

The Milky Way: Home to Star Clusters

Our Galaxy, the Milky Way, is something of a paradox. It is just one of the many billions of galaxies scattered throughout the Universe, a large, but quite normal spiral galaxy in any sense of the word. On the other hand, it is the most important galaxy known, and is unique because it is the only place we know that harbours life.

It is difficult to obtain a clear picture of the Milky Way's structure as we are living on the inside, looking out across one of its spiral arms. We will never be able to travel far way enough to see the Galaxy in its entirety, but to gain some perspective on the size, scale and structure, we can study other galaxies of similar types to fill in the gaps.

By combining these, we have the “best of both worlds,” a close-up insider's viewpoint, and billions of distant related galaxies for a “bird's-eye” view comparison.

The Milky Way is like an enormous city, bustling with life, but is also witness to death. Stars are being nurtured to this very day within its nebulous clouds of gas and dust, and these stars are also being dramatically snuffed out, reseeding the galaxy with fresh matter to form new stars. It is a continuous cycle of life, the largest recycling plant you can ever imagine. Even today, 15 billion years after the Galaxy was formed, it is still evolving, constantly changing and regenerating.

Professional interest in our Galaxy and its contents has awakened new interest in recent years as new technology has allowed astronomers to probe and scrutinize the Milky Way as never before. Every tool within the modern astronomer's arsenal has been used to reveal new discoveries in optical, x-ray, infrared and radio wavelengths. However, because the dust and gas within the galaxy obscures our view, there are many regions that are difficult to examine. So, there are probably many star clusters that have eluded us so far.

Galaxy Formation

The general theory for the creation of the Galaxy is in many ways similar to the star formation model explained in Chapter 1, although on a much more massive scale. Dust and gas conglomerated to form a protogalaxy (similar to a protostar) which eventually coalesced to form the globular clusters first in the galactic halo. The spiral arms then formed, and with them, the open clusters, associations and, of course, all the other stars and nebulae. However, there is some controversy as to which

parts of the Galaxy actually formed first. The standard theory supports that the halo was the original extent of the galaxy, and that this was created first, from the primordial gas that eventually collapsed in on itself, also demonstrated by the old stars contained within the globular clusters. This matter condensed to create the central bulge, which ultimately began to rotate, creating the disc and spiral arms. This scenario is reasonably confirmed by observations; older stars are found at the outer edges of the galaxy, and young stars towards the galactic center.

New data concerning the placement and distribution of gases in the Galaxy opposes the current models, and suggests that the bulge and the halo formed in a much closer time span, and the disc formed soon after. To confirm this, the halo has also been found to be still accreting new matter from red giant stars that are increasing in mass. It has long been known that our galaxy has fed on stars from other galaxies within our local group (e.g., the Sagittarius Dwarf Galaxy). In fact, one theory goes even further and implies that all globular clusters within the Milky Way are the leftovers of dwarf galaxies that have been cannibalized by our own galaxy, leaving only their cores, which we observe as globular clusters. Nevertheless, a recent spectrographic survey found an alarming similarity in the chemical content of a vast range of halo stars. This challenges the gradual growth by feeding model and implies that most, if not all, halo stars evolved at the same or similar time. To complicate matters further, other studies appear to show that the chemical content of lone and cluster stars within the halo are different to those in dwarf galaxies, further disproving the cannibalization theory. Perhaps a combination of these theories is correct, but this is certainly a hot topic still open for debate.

Size and Scale

It is estimated that there are over 200 billion stars within the Milky Way and its overall diameter is over 100,000 light-years. The Sun lies in the main plane, about two-thirds of the way out from the central hub, at a distance of 26,000 light-years. The Galaxy is in constant rotation, and the Sun takes about 225 million years to complete one orbit, called the cosmic year. Appearing as a band of stars overhead in the sky, from the constellations Cygnus to Vela, the Milky Way is seen in two opposing directions of the local arm, stretching out from the galaxies center. In the Northern Hemisphere, its brighter regions are visible in Cygnus and Aquila, but in the Southern Hemisphere, the areas in Scorpius and Sagittarius are more prominent. From our position in the Galaxy, our viewpoint is across one of the spiral arms towards the galactic center, also in Sagittarius.

Galaxy Components

As we are mainly concerned with star clusters, the most important areas of the Galaxy for our purposes are the spirals arms, situated in the disc, where the open clusters and stellar associations reside, and the outer halo, which provides a home for all galactic globular clusters. The most remote globular clusters are believed to map the original outer extent of the Milky Way soon after its formation, and the Milky Way's shape was originally defined by studying these globular clusters.

The main components of the Galaxy are: the central bulge or nucleus, the disk containing the spiral arms, and the outer halo which envelopes the Milky Way.

The Galaxy is also surrounded by a massive corona of hot gas, the residue of its original formation.

Nucleus and Spiral Arms

Recent research provides evidence for a supermassive black hole, known as Sgr A, lurking within the central bulge. Currently, it is lying dormant, having already snacked on much of the stellar material within the Galaxy, although it may become active again some time in the future. The galactic nucleus or central bulge is 20,000 light-years in diameter and 3,000 light-years thick. The nucleus or core has the greatest proportion of stars in the Milky Way, and these are tightly packed, only 1000 AU apart; so collisions must be quite frequent. A dense star cluster near Sgr A has also been discovered recently.

Astronomers have also detected congregations of stars near the galactic center, and due to the dimensions and size of these carbon stars, a possible barred structure is inferred. This means that our Galaxy may, in fact, be a barred spiral, and not an ordinary spiral, as originally thought. There is, however, much speculation on the actual arrangement and distribution of the stars, and their shape within these arms. Even the size and extension of the spiral structure, and indeed exactly how many arms are involved, is in doubt.

Only recently, a fifth spiral arm was detected by radio astronomers in the outer regions of the disk, but more evidence is required to prove that it is a completely distinct feature, and not an extension of the existing outer arm. Defining the spiral arms from our vantagepoint is difficult, but progress has been made by studying star clusters, and the gas contained within them, as beacons to define their paths. Rather like the “cats’ eyes” on a dark road, we cannot see the actual road but we can determine its shape.

The Halo

The outline of the halo is traced by the extent of globular clusters, and they traverse the Galaxy in an elliptical orbit inclined to the galactic disc. Due to this orbit, halo stars can actually pass right through the disc, but generally spend most of their time far away from the galactic plane. The halo extends beyond the galactic disc and the globular clusters are arranged randomly within it, above and below the plane of the galaxy. The halo and nucleus are also referred to as the spherical component of the galaxy, as they are aligned in a circular tendency towards the galactic center. Some of the oldest stars in the galaxy are contained in the halo, up to 15 billion years old, but there is very little gas or dust in this region, and hence few new stars are forming. Hot, ionised gas is also predominant in the halo, which emits highly at gamma ray wavelengths.

The Disk

In the halo and central bulge, star formation was high after their initial formation, and has now slowed considerably. In the disk, however, stars are still being formed at a continued, albeit decreased pace. The disc itself is divided into two parts, the

thick and thin discs, respectively. In the thin disk many stars had already formed, whilst the disk was still in the process of creation from in-falling gas. Its stellar components were forged from the inner first, to the outer parts last, and the thin disk is probably still forming today. Matter within the thick disc revolves more slowly around the galactic nucleus, and is 3 or 4 times the diameter of the thin disc. The metallicity of the stars in the thick disc is lower than in the thin disc, which means that the stars are much older. Some are believed to be as old as some of the halo stars, at 10 to 12 billion years. Each disc type, therefore, formed at different times and over different time spans. Overall, the thickness of the disk is approximately 1000–2000 light-years in depth. Many hot young stars are contained within the disk, which is why it appears so bright, and a large proportion are assembled in groupings, which typically move in circular orbits. These are the stellar associations with 10 to 100 component stars, and the open clusters containing 100 to 1000 stars or more, but we will discuss these in detail in a later chapter. The vast majority of gas and dust in the interstellar material is contained within the disc, and the disc itself has no discernible definite boundary – its shape and size are different, depending on the wavelength used to view it. As we move further from the galactic center, the concentration of stars also decreases.

Further Studies

As well as the main components of the Galaxy that are optically visible, the Milky Way also contains a galactic magnetic field and many charged particles. There does appear to be a missing element though, as there is not enough observable material in the Galaxy to account for the gravitational forces working on the stars, gas and dust. This missing material, could be the elusive dark matter, believed to account for over 90% of the Universe's content. A halo of dark matter could, in fact, surround the galaxy up to 100,000 parsecs (or 326,000 light-years) from its center.

The Milky Way contains a vast selection of star clusters within its disk and halo that can be observed using amateur equipment. In fact, most of the clusters mentioned in this book reside in our own Galaxy. Of the roughly 5,000 known star clusters, over 1,750 are visible within the Milky Way alone. However, the Milky Way is not unique, and has no exclusivity over these objects. Star clusters appear in all the galaxies that have been observed in any detail, and we will visit these extragalactic clusters in a later chapter.

As with most astrophysical objects, there seem to be many different and conflicting theories on the formation and evolution of the Milky Way and its contents, but this is a healthy situation, proving that real progress is being made. If the current models were not continually challenged, we might still believe that the planets revolved around the Earth!