

The Cosmic Landscape - What's in the Universe?

Cosmic scales

Powers of Ten

$$10^0 = 1$$

- $10^1 = 10$

$$10^2 = 100$$

$$10^3 = 1000$$

$$10^{-1} = 0.1$$

- $10^{-2} = 0.01$

$$10^{-3} = 0.001$$

Common prefixes:

- kilo - 10^3
- mega - 10^6
- centi - 10^{-2}
- milli - 10^{-3}
- micro - 10^{-6}
- nano - 10^{-9}

Units of length:

- nanometer 1/1,000,000,000 of a meter
- micrometer 1/1,000,000
- millimeter 1/1000 of a meter
- centimeter 1/100 of a meter
- meter
- kilometer 1000 meters
- AU (astronomical unit): 93 million miles, 150 million kilometers
- Light Year (ly): $(3 \times 10^8 \text{ m/s})(3.16 \times 10^7 \text{ s}) = 9.5 \times 10^{15} \text{ m}$
- Parsec - the distance at which 1 AU subtends an angle of 1 arc second (3.26 ly or $3.09 \times 10^{13} \text{ km}$).

Cosmic Structure

Elements/Atoms/Matter/Energy

- The universe is made up of matter consisting of elements, atoms, and subatomic particles.
- Atoms consist of electrons, protons and neutrons. There are smaller particles within atoms but we not consider them here.
- A hydrogen atom is less than 10^{-10} meters across and most of that is empty space (sub atomic particles are much smaller).
- Matter and energy are equivalent. In fact they are two forms of the same thing!
- It is possible to convert matter to energy and vice versa. Einstein's equation $E = mc^2$ gives a mathematical relationship between matter and energy.
- When sub atomic particles combine they form atoms. Atoms form elements. Elements combine to form molecules and compounds.

The Electromagnetic Spectrum

- Energy has many forms: mechanical energy, thermal energy, and electromagnetic energy, chemical energy, etc.
- The mechanical energy of bodies may be potential and/or kinetic. Potential energy is the energy of position. Kinetic energy is the energy of motion.
- The electromagnetic spectrum is an important source of energy in astronomy. The E/M spectrum consists of E/M waves from very small (gamma rays - 10^{-14} meters wavelength) to very large (radio waves - > 1 kilometer wavelength).

The Four Fundamental Forces - Exchange Particles - Affect

- Gravity - Graviton (Boson - but not yet verified) - Mass
- Coulomb - Photon (Boson) - Charge
- Strong Nuclear - Gluons (Boson) - Quarks
- Weak Nuclear - W^+ , W^- , Z^0 (Boson) - quarks and leptons

The Size and Scale of the Universe

10^{-15} meters - size of a proton

10^{-12} meters - size of an atomic nucleus

10^{-10} meters - size of an atom

10^{-9} meters - wavelength of light

10^{-6} meters - size of a virus

10^{-3} meters - microwaves, lower limit of resolution for human vision

10^0 meters - human scale objects

10^1 - 10^3 meters - mesoscale objects

10^5 meters - synoptic structures (weather map sized)

10^7 meters - diameter of the earth

10^9 meters - diameter of the sun

10^{11} meters - 1 AU

10^{16} meters - distance to nearby stars

10^{21} meters - diameter of Milky Way

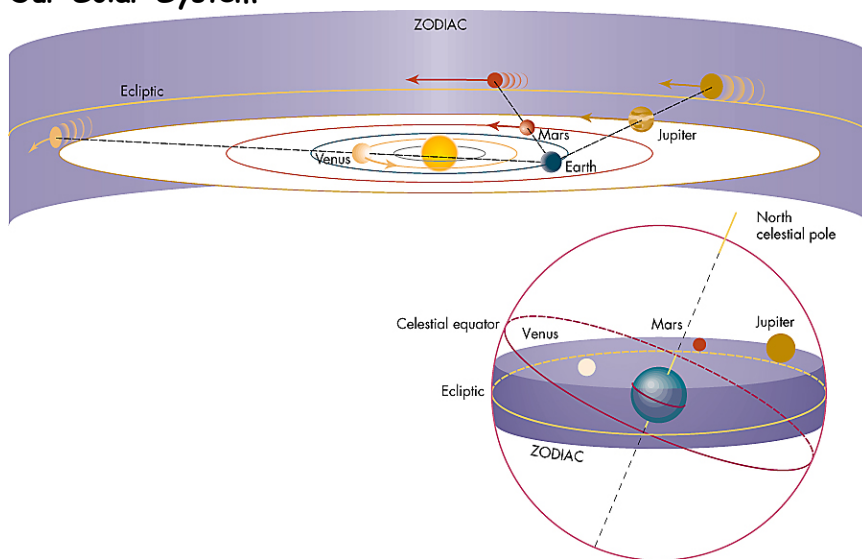
10^{24} meters - galactic clusters

10^{26} meters - size of the observable universe

Notice that the difference between the smallest and largest observable structures in our universe is 40+ orders of magnitude!

Astronomical Scales

Our Solar System



Our Galaxy

- The Milky Way. At least a hundred billion stars. About 100,000 light years across. The sun orbits the galactic core once about every 240 million years. All of the constellations and stars seen in the night sky are in the Milky Way. Mostly empty space.

Our Galactic Cluster

- The local group: about 30 galaxies, three million light years in diameter.

Our Supercluster

- The local supercluster: several dozen galaxies. One hundred million light years across.

Our Great Attractor

- A cluster of superclusters Two hundred million light years across.

The Universe

- The largest scale in astronomy.