Chapter 8

Our Place in the Universe

Objectives: When you complete this chapter, you will be able to describe the relative position of Earth in the solar system and our solar system in the galaxy; describe the approximate size of the known universe; and summarize the major issues astronomers have considered in the search for extraterrestrial intelligence.

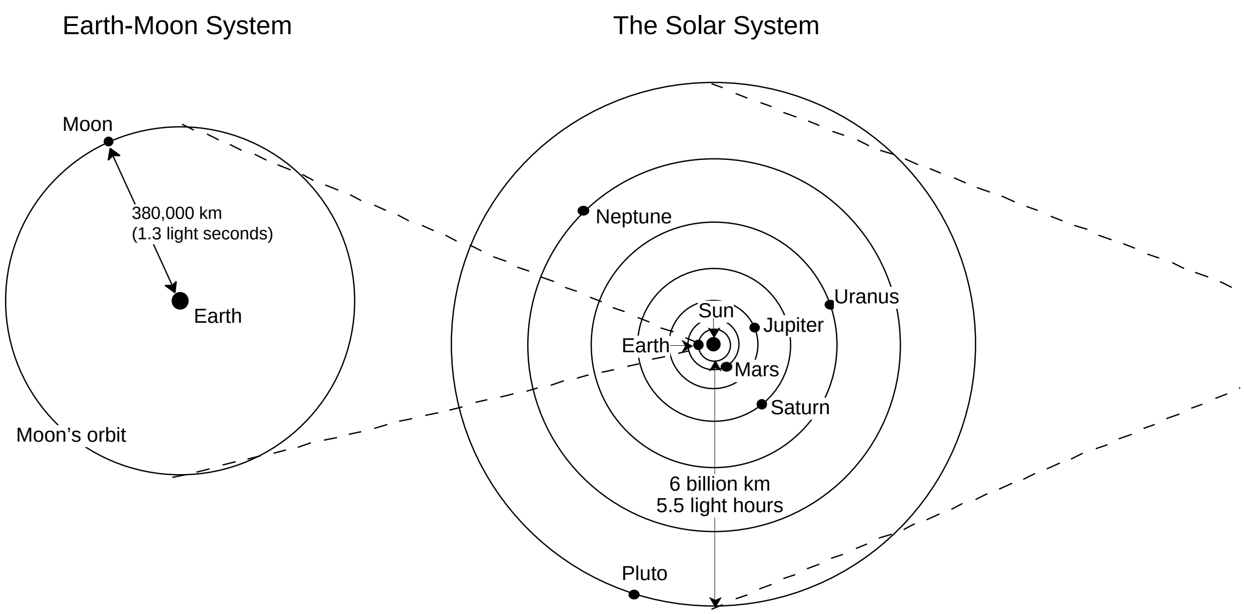
The Universe in Six Steps

The vastness of the universe is unimaginable for us humans. Perhaps the best we can do is to try to conceive a model of the universe that begins to show us our relative size and position, at least in our local neighborhood.

Gareth Wynn-Williams in *The Fullness of Space* uses the following analogy to help demonstrate some of these distances:

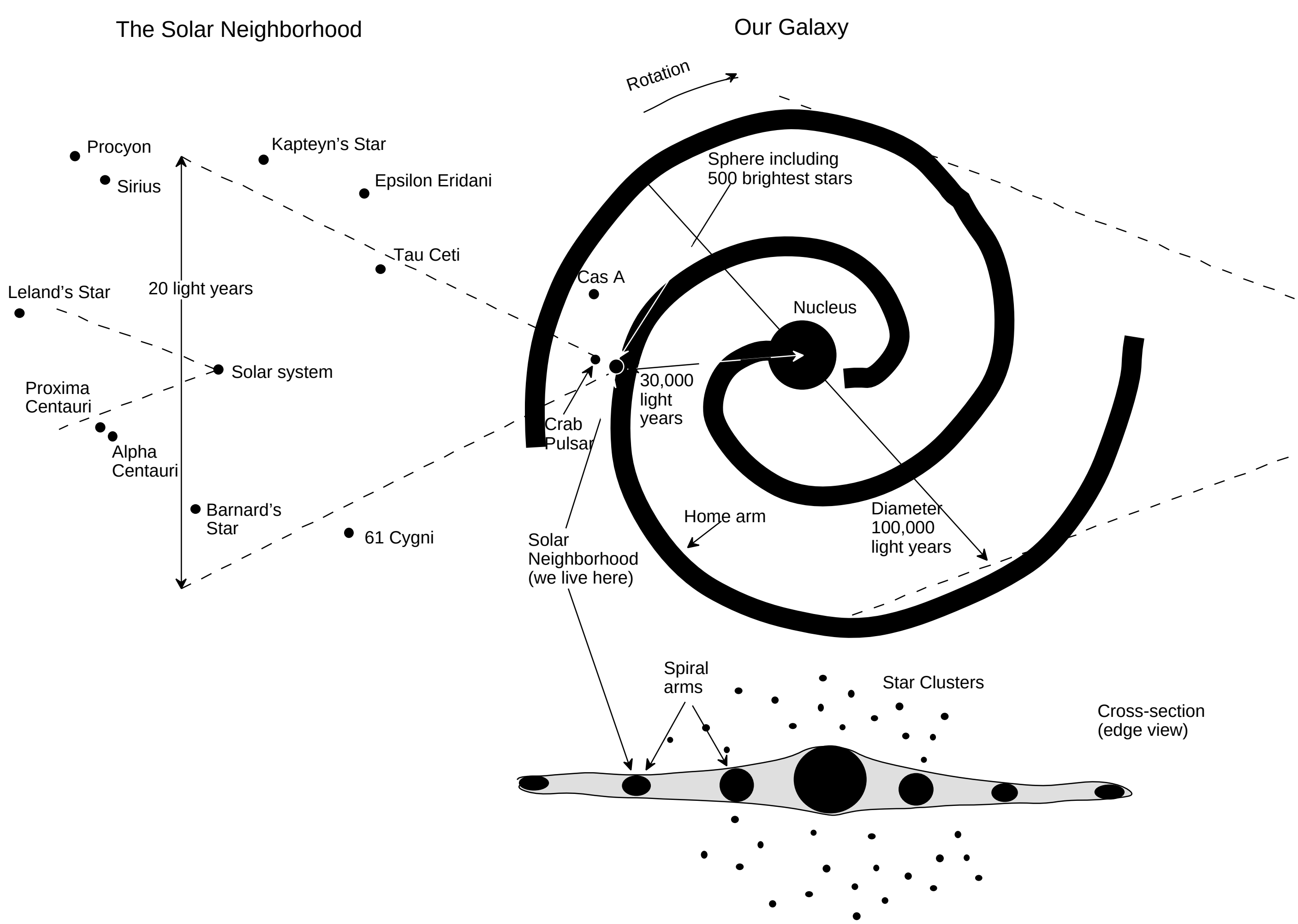
> Some idea of the vastness of the Universe may be gained by considering a model in which everything has been scaled down by a factor of a billion. In this model the Earth would have the dimensions of a grape. The Moon would resemble a grapeseed 40 cm away while the Sun would be a 1.4-meter diameter sphere at a distance of 150 meters. Neptune would be more than 4 km away. On this one-billionth scale, the nearest star would be at a distance of 40,000 km – more than the actual diameter of the Earth. One would have to travel five thousand times farther yet to reach the center of the Milky Way Galaxy, another 80 times farther to reach the next nearest spiral galaxy, and another several thousand times farther still to reach the limits of the known Universe.

To further make our point, the following drawings (from Kraus, 1986) represent the universe in six steps: (1) the Earth Moon system, (2) the solar system, (3) the solar neighborhood, (4) our galaxy, (5) the galactic neighborhood, and (6) the universe.

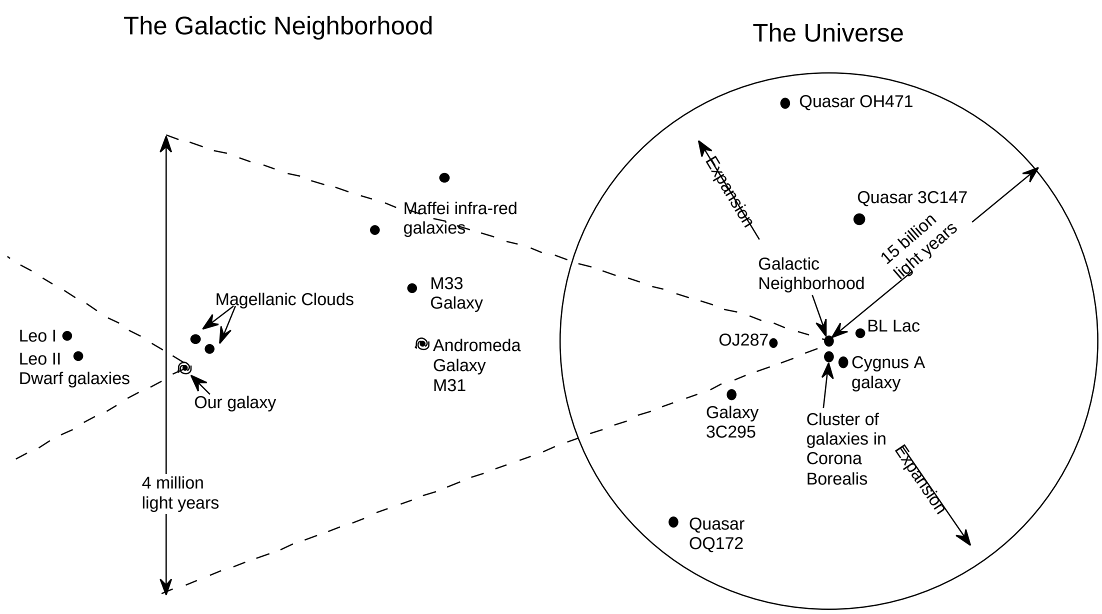


Orbits not to scale. This table gives mean distance from sun of each planet in astronomical units (AU). (1 AU = mean Earth-sun distance.)

Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	5.20
Saturn	9.54
Uranus	19.19
Neptune	30.06
Pluto	39.53



The Solar Neighborhood
Our Galaxy
Rotation
Procyon
Sirius
Kapteyn's Star
Epsilon Eridani
Tau Ceti
Leland's Star
20 light years
Solar system
Proxima Centauri
Alpha Centauri
Barnard's Star
61 Cygni
Sphere including 500 brightest stars
Cas A
Nucleus
Crab Pulsar
30,000 light years
Home arm
Diameter 100,000 light years
Solar Neighborhood (we live here)
Spiral arms
Star Clusters
Cross-section (edge view)


The Galactic Neighborhood
The Universe
Quasar OH471
Expansion
Quasar 3C147
Maffei infra-red
galaxies
15 billion
light years
Galactic
Neighborhood
M33
Galaxy
Magellanic Clouds
BL Lac
Leo I
OJ287
Andromeda
Galaxy
M31
Leo II
Dwarf galaxies
Cygnus A
galaxy
Our galaxy
Galaxy
3C295
Cluster of
galaxies in
Corona
Borealis
Expansion
4 million
light years
Quasar
OQ172

The Search for Extraterrestrial Intelligence

Perhaps the most urgent question the human species ever asks itself is “are we alone?” Scientists, philosophers, and “ordinary” people address the question in unique ways, some optimistic, some pessimistic, some very certain the answer is “No,” despite a dearth of physical evidence or likelihood. Unable to travel interstellar distances, humans have only one tool currently capable of answering this question, and that is the radio telescope. So let’s have a closer look at these endeavors.

Even the most objective attempts to calculate the likely number of planets in our galaxy that could produce an intelligent life form with whom we might communicate come up with estimates of anywhere from 1 (us) to 10 million planets. These planets include those that

(a) could support life as we know it,

(b) have evolved a species with enough intelligence to have a technology,

(c) are in a period of the planet’s history when this intelligent species has the capability of transmitting electromagnetic signals into space,

(d) is in a period of the planet’s history before that intelligent species goes extinct or otherwise loses its technology, and

(e) the planet is at the right distance from us for their signals to be reaching us about now.

Since the early 1980s, several projects have been undertaken to search for some sort of signal from outer space that could be a message from another civilization. Complicating this type of search is the possibility that another species might choose any frequency along the entire electromagnetic spectrum to carry its signal. However, frequencies within the radio band would be the most reasonable choices for communication because a minimum of energy is required to transmit signals in this range. Furthermore, frequencies within the 1-10 GHz ranges, known as the “microwave window,” are considered likely candidates since they would stand out from the galactic background radiation. In addition to searching over a considerable range of frequencies, there is the problem of where to look. Even within the Milky Way galaxy, the number of target stars with possible planets is in the billions.

In 1960, radio astronomer Frank Drake conducted the first radio frequency search, Project Ozma, for signals from other planetary systems. He aimed his 85-foot radio telescope toward two close by sun-like stars, and tuned it to the frequency of radiation emitted by neutral hydrogen, assuming that another intelligent species might select this frequency because of its astronomical importance. He didn’t find anything, but his attempt spurred others to take up the search for extraterrestrial intelligence (SETI).

The Soviet Union dominated SETI in the 1960s, turning their antennas in almost every direction, hoping that at least a few advanced civilizations might be radiating very strong signals. Then, in the early 1970s, NASA’s Ames Research Center in Mountain View, California, did a comprehensive study called Project Cyclops. This project produced an analysis of the scientific and technological issues involved in SETI that has been the basis of much of the SETI work since.

During the 1970s, many American radio astronomers conducted searches using existing antennas and receivers. A few efforts from that era continue to this day. By the late-’70s, SETI programs had been established at NASA’s Ames Research Center and at the Jet Propulsion Laboratory

(JPL). These two labs developed a dual strategy for a large scale study. Ames would examine 1,000 sun-like stars in a targeted search capable of detecting weak or sporadic signals. JPL, on the other hand, would systematically survey the sky in all directions. In 1992, NASA had formally adopted and funded this strategy, and observations began. This project was called the High Resolution Microwave Survey (HRMS). However, within a year, Congress terminated the funding.

Since then, SETI programs have continued with private funding. The SETI Institute, founded in 1984, helps coordinate research and find funding for numerous SETI researchers and projects. The most comprehensive SETI project ever undertaken is Project Phoenix. Project Phoenix will "listen" for radio signals from 1000 nearby, Sun-like stars, using the largest antennas in the world. In addition, The Planetary Society, based in Pasadena, California, also has an active SETI program.

NASA has recently initiated its new Origins Program, which takes a different approach in addressing the question of life elsewhere in the Universe. The Origins Program seeks to learn how stars and planets are formed. In the process, very advanced technology telescopes will use the techniques of astrometry and direct imaging to look for evidence of planets around other stars. The assumption is that a planet is the first requirement for life to emerge and evolve. If we discover that planets are very common, then we will at least be encouraged in our other techniques for detecting extraterrestrial intelligence.

Recap

1. On a one-billionth scale, wherein Earth is the size of a grape, the nearest _____________ would be at a distance greater than the diameter of the actual Earth.
2. Our solar system is located in one of the spiral ______ of what we call the Milky Way Galaxy, about _____________ light years from the galaxy's center.
3. One of the difficulties of searching for intelligently modulated signals of extraterrestrial origin is guessing what _______________ another intelligent species might use for its signal.

1. star 2. arms, 30,000 3. frequency (or wavelength)

For Further Study

- *The vastness of the Universe:* Powers of Ten. Video, Pyramid Films.
- *Cosmology (origin and fate of the Universe):* Kaufmann, 526-552; Morrison et al., 602-624.
- *SETI:* Kaufmann, 572-578; Morrison et al., 475-478; SETI Institute Home Page, http://www.seti-inst.edu.