June 12, 2021 SMCAS Virtual Star Party: Globular Clusters

By Bill Lockman and Michael Cooke

Introduction[1]

A **globular cluster** is a spherical collection of stars. Globular clusters are very tightly bound by gravity, giving them their spherical shapes and high concentrations of stars toward their centers. Their name is derived from Latin *globulus*—a small sphere. Globular clusters are occasionally known simply as *globulars*.

In spiral galaxies like the Milky Way, globular clusters are mostly found in the outer, spheroidal part of the galaxy—the galactic halo. They are the largest and most massive type of star cluster, tending to be older, denser, and composed of fewer heavy elements than open clusters, which are generally found in the disks of spiral galaxies. The Milky Way has over 150 known globulars and possibly many more undiscovered. No active star formation has been seen in any of the known globular clusters.

Our observing session was held at The Cooke residence in San Mateo, CA. The portion of the northern sky visible from this location covered a range in azimuth from northeast to southeast and everything above about 10 degrees in altitude. We selected eight globulars in this range. Their physical properties are summarized in the table below. Their locations in the sky are shown in the deep sky object map at the end of this section.

In the sections following, each globular is discussed. A high-resolution photograph of the described globular is shown. At the end of each section, a wider field view of each globular taken with our eVscopes is also shown for comparison.

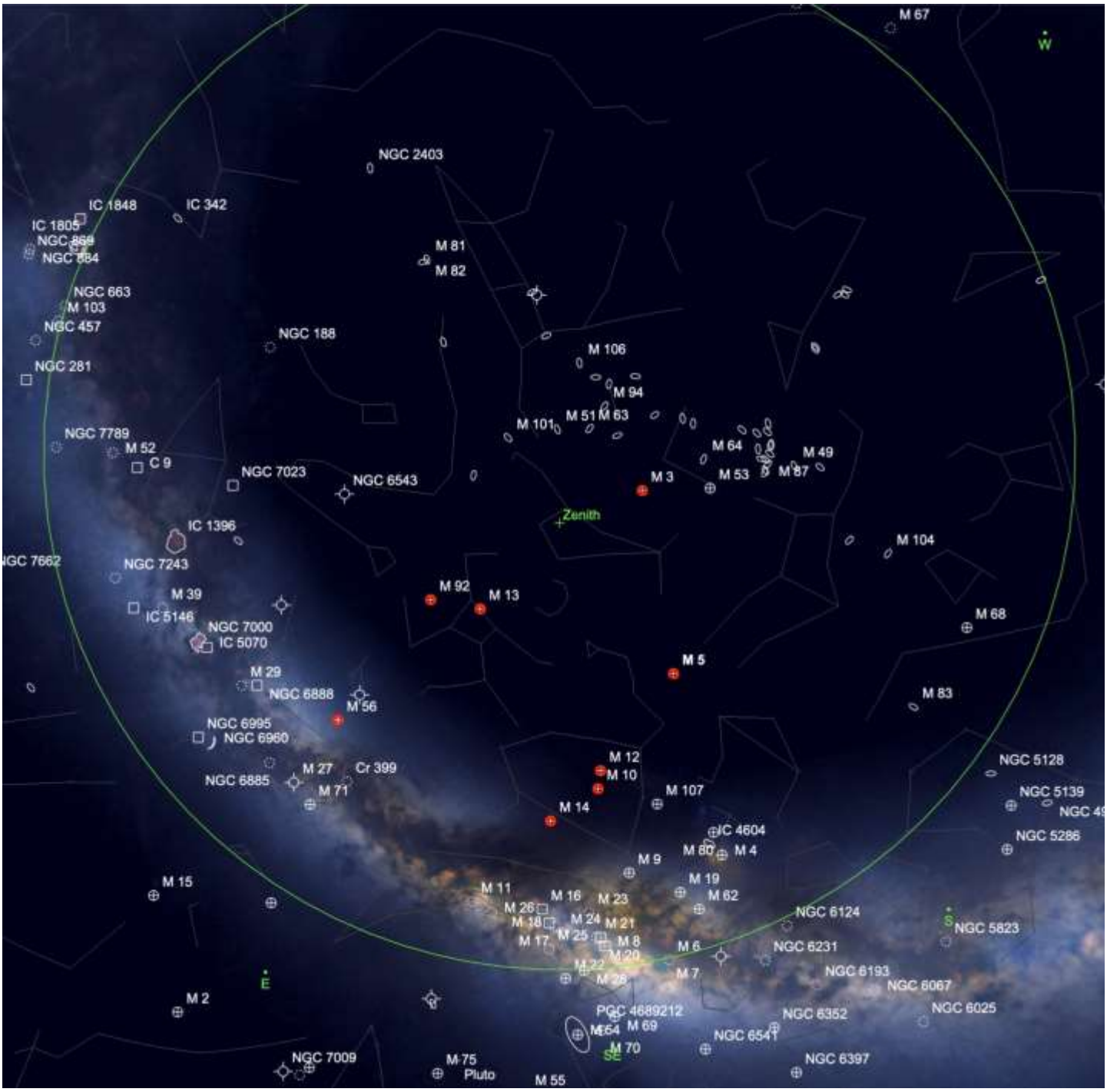
Properties of Selected Globular Clusters[2]

Messier Number	*Apparent Magnitude*	*Distance (light years)*	*Mass (Solar Masses)*	*Radius (light years)*	*Age (billion years)*
M3	6.2	33,900 ly	245,000 M⊕	90 ly	11.39 Gyr
M5	5.6	24,500 ly	857,000 M⊕	80 ly	10.62 Gyr
M13	5.8	22,000 ly	600,000 M⊕	84 ly	11.65 Gyr
M92	6.3	26,700 ly	200,000 M⊕	~56 ly	11 Gyr
M10	6.4	14,300 ly	225,000 M⊕	41.6 ly	11.39 Gyr
M12	7.68	14,700 ly	87,000 M⊕	37.2 ly	12.67 Gyr
M14	8.32	30,300 ly	1,040,000 M⊕	50 ly	~13 Gyr
M56	8.3	32,900 ly	230,000 M⊕	42 ly	13.7 Gyr

[1] From Wikipedia.

[2] From Wikipedia.

Deep Sky Objects at 9:30 pm, June 12, 2021 from San Mateo, CA[3]



The positions of the targeted clusters are shown as red dots in the sky visible from the Cooke residence. The green circle represents a "horizon" at 10° elevation.

[3]The sky map above and the following descriptions of globular clusters are based on the information presented in SkySafari 6 Pro (MacOS version).

Messier 3 (NGC 5272) in Canes Venatici

Messier 3, in the constellation Canes Venatici, is one of the three brightest globular clusters in the northern sky. It lies on the border of Canes Venatici with Bootes, about 6° NNE of Beta Comae Berenices.

Globular Cluster M3. Jim Misti.

Discovery and Observation

M3 was discovered by Charles Messier in 1764, and first resolved into stars by William Herschel around 1784.

Messier 3 is one of the most beautiful and easily seen globulars. With an apparent magnitude of 6.2, it is visible to the naked eye under dark conditions - and a superb object with the slightest optical aid. In binoculars, it appears as a hazy, nebulous patch. A 4-inch telescope shows a bright compact core within a round and mottled, grainy glow, which fades slowly and uniformly to the outer edges.

In an 8-inch telescope, the cluster is fully resolved. It is a glittering ball of stars with an extremely bright, rich, elongated core measuring 1.1' in diameter, and surrounded by an 18'-diameter halo of pinpoint stars. The stars are well resolved across the core, and radiate outward from it in curved chains. The cluster's brightest stars are of magnitude 12.7.

Properties and Evolution

At a distance of 33,900 light years, M3 is further away than the center of the Milky Way. Its absolute magnitude is -8.93, corresponding to a luminosity of about 300,000 Suns. Its apparent diameter corresponds to a linear size of about 180 light years. Its tidal radius, beyond which member stars would be torn away by the tidal gravitational force of the Milky Way galaxy, is even larger: the cluster gravitationally dominates a spherical volume 760 light-years in diameter. Its total mass has been estimated at 245,000 solar masses. Situated in the galactic halo, about 40,000 light-years from the Galactic Center, M3 is moving in an inclined orbit that takes it 49,000 light-years above and below the galactic plane; currently it is about 33,000 light-years above that plane. Its orbital eccentricity of e=0.55 takes it up to 66,000 light-years from the galactic center. But its perigalactic distance is only 22,000 light-years; at that distance, its tidal radius will go below 200 light-years, so its outermost stars may escape.

M3 contains approximately 500,000 stars. It is famous for the large number of variable stars discovered in it, the first discovered by E. C. Pickering in 1889. These stars have served as "standard candles" to determine the cluster's distance.

The cluster has an age of roughly 11 billion years and contains mostly old, red stars. But it also contains a relatively large number of so-called "Blue Stragglers", blue main-

sequence stars which appear to be much younger than the rest of the globular's stellar population. Once puzzling to astronomers, these stars are now thought to form as a result of stellar interactions; their cooler outer layers are stripped away in close encounters, which occur when they pass through the dense central regions of the cluster.

M3 photographed through Bill Lockman's eVscope.

Messier 5 (NGC 5904) in Serpens

The globular cluster Messier 5 (NGC 5904), in the constellation Serpens, is one of the finest in the sky.

Globular Cluster M5. Jim Misti.

Globular cluster M5 was discovered by Gottfried Kirch and his wife Maria Margarethe in 1702, while observing a comet; he described it as a "nebulous star". Charles Messier found it independently in 1764, and described it as a round nebula which "doesn't contain any stars". William Herschel resolved individual stars in the cluster in 1791; he counted 200 of them with his 40-foot reflector, "although the middle is so compressed that it is impossible to distinguish the components."

Observing Messier 5

Visually, Messier 5 is nearly as impressive as the great Hercules Cluster, Messier 13. At magnitude 5.6, M5 can just be seen with the naked eye on a clear night. To find M5, first locate the nearby star 5 Serpentis. The globular cluster is easily visible as small fuzzy patch in good binoculars.

At low power, M5 shows a well-concentrated core, and some resolution around the periphery of its halo. Its brightest stars, of magnitude 12.2, can just be resolved with a 4-inch telescope; they form curved patterns extending from the central part, suggesting a spider. Larger telescopes or photographs reveal thousands of stars, and a few less-populated gaps. At 100x the outer halo is well-resolved, and extends out to a diameter of 15'.

The nearby double star 5 Serpentis consists of components of magnitude 5 and 10 separated by 11". This star is mentioned in Messier's description. Also situated nearby, just about 40' south 5 Ser, is the faint and distant globular cluster Palomar 5 (magnitude 11.8; diameter 6.9').

Physical Properties

The distance to M5 is about 24,500 light-years, and the cluster contains more than 100,000 stars - up to perhaps 500,000, according to some estimates. Spanning 165 light-years across, M5 is one of the larger

globular clusters known. Its tidal radius, beyond which member stars would be torn away by the Milky Way Galaxy's tidal gravitational forces, is 202 light years. At 13 billion years old, it is also one of the older globulars in the Milky Way Galaxy. M5 is receding from us at about 52 km/sec.

M5 contains 105 known variable stars, of which 97 are the RR Lyrae type. RR Lyrae stars, sometimes referred to as "cluster variables", are somewhat similar to Cepheid variables, and can be used to measure distance since the relation between their periods and luminosities are well known. The brightest variable in M5 varies from magnitude 10.6 to 12.1 over a period of 26.5 days. A dwarf nova has also been observed in this cluster.

M5 photographed through Michael Cooke's eVscope.

Messier 13 (NGC 6205) – Great Hercules Cluster

Messier 13, also designated NGC 6205, and sometimes called the Great Hercules Cluster, is considered the most spectacular globular cluster in northern skies.

The Great Hercules Cluster, M13. Jim Misti

History and Observation

The Great Hercules Cluster was discovered by Edmond Halley in 1714, who noted that "it shows itself to the naked eye when the sky is serene and the Moon absent." Fifty years later it was examined by Charles Messier, who cataloged it in 1764. M13 is also reported in John Bevis' Celestial Atlas. In 1787, Sir William Herschel pronounced it "a most beautiful cluster of stars, exceedingly compressed in the middle, and very rich."

At magnitude 5.8, M13 is barely visible to the naked eye on very dark nights. It appears about 1/3 of the distance from Eta to Zeta Herculis, the two western (leading) stars in the Keystone asterism of Hercules. Even small telescopes resolve it into an extensive, magnificent mass of stars, perhaps 13' across visually. Observers note four apparently star-poor regions. The faint, 11th-magnitude galaxy NGC 6207 lies nearby, about 28' to the north east, and is visible in many wide-field photographs of M13.

Properties and Evolution

One of the reasons M13 appears so large and bright is that is relatively nearby, about 25,100 light years away. At that distance, its

angular diameter of 23' corresponds to 145 light years. The cluster also looks large and bright because it *is*, intrinsically, large and bright. M13 has an absolute magnitude of -8.7, which corresponds to a luminosity of a quarter million suns.

The center of M13, imaged by the Hubble Space Telescope.

Messier 13 contains several hundred thousand stars; some sources even quote more than a million. The brightest is the variable star V11, with an apparent magnitude of 11.95. Toward the center of M13, stars are about 500 times more concentrated than in the solar neighborhood. While the probability of collisions between stars in such a crowded region is negligible, the night sky seen from a planet near the center of this globular cluster would be filled with thousands of stars brighter than Venus and Sirius! Unlike open clusters, such as the Pleiades, globular clusters are tightly bound together by gravity, and contain very old, mostly red stars. The age of M13 has revised to 12 billion years - nearly as old as the Milky Way galaxy itself. Born before the Galaxy's stars had a chance to create metals and distribute them in its star-forming regions, M13's iron content relative to hydrogen is just 5% of the Sun's.

Strangely, for such an old cluster, M13 contains one young blue star: Barnard No. 29, of spectral type B2. The membership of this star is confirmed by radial velocity measurements; apparently it is a captured field star.

M13 photographed through Bill Lockman's eVscope.

Messier 92 (NGC 6341) in Hercules

Messier 92 (NGC 6341) is a globular cluster in the constellation Hercules. It is one of the brighter globular clusters in the northern hemisphere, but it is often overlooked by amateur astronomers because of its proximity to the even more spectacular Messier 13.

Globular cluster M92. Doug Matthews/Adam Block/NOAO/AURA/NSF.

M92 was discovered by Johann Elert Bode in 1777. Charles Messier independently rediscovered it and cataloged it in 1781, along with eight other objects (M84-M91) which

are all Virgo Cluster galaxies. William Herschel first resolved it into stars in 1783.

Observing Messier 92

Located on the north edge of Hercules, this impressive globular cluster deserves more attention than it gets, but is outclassed by the Great Hercules cluster, M13, to its southwest. M92 is harder to locate than its more famous cousin, but is still a splendid object, visible to the naked eye under very good conditions, and a showpiece for optics of every size. At visual magnitude 6.3, it is only slightly fainter than M13, and about 1/3 smaller, with an angular diameter of 14'.
Interesting trivia on M92: the North Celestial Pole occasionally passes within 1° of this cluster, due to the precession of Earth's axis. M92 becomes the "North Cluster" in about 14,000 years (16,000 AD), as it was about 12,000 years ago (10,000 BC).

Physical Properties

M92 is about 26,000 light years distant, only little farther away than its brighter apparent neighbor M13; and it is intrinsically smaller and fainter. Its true diameter is about 100 light years; its absolute magnitude is -8.1, a luminosity of 150,000 Suns (60% that of M13), and it may contain a mass of up to 330,000 Suns. M92 is approaching us at 112 km/sec.
The stars of M92 are exceptionally poor in iron and other elements heavier than hydrogen. This suggests that M92 was formed before the gas and dust of our galaxy were enriched with heavy elements, and therefore that M92 is exceptionally old, even for a globular cluster. M92 may be a bit younger than M13, or about 12 billion years old.

Only 16 variable stars have been discovered in this globular, 14 of which are of the RR Lyrae type. One is of the W Ursae Majoris type, and one of the very few eclipsing binaries found in a globular cluster. In these dense stellar agglomerates, close encounters occur frequently, so that binary systems will be disturbed, and eventually destroyed.

M92 photographed through Bill Lockman's eVscope.

Messier 10 (NGC 6254) in Ophiuchus

Messier 10 (NGC 6254) is one of the bright globulars populating the constellation Ophiuchus. It was discovered by Charles Messier in 1764, who described it as a "nebula without stars". Although they are plainly visible in a modern 4-inch telescope, William Herschel was the first to resolve M10 into stars.

Globular Cluster M10. Michael and Michael McGuiggan/Adam Block/NOAO/AURA/NSF.

Messier 10 is a very rich globular cluster, located in the rather barren central region of Ophiuchus, near ε Oph. At magnitude 6.5, it is one of the better globulars in the sky. M10 has an apparent diameter of some 20', about 2/3 the apparent diameter of the Moon. At an estimated distance of 14,300 light-years, this translates to a physical diameter of 83 light-years. Viewed through medium-sized telescopes, it appears about half that size (8' to 9'), as its bright core is only 35 light-years across. Four variable stars have been discovered in M10.

M10 is receding from us at 69 km/sec. The cluster completes an orbit through the Milky Way galaxy about every 140 million years, during which it crosses the plane of the galactic disk every 53 million years. This orbit has an eccentricity of e=0.21.

M10 photographed through Michael Cooke's eVscope.

Messier 12, NGC 6218 in Ophiuchus

Messier 12 (NGC 6218) is a globular cluster in the constellation Ophiuchus, discovered by Charles Messier in 1764. William Herschel was the first to resolve it into stars, in 1783.

Globular Cluster M12. Jim Misti.

M12 is easily found, 8.5° east of Delta Ophiuchi, and 3° west of the globular cluster Messier 10. It is nearly a twin of its apparent neighbor; M12 is only slightly larger (16') and a little fainter (magnitude 6.7) than M10. Messier 12 is a loosely-packed globular cluster and was once thought to be a tightly concentrated open cluster; its brightest stars are of 12th magnitude.

Messier 12 is about 16,000 light-years distant, and has a spatial diameter of 75 light-years. A recent study has concluded that M12 has lost over a million stars, stripped from the cluster by the gravitational influence of the Milky Way.

Messier 14 (NGC 6402) in Ophiuchus

Messier 14 (NGC 6402) is a globular cluster in the constellation Ophiuchus. It was discovered by Charles Messier in 1764, and first resolved into stars by William Herschel in 1783.

Globular Cluster M14. Jim Misti.

M14 is a bit isolated from brighter stars. It is perhaps easiest to find by going 10° east from M10. At magnitude 7.6, Messier 14 can be easily observed with binoculars. A medium-sized telescope shows a hint of individual stars, the brightest of which are 14th magnitude. The cluster is decidedly elongated in shape, and appears more like an elliptical galaxy at first glance.

At a distance of about 30,000 light-years, M14 is about 100 light-years across. It is approaching us at 77 miles per second, and contains several hundred thousand stars. The absolute magnitude of M14 is -9.12, which corresponds to a total luminosity of 400,000 Suns. So, while M14 is intrinsically much more luminous than the two other great Ophiuchus globulars (M10 and M12), it appears dimmer because of its greater distance.

In 1938, a nova appeared in this globular cluster, but was not discovered until photographic plates from that era were studied in 1964. The nova reached a maximum magnitude of +9.2, over 100 times brighter than the brightest stars in the cluster. Over 70 variable stars are known in M14; most are of the W Virginis type common in globular clusters.

The faint globular cluster NGC 6366 lies 3° southwest of Messier 14.

M14 photographed through Michael Cooke's eVscope.

Messier 56 (NGC 6779) in Lyra

Messier 56 (NGC 6779) is a globular cluster in Lyra, located about halfway between β Cyg (Albireo) and γ Lyr. It was discovered by Charles Messier in 1779, and first resolved into stars by William Herschel around 1784.

Globular Cluster M56. Jim Misti.

Messier 56 lies in a nice low-power Milky Way star field. At magnitude 8.3, this cluster is one of the fainter Messier globulars, especially lacking the bright core which most globulars have. Nevertheless, it is not too difficult to resolve, even at its rather large distance.

Only about the inner third of this great ball of stars, about 8.8' in diameter, is visible. While the NGC mentions "stars of 11th to 14th magnitude", more modern measurements have shown that the brightest stars in this cluster are of about 13th magnitude.
At its distance of 32,900 light-years, its angular diameter corresponds to a linear extent of about 85 light years. It contains only about a dozen known variable stars. M56 is approaching us at the high velocity of 145 km/sec.

M56 photographed through Bill Lockman's eVscope. The surrounding Milky Way star field in Lyra is apparent.