MESSIER 4, A GLOBULAR CLUSTER

Messier 4 or M4 (also designated NGC 6121) is a globular cluster in the constellation of Scorpius. It was discovered by **Philippe Loys de Chéseaux** in 1746 and catalogued by **Charles Messier** in 1764. **It was the first globular cluster in which individual stars were resolved.** Unlike open star clusters – such as the Pleiades and the Hyades – the Milky Way's 200 or so globular star clusters are not part of the galactic disk.

M4 is conspicuous in even the smallest of telescopes as a fuzzy ball of light. It appears about the same size as the Moon in the sky. It is one of the easiest globular clusters to find, being located only 1.3 degrees west of the bright star Antares, with both objects being visible in a wide field telescope. Modestly sized telescopes will begin to resolve individual stars of which the brightest in M4 are of apparent magnitude 10.8.

CHARACTERISTICS

M4 is a rather loosely concentrated cluster of class IX (see below) and measures 75 light years across. It features a characteristic "bar" structure across its core, visible to moderate sized telescopes. The structure consists of 11th magnitude stars and is approximately 2.5' long and was first noted by **William Herschel** in 1783. At least 43 variable stars have been observed within M4. M4 is approximately 7,200 light years away, the same distance as NGC 6397 in the constellation Ara, making these two the closest globular clusters to the Solar System. It has an estimated age of 12.2 billion years.

In astronomy, the abundance of elements other than hydrogen and helium is called the metallicity, and it is usually denoted by the abundance ratio of iron to hydrogen as compared to the Sun. M4 has an abundance of iron equal to 8.5% of the iron abundance in the Sun. Based upon the abundance measurements, there is evidence that this cluster hosts two distinct stellar populations. Each of the populations is a group of stars that all formed at about the same time. Thus the cluster may have undergone at least two separate cycles of star formation, or a merger with another cluster.

The space velocity of this cluster is following an orbit through the Milky Way that has a period of 116 million years and an eccentricity of 0.80. During peri-apsis it comes within 0.6 kpc from the Galactic core, while at apo-apsis it travels out to a distance of 5.9 kpc. The orbital inclination is at an angle of 23° from the galactic plane, carrying it as much as 1.5 kpc above the disk. When passing through the disk, this cluster does so at distances of less than 5 kpc from the galactic nucleus. The cluster must undergo a tidal shock during each passage, which can cause the repeated shedding of stars. Thus the cluster may have been much more massive in the past.

NOTABLE STARS

Photographs taken with the Hubble Space Telescope in 1995 have revealed white dwarf stars in M4 that are among the oldest known stars in the Milky Way Galaxy at an age of 13 billion years. One such white dwarf has been found to be a binary star with a pulsar companion, PSR B1620-26 and a planet orbiting it with a mass of 2.5 times that of Jupiter. Another Pulsar, a millisecond pulsar was discovered in M4 in 1987 with a period of 3.0 milliseconds, or about ten times faster than the Crab Pulsar.

ABOUT GLOBULAR CLUSTERS

A globular cluster is a gravitationally bound spherical collection of stars that orbits a galactic core as a satellite. Globular clusters are very tightly bound by gravity, which gives them their spherical shapes and relatively high stellar densities toward their centres. The name of this category of star cluster is derived from the Latin globulus—a small sphere. A globular cluster is sometimes known more simply as a globular.

Globular clusters, which are found in the halo of a galaxy, contain considerably more stars and are much older than the less dense galactic, or open clusters, which are found in the disk, such as the Pleiades or the Beehive cluster.

Globular clusters are fairly common; there are about 150 currently known globular clusters in the Milky Way, with an expected 10 to 20 more still undiscovered. These globular clusters orbit the Galaxy at radii of 130,000 light-years or more. Larger galaxies can have more: the Andromeda Galaxy, for instance, may have as many as 500. Some giant elliptical galaxies (particularly those at the centres of galaxy clusters such as M87, have as many as 13,000 globular clusters.

Every galaxy of sufficient mass in the Local Group has an associated group of globular clusters, and almost every large galaxy surveyed has been found to possess a system of globular clusters. The Sagittarius Dwarf galaxy and the disputed Canis Major Dwarf galaxy appear to be in the process of donating their associated globular clusters to the Milky Way. This demonstrates how many of this galaxy's globular clusters might have been acquired in the past.

Although it appears that globular clusters contain some of the first stars to be produced in the galaxy, their origins and their role in galactic evolution are still unclear. It does appear clear that globular clusters are significantly different from dwarf elliptical galaxies and were formed as part of the star formation of the parent galaxy rather than as a separate galaxy.

CLASSIFICATION OF GLOBULARS

In 1927–29, **Harlow Shapley** and **Helen Sawyer** began categorizing clusters according to the degree of concentration the system has toward the core. **The most concentrated clusters were identified as Class I, with successively diminishing concentrations ranging to Class XII. This became known as the Shapley–Sawyer Concentration Class (it is sometimes given with numbers [Class 1–12] rather than Roman numerals.**) In 2015, a new type of globular cluster was proposed on the basis of observational data, the dark globular clusters

FORMATION

The formation of globular clusters remains a poorly understood phenomenon and it remains uncertain whether the stars in a globular cluster form in a single generation or are spawned across multiple generations over a period of several hundred million years. In many globular clusters, most of the stars are at approximately the same stage in stellar evolution, suggesting that they formed at about the same time. However, the star formation history varies from cluster to cluster, with some clusters showing distinct populations of stars. The Hubble Space Telescope has observed clusters of clusters, regions that span hundreds of parsecs, where many of the clusters will eventually collide and merge. Many of them present a significant range in ages, hence possibly metallicities, and their merger could plausibly lead to clusters with a bimodal or even multiple distribution of populations.

OBSERVATION HISTORY

The first known globular cluster, now called M22, was discovered in 1665 by **Abraham Ihle**, a German amateur astronomer. The first eight globular clusters discovered are shown below

Cluster name	**Discovered by**	**Year**
M22	Abraham Ihle	1665
þ Cen	Edmond Halley	1677
M5	Gottfried Kirch	1702
M13	Edmond Halley	1714
M71	Philippe Loys de Chéseaux	1745
M4	Philippe Loys de Chéseaux	1746
M15	Jean-Dominique Maraldi	1746
M2	Jean-Dominique Maraldi	1746

William Herschel coined the term "globular cluster" in his Catalogue of a Second Thousand New Nebulae and Clusters of Stars published in 1789.

AK, with EarthSky and Wikipedia Notes