Chapter 9

Zettaworld

1 000 000 000 000 000 000 000 (1.0 x 10^{21}) Z

9.1 Zettaworld Length

1 – 1000 Zettameters (Zm) 1 x 10^{21} m

Zettameters are a useful size for describing the distance to galaxies from the Sun. Table 9.1 has some representative examples of Zettameter-distant galaxies.

Galactic Distances

Galaxy	Distance from Sun
Large Magellanic Cloud	1.54 Zm
Ursa Major I Dwarf	3.12 Zm
Hoag's Object	5.68 Zm
Phoenix Dwarf	13.62 Zm
Tucana Dwarf	27.20 Zm
Sextans B (UGC 5373)	44.46 Zm
Diameter of Local Group	100.00 Zm

Table 9.1: Table of Zettameter Distance Examples

The Large Magellanic Cloud (LMC) is seen as a faint patch of light in the southern hemisphere. It is over over 20 times the width of the Moon. The first recorded observation of the LMC was

in 964 by Persian Astronomer Abd al-Rahman al-Sufi (903–986). Italian explorer Amerigo Vespucci (1454–1512), whose name was used to derive the word America, noted the LMC in about 1503. Ferdinand Magellan (1480–1521) also noted the LMC. His writings propagated knowledge of the LMC to a large enough audience, the Large Magellanic Cloud was named after him.

The Ursa Major I Dwarf galaxy, discovered in 2005, is only around 40 Exameters or so across. It is a spheroidal galaxy orbiting our own Milky Way at about a 3 Zettameter distance.

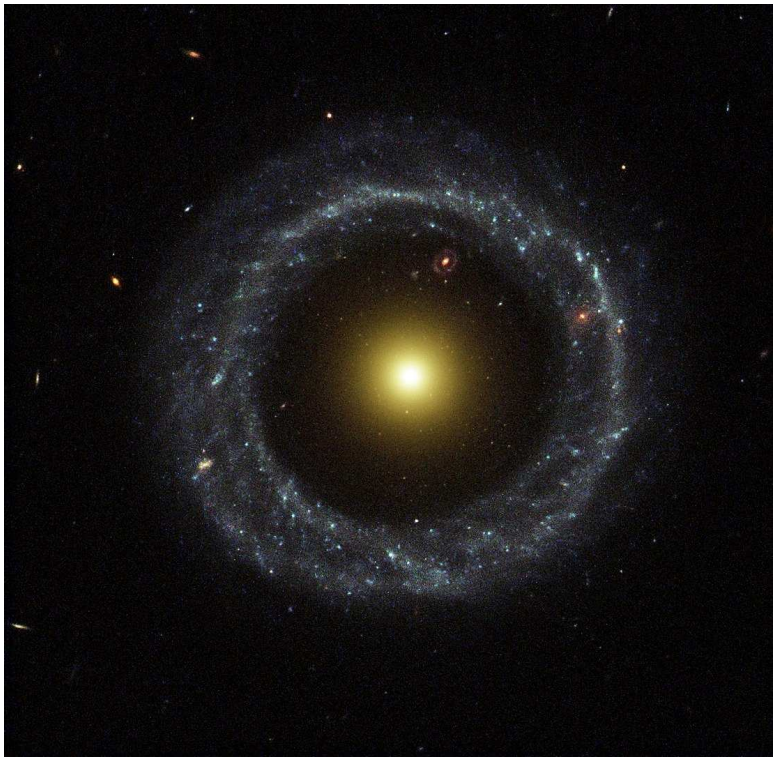

Figure 9.1: Hoag's Object – Hubble Telecope 2001

Hoag's Object (Figure 9.1) had been left off a number of catalogs of galaxies, and remained obscure until it was brought to

larger attention in 1950 by American astronomer Arthur Hoag (1921–1999). Hoag's Object has been described as a galaxy within a galaxy. Hoag's object consists of a rare ring-shaped galaxy of young hot blue stars. The ring has an inner diameter of about 710 Exameters, and an outer diameter of about 1145 Exameters. It's slightly larger in extent than our Milky Way galaxy. The ring encompasses an older spheroidal yellow nucleus with a diameter of only 161 Exameters. Between the two bodies, is a transparent dark band, through which one can see another galaxy in the distance, which is another rare ring galaxy (SDSS J151713.93+213516.8)

How this object formed is of considerable interest and speculation among astronomers. There is still no currently accepted hypothesis that explains its formation, and Hoag's Object remains a mysterious and intriguing member of the night sky.

The Phoenix Dwarf is an irregular galaxy, which means it has no distinct identifiable shape. It resides at a distance of about 14 Zettameters from us.

The Tucana Dwarf galaxy is a spheroidal galaxy comprised of old stars which were all formed at about the same time the globular clusters of the Milky Way organized themselves.

Sextans B is an irregular galaxy which has a stellar population which is uniform; this means they all have similar metallic content.

Stars Outside of the Milky Way

Star	Distance from Sun
SN 1987A (Sanduleak)	1.54 Zm
S Doradus	1.60 Zm
AB7	1.86 Zm
AE Andromedae	23.61 Zm
NGC 2363-V1	102.17 Zm

Table 9.2

Stars with distances in the Zettameter range are external to the Milky Way Galaxy. Some of the larger stars in the Large Mag-

ellanic Cloud can be viewed with a telescope. The brightest star is S Doradus, which is 1.6 Zettameters from Earth. S Doradus is a hypergiant star, and one of the most luminous stars known. It is approximately 480 000 times as luminous as the Sun. Stars in the Large Magellanic Cloud are all estimated to be at the approximate distance of the LMC. A large number of stars have been located outside our galaxy; Table 9.2 contains an abbreviated list of them. SN 1987A was a type II supernova within the Large Magellanic Cloud. Its light reached Earth on February 23, 1987 (1987-02-23), and is the most recent naked-eye supernova. The star which went supernova was a blue supergiant Sanduleak -69 202, which subsequently disappeared.

9.2 Zettaworld Area

1 – 1 000 000 Square Zettameters (Zm^2) 1 x 10^{42} m^2

Enclosing Spheres of Square Zettameter Area

Enclosing Sphere	Surface Area
Local Group of Galaxies	31 416 Zm^2
Virgo Supercluster	3 402 370 Zm^2

Table 9.3: Enclosing Spheres of Square Zettameter Area

A sphere which encloses the local group of galaxies has a surface area of 31 416 square Zettameters.

Superclusters are large groups of galaxies with a mutual gravitational interaction. They are thought to be the largest structures in the Universe. The Milky Way is part of the Virgo Supercluster, which also contains the Andromeda Galaxy and the Local Group of Galaxies. Its largest extent is 1041 Zettameters. A sphere enclosing the Virgo Supercluster has a surface area of 3 402 370 square Zettameters.

9.3 Zettaworld Volume

1 – 1 000 000 000 Cubic Zettameters (Zm^3) 1 x 10^{63} m^3

1 – 1000 Zettaliters (ZL) 1 x 10^{21} L

The volume of water in the Earth's oceans is estimated to be 1.34 Zettaliters.

The volumes of the inner rocky planets are all readily expressible in Zettaliters, but the outer gaseous planets have volumes so large they are well into Yottaworld. Table 9.4 has the volumes of the planets in our solar system expressed in Zettaliters. Zettaliters allow a person to effortlessly understand the relative volumes of the inner planets. We see Venus and Earth are very similar in terms of volume. Mars has a volume nearly six times smaller than Earth. Mercury has a volume 38% smaller than Mars.

Volume of Planets in The Solar System

Planet	Volume
Mercury	61 ZL
Venus	938 ZL
Earth	1080 ZL
Mars	160 ZL
Jupiter	1 430 000 ZL
Saturn	827 000 ZL
Uranus	68 330 ZL
Neptune	63 000 ZL

Table 9.4: Volume in Zettaliters

Jupiter, the largest of the gaseous giants, overwhelms the combined volumes of all the inner planets. Although the outer planets by themselves could best be expressed using Yottaliters, it is useful for comparison purposes to express them all in Zettaliters. One can immediately grasp the astonishing volume difference between the inner and outer planets when they are presented this way.

Zm^3 • • • Zm^3

Cubic Zettameter Volumes

Example	Spherical Volume
Condor Galaxy (NGC 6872)	63.1 Zm^3
Local Group of Galaxies	448 921 Zm^3

Table 9.5

NGC 6872 (aka the Condor Galaxy) is one of the largest known spiral galaxies. Its diameter is estimated at 4.94 Zettameters, which corresponds to a spherical volume of 63.1 cubic Zettameters. The local group of galaxies is comprised of over 54 galaxies (including The Milky Way) and extends over a distance of about 95 Zettameters. The volume of a sphere enclosing the local group of galaxies is 448 921 Zm^3

9.4 Zettaworld Mass

1 – 1000 Zettagrams (Zg) 1 x 10^{21} g

The Earth's atmosphere has a total mass of approximately 5.1 Zettagrams.

. . .

The total mass of the Earth's permanent ice and snow is 24 Zettagrams. The Earth's atmosphere is about five times less massive than the ice and snow found on the Earth.

. . .

The amount of salt in the Earth's oceans is estimated to be 47 Zettagrams.

. . .

On Thursday January 1st 1801, Italian astronomer Giuseppe Piazzi (1746–1826) noticed an object which looked much like a star, but after several observations, it was seen to move across the sky. The location of the small object is between Mars and Jupiter

List of Zettagram Mass Items

Example	Mass
Earth's Atmosphere	5 Zg
Saturn's Rings	15 Zg
Earth's Permanent Ice & Snow	24 Zg
Juno (Asteroid)	27 Zg
Salt in the Earth's Oceans	47 Zg
Pallas (Asteroid)	211 Zg
Vesta (Asteroid)	259 Zg
Ceres (Dwarf Planet in The Asteroid Belt)	938 Zg
Total Mass of The Asteroid Belt	3000 Zg

Table 9.6

and is consistent with a mathematical hypothesis for planet distribution called the Titius–Bode Law. Piazzi named the new planet Ceres after the Roman goddess of agriculture. Our word cereal is derived from the name of this goddess.

The dwarf planet Ceres is small, with a mean radius of about 476 Kilometers (952 Km diameter). Ceres has a surface area that is about the same size as Alaska and California combined. It would have remained a planet, but fifteen months later another was discovered by astronomer Heinrich Wilhelm Olbers (1758–1840) and named Pallas. It was also considered a planet, but over the next decade a large number of small objects with similar orbits were observed. They are all so small, even with the best telescopes of the time, they appeared as tiny points of light, and looked like stars. Shortly after the discovery of Pallas, the German-born English astronomer William Hershel (1738–1822) suggested the term asteroid for objects which have a star-like appearance when viewed with telescopes. The word asteroid is from Greek roots and means "star-like." These celestial bodies appear much like the small moons orbiting the giant outer planets. The label asteroid was later adopted for these bodies, and was not controversial until the twenty-first century.

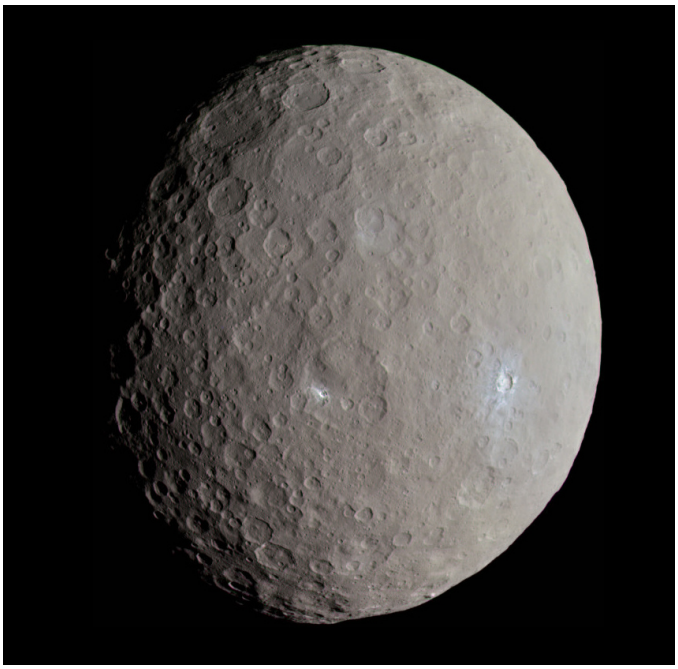

Figure 9.2: Ceres – NASA / JPL-Caltech / UCLA / MPS / DLR / IDA / Justin Cowart

Ceres is the largest body in the asteroid belt, and with a mass of 938 Zettagrams it is near the formal limit of Zettaworld mass. Ceres is so massive, it contains about one-third of all the mass found within the asteroid belt, estimated to be about 3000 Zettagrams.

Ceres has enough mass to pull it into a nearly spherical shape. In recent years, some have reclassified Ceres as a dwarf planet in the asteroid belt. This change occurred following the redefinition of the term planet, which reclassified Pluto as a dwarf planet in the Kuiper Belt. Pluto was not discovered until the twentieth century, and so did not affect nineteenth century discussions. The designations of Vesta (the second most massive asteroid after Ceres) and Pallas are also in flux.

