Grand tour of globular clusters

Sean G. Ryan

In late summer in the northern hemisphere, it's easy to know where you are in the Galaxy. At dusk, the Milky Way extends almost vertically from the southern horizon to the zenith (and further east, of course), and low on that south-western horizon is the constellation of Sagittarius. Looking towards Sagittarius, we are facing the Galactic Centre, some 26000 lightyears away. From a dark site, the Milky Way is notably more expansive around Sagittarius than in other directions because of the greater number of stars and more interstellar matter towards the central regions of the Galaxy.

Although Sagittarius never rises particularly high above the horizon from northern latitudes, the fact that the Milky Way extends up from the Galactic Centre on the horizon means that the plane of the Galactic Disk is presented very clearly before us. The orbit of the Sun around the Galaxy is confined to the disk, and as its orbit is almost circular, it is headed at right angles to the Galactic Centre, more or less in the direction of the star Deneb in the constellation Cygnus, which is almost directly overhead at this time of year. Almost every star you can see with your naked eye is also a member of the Galactic Disk, and all are flowing in nearly circular orbits around the Galactic Centre at about the same speed, typically some 220 kilometres per second. Their speeds and directions of motion are not identical, of course, but most relative motions are small, rarely more than a few tens of kilometres per second. The disk is around 1000 lightyears thick near the Sun, and the paucity of stars seen away from the plane of the Milky Way attests to its thinness.

However, there is a second population of objects in the Galaxy which do not have orbits like the disk stars; these are called Population II objects, of which globular star clusters are the most obvious. They formed very early in the lifetime of the Galaxy, around 12 billion years ago, before star formation in the Galactic Disk began, and long before the Sun formed 4.5 billion years ago. The Milky Way currently has a system of around 150 known globular clusters, though the number was probably greater in the past prior to gravitational disruption and tidal stripping of the clusters as they passed periodically through the Galactic disk, especially its inner regions. The Galactic Centre marks the centre of mass of the Galaxy, and the globular cluster system is likewise centred there, but in a much more spherical – or at least spheroidal – system rather than as a flattened disk-like system. Because of this, we find most globular clusters in constellations close to our line of sight towards the Galactic Centre, especially in Sagittarius, Scorpius and Ophiuchus, but also extending further outwards from the plane of the Milky Way where there is less obscuring dust. Late-summer evenings in the northern hemisphere are therefore prime time for observing the globular cluster system.

While Sagittarius and Scorpius are both a little too far south for most northern hemisphere observers, the large adjacent constellation Ophiuchus makes an excellent starting point for observing the globular cluster system. The fourteen targets set out below, not all in Ophiuchus, are observable with a 4 inch telescope, though one is quite faint. I would recommend observing all with the same eyepiece so you can appreciate the variation in size and brightness with a fixed setup. For globular clusters, I recommend an eyepiece with a focal length in millimetres no shorter than 1.2x your telescope f/ratio (so no shorter than 12 mm for an f/10 telescope), and with a field of view large enough to encompass at least 15 arcmin so you can see some of the dark field around each cluster; my personal favourite for my f/10 telescope is a 15 mm focal-length, ultrawide-field eyepiece (66° apparent, 32 arcmin true field of view).

Two accompanying diagrams show:
(1) a set of three star charts for identification purposes, showing the locations of the globular clusters

as 1° diameter circles and neighbouring stars down to about $m_V = 7$.
(2) top-down and side-on views of the quadrant the Galaxy occupied by these fourteen clusters (blue for those north of the galactic equator ("above" the plane), and red for those south/below) to show their positions relative to the Sun, the Galactic centre, and the Sun's orbit, in galactic X, Y, Z coordinates. The Sun is at the origin, and the Galactic Centre is at (X,Y,Z) = (26000,0,0). The XY plane corresponds to the Galactic plane (and hence the Galactic disk), while the Z-axis measures distances above (+) or below (-) the plane.
All distances quoted below are based on coordinates and parallaxes from the Simbad database.

M10 and **M12** make a good starting pair of targets. They are both bright ($m_V = 5$ and 6) and large (8-9 arcmin across), and just a few degrees apart. Located 16000-17000 lightyears from Earth, they are on our side of the Galaxy, just over halfway towards the Galactic Centre and about 25 degrees off that line of sight, above the Galactic Plane.

In the same region of the sky, **M14** is on almost the same line of sight, and it is similarly bright, but its smaller apparent diameter (3 arcmin) is a clue that this cluster is much further away, and at a distance of 25000 lightyears, it is almost twice as far away as the others and similar to the distance to the Galactic Centre. **M9** is at a similar distance (24000 lightyears), but is considerably fainter ($m_V = 8$) and a little smaller (2 arcmin). It is quite close to the Galactic Centre, only 5500 lightyears away from it.

Located barely 1 degree NE of M9, but well beyond the Galactic Centre, is **NGC 6356** at a distance of 34000 lightyears. Despite its distance, it is still a similar apparent size to M9 and even brighter, at $m_V = 7$.

Stepping further away from the Milky Way we find **M5** in Serpens (Caput), which at magnitude $m_V = 6$ and with a diameter of 13 arcmin is one of the more prominent globular clusters, while **M13** and **M92** in Hercules are of similar brightness and just slightly smaller. These three impressive clusters are all at similar distances, 23000-29000 lightyears, placing them at similar distances as the Galactic Centre, but more than 16000 lightyears north of/above the Galactic plane. In stark contrast, **NGC 6229**, also in Hercules, is small and faint (1 arcmin, $m_V = 9$) because it is located a staggering 80000 lightyears away, far outside the Sun's galactic orbit, and over 50000 lightyears above the Galactic Plane. This is one of the most distant objects you are likely to observe in our Galaxy; the Magellanic Clouds are naked-eye satellite galaxies at even greater distances of 160000 and 200000 lightyears, and are favourites of southern hemisphere observers, but they are too far south for most UK, European and North American observing sites.

Returning to the Galactic Centre and switching to the southern side of the Galactic Plane, we find **NGC 6712** ($m_V = 9$, 2 arcmin) in Scutum, 22000 lightyears from the Sun and relatively close to the Galactic Centre. **M71** in Sagitta is still close to the Galactic Equator, but further "around" the Galaxy. At a distance of only 13000 lightyears, it is the closest of the globular clusters in this tour, though not the brightest ($m_V = 8$) or largest (6 arcmin). Three further clusters at similar galactic longitude but progressively further from the Galactic Equator are the relatively small and faint **NGC 6934** (Delphinus, $m_V = 9$, 2 arcmin), and the two considerably larger and brighter examples **M15** (Pegasus, $m_V = 6$, 7 arcmin) and **M2** (Aquarius, $m_V = 6$, 8 arcmin). The three span the range 34000-42000 lightyears from the Sun, and all are more than 13000 lightyears below the Galactic Plane, placing them well outside (below) the disk of the Galaxy.

For me, globular clusters not only rate one of the prettiest classes of objects to observe with a small telescope, they also serve to convey the size and shape of the Galaxy in a way that most other objects cannot. I hope you enjoy taking with little "grand tour" with your own telescope.