About 6.5 million light-years in diameter
- Contains 3 large spiral galaxies -- Milky Way, Andromeda (M31), and Triangulum (M33) -- plus a few dozen dwarf galaxies with elliptical or irregular shapes

# THE LOCAL GROUP
## (OF GALAXIES)




- Gravitationally bound together—orbiting about a common center of mass
- Roughly shaped like a football

Image Credit: Andrew Colvin

# THE LOCAL SUPERCLUSTER

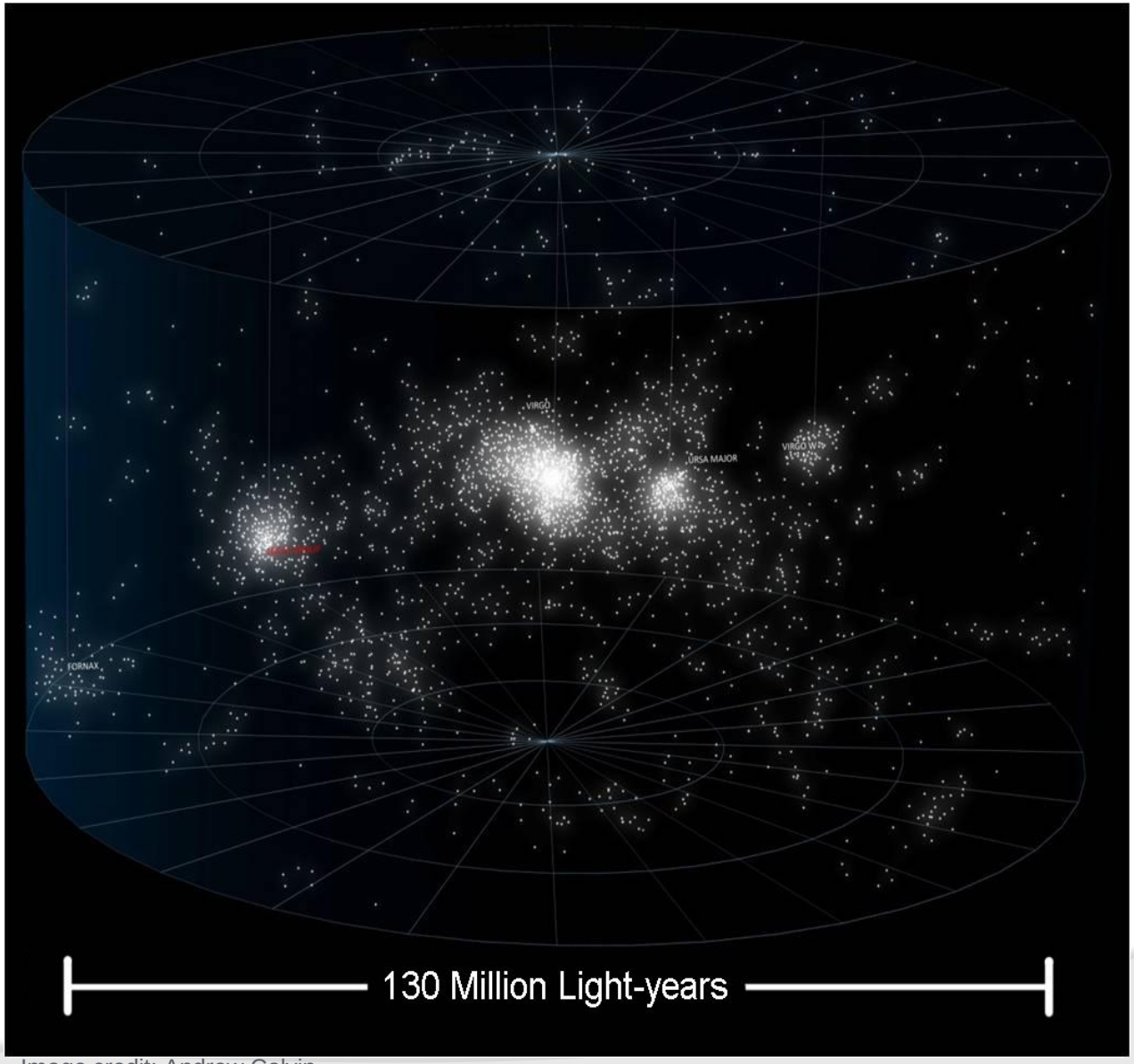



Image credit: Andrew Colvin

- The Local Supercluster is about 130 million light-years across
- It's a huge cluster of thousands upon thousands of galaxies
- Largest cluster is the Virgo cluster containing well over a thousand galaxies

# THE LOCAL SUPERCLUSTER

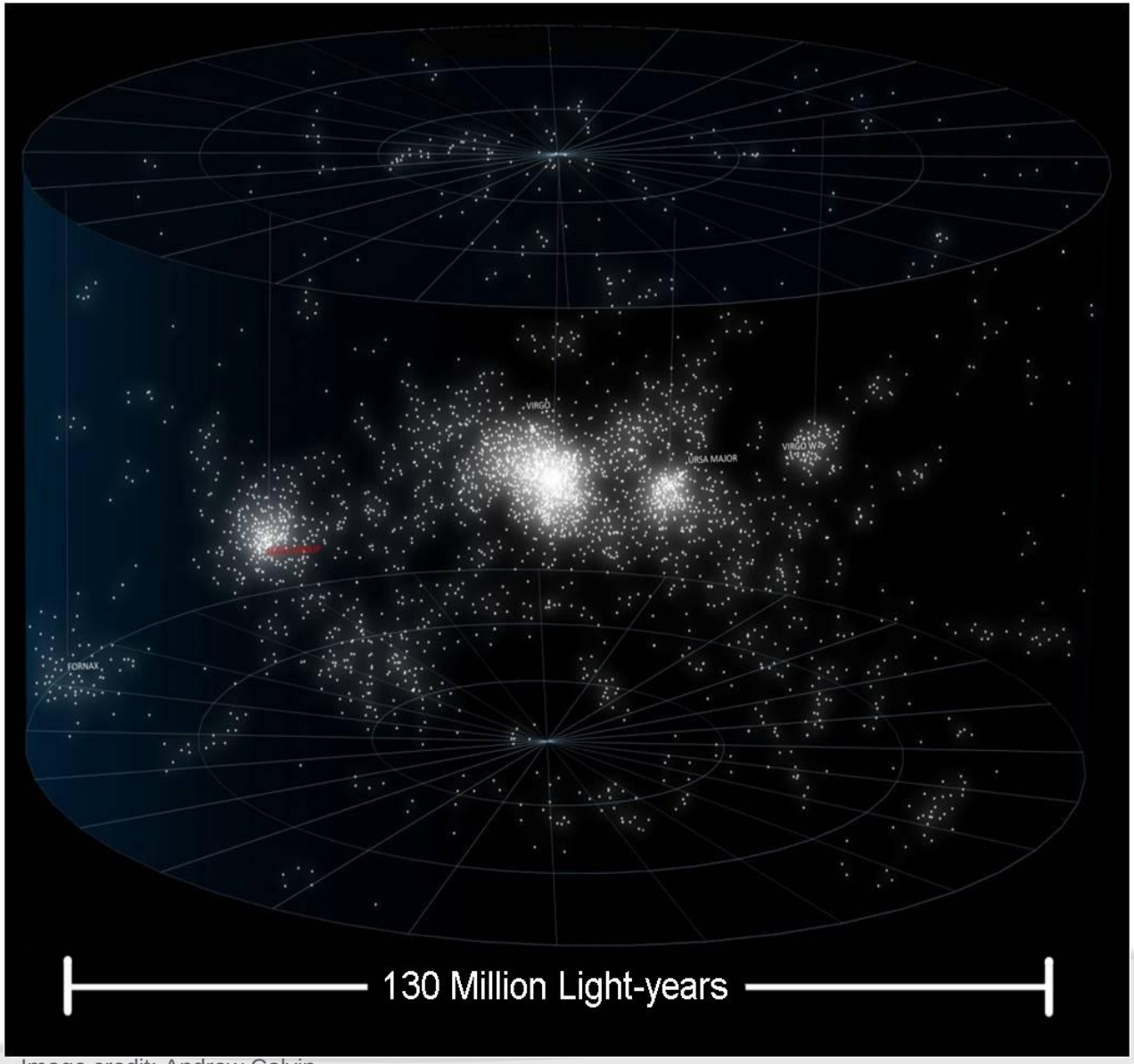



Image credit: Andrew Colvin

- Clusters and groups of galaxies are gravitationally bound together, however the clusters and groups spread away from each other as the Universe expands
- Roughly pancake shaped

# THE UNIVERSE
## (THE OBSERVABLE PORTION)

- Great walls and filaments of galaxy clusters surrounding voids containing no galaxies
- Probably at least 100 billion galaxies in the Universe
- Surveys of galaxies reveal a web-like or honeycomb structure to the Universe

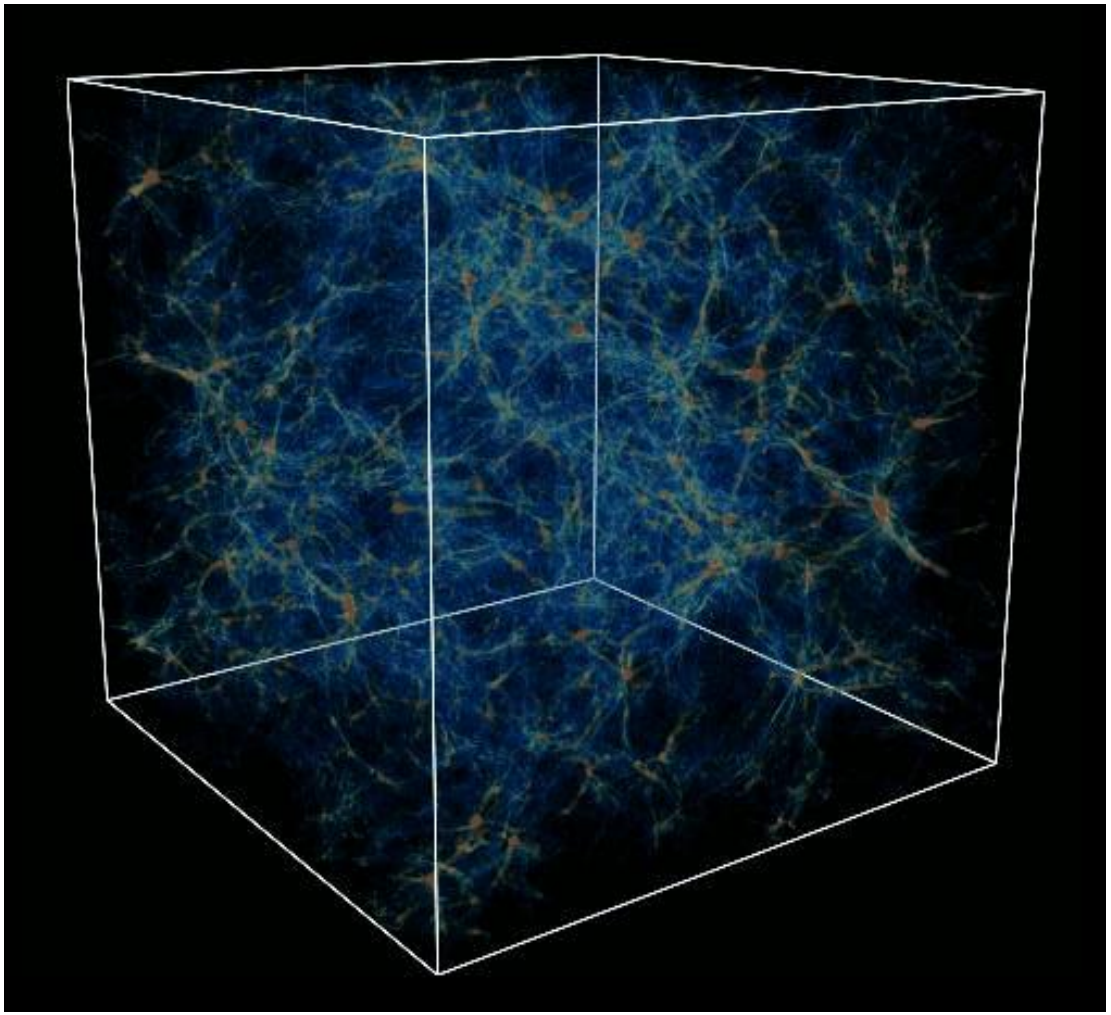


Image Credit: G.L. Bryan, M. L. Norman, UIUC, NCSA, GC3

- Computer simulations also show a similar structure, often called the “Cosmic Web”

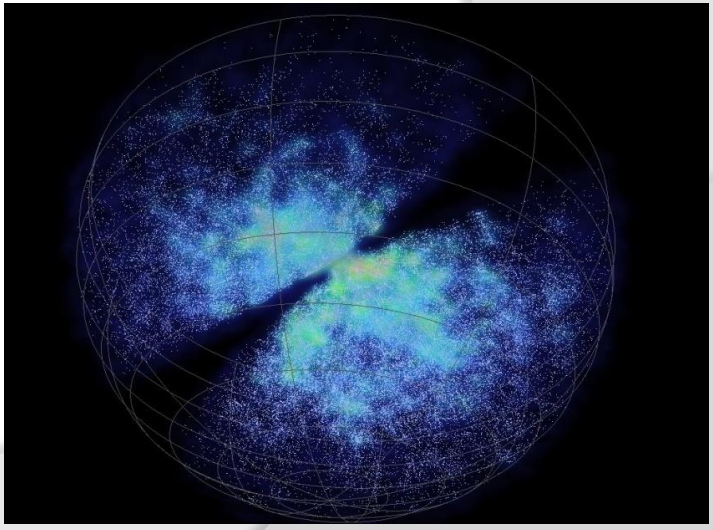


Image Credit: Dr Chris Fluke, Centre for Astrophysics and Supercomputing, Swinburne University of Technology

# THE UNIVERSE
## (THE OBSERVABLE PORTION)

- The Observable Universe is currently about **91 billion light-years** across
- There could be (and likely is) much more beyond that, but we cannot see it from this point in spacetime
- *Note: The matter that we can see glowing shortly after the Big Bang (detected by the light it emitted 13.7 billion years ago) is now about 46 billion light-years away due to the ongoing expansion of the fabric of the Universe*

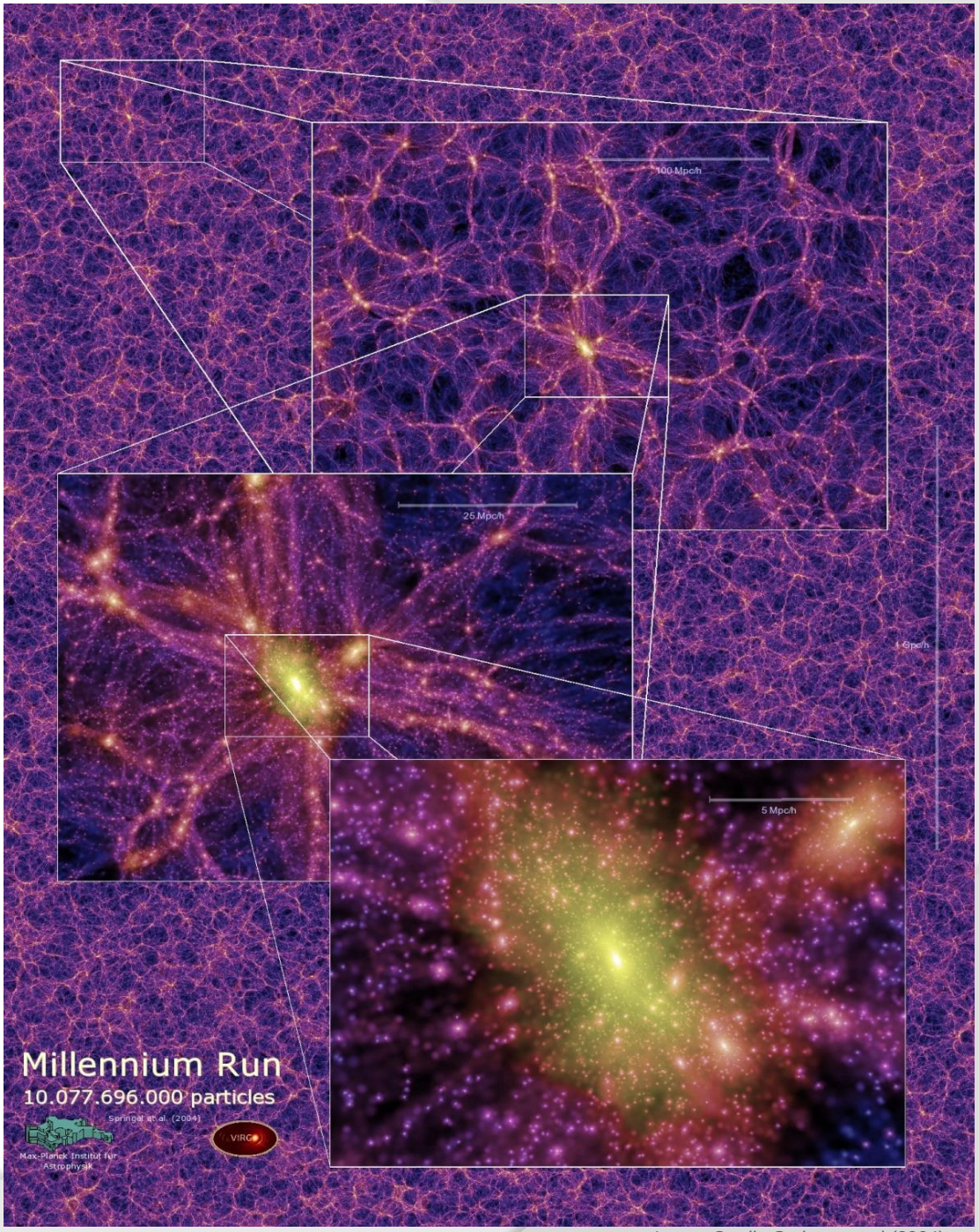
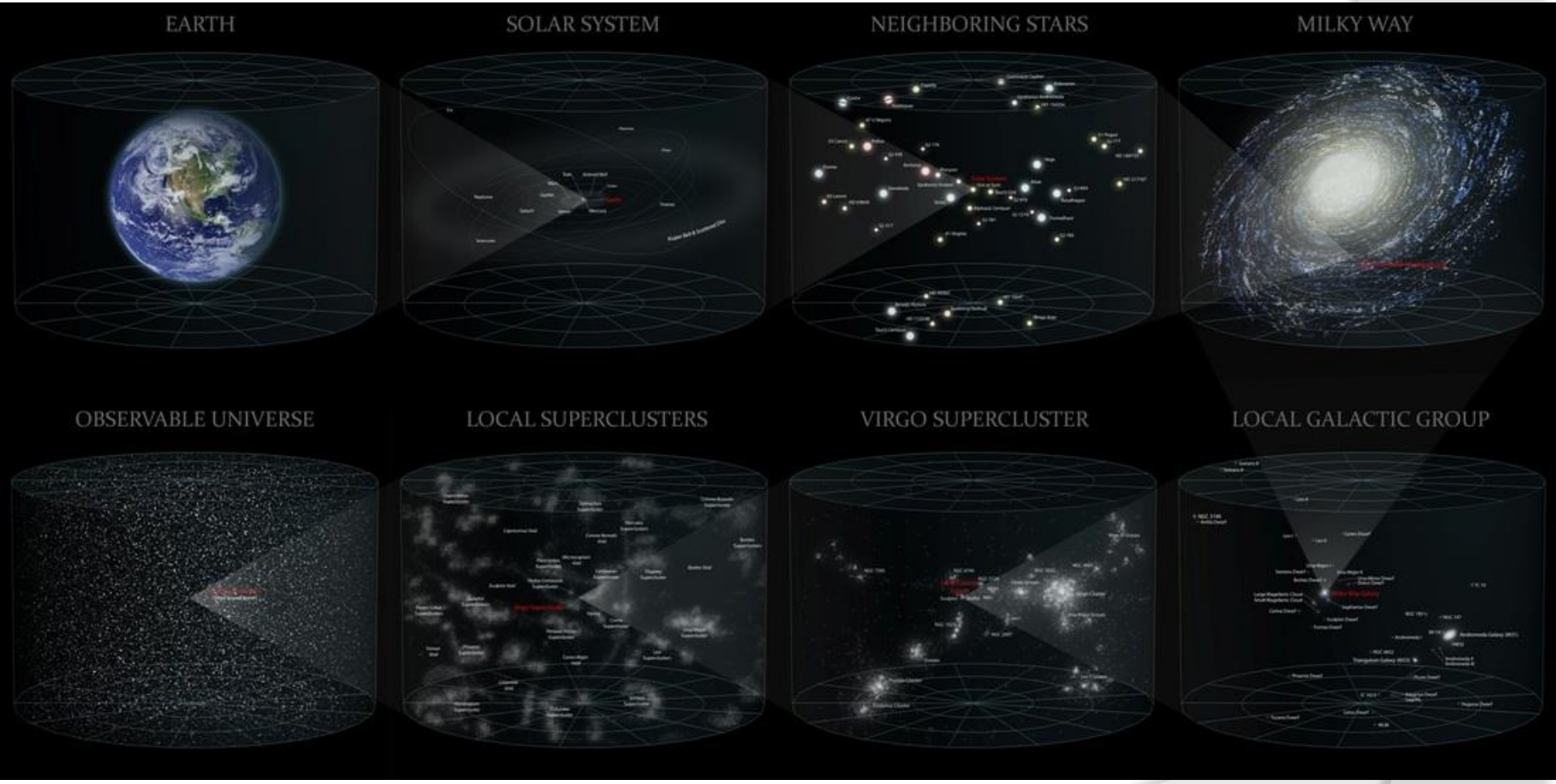



Image Credit: Springer et al (2004)




https://www.youtube.com/watch?v=8Are9dDbW24

# Size and Scale of the Universe

| Realm | Actual Size (diameter in km) | Actual Size (in light-years) | Multiple "X" larger than Earth | Scale Model |
|---|---|---|---|---|
| **Earth** | 12,700 (1.27E+4) | 1.4 billionths (1.4E-9) | 1 | **salt grain** (0.1 mm) |
| **Sun** | 1.39 million (1.39E+6) | 1.5 ten-millionths (1.5E-7) | 109 (1.09E+2) | **gum ball** (1.09 cm) |
| **Solar System** | 30 billion (3.0E+10) | 0.0032 (3.2E-3) | 2.34 million (2.34E+6) | **football stadium** (234 meters) |
| **Solar Neighborhood** | 378 trillion (3.78E+14) | 40 (4.0E+1) | 30 billion (3.0E+10) | **~ size of Moon** (3,480 km) |
| **Galaxy** | 946 quadrillion (9.46E+17) | 100,000 (1.0E+5) | 75 trillion (7.5E+13) | **5.4 Suns** (7.5 million km) |
| **Local Group (of galaxies)** | 62 quintillion (6.15E+19) | 6.5 million (6.5E+6) | 4.8 quadrillion (4.8E+15) | **orbit of Mars** -diameter (~3 AU) |
| **Local Supercluster** | 1.2 sextillion (1.2E+21) | 130 million (1.3E+8) | 97 quadrillion (9.7E+16) | **orbit of Neptune** -diameter (~60 AU) |
| **Universe** | 860.9 sextillion (8.6E+23) | 91 billion (9.1E+10) | 68 quintillion (6.8E+19) | **Oort Cloud**-radius (48,000 AU or 0.76 ly) |

# SO HOW DO WE KNOW THESE DISTANCES?...

https://www.youtube.com/watch?v=CWMh61yutjU