Subject: The Milky Way: Armed and Dangerous
Memo: 24, Revision 2
From: Glen Langston,
Date: 2021 February 2

Summary:

We live in the Milky Way Galaxy, a grand design spiral galaxy. Astronomers have made many fascinating discoveries about our home galaxy. Here we list a few of the most important things everyone should know about our Milky Way Galaxy. For example, our Milky Way has several arms. In these arms, stars are born, these stars live there for millions and billions of years, then explode violently, disrupting the arms.

Our solar system is far from the center of the Milky Way and we are currently between two main arms. These arms are named for the constellations of stars in the directions of the closest parts of the arms. The nearby arms are the Sagittarius-Carina arm, in the direction of the center of our galaxy, and the Perseus Arm, in the opposite direction, out of our galaxy. See Figure 1.

In this note we have a checklist of things you should know about the Milky Way and suggest a way you can re-discover these properties of our home galaxy. The National Science Foundation supports astronomers, through the United States, who work to discover the properties of our galaxy and the history that led to life on Earth.

Background

The LightWork memo series is a part of the Open Source Radio Telescope project. (http://opensourceradiotelescope.org project/wk/).

This project seeks to enable Aficionados, that is hobbyists, high school students and college students, to build their own radio telescopes, so that they can both contribute to research and understand how radio astronomy reveals the hidden universe. The center of our Milky Way galaxy is easier to see with a radio telescope than with your eyes.

What should you know about our Milky Way Galaxy?: These are important facts:

1. Our solar system is far from the center of the Milky Way. We're 30000 light-years from the center of the Milky Way (about 170,000,000,000,000,000 miles).
2. The Milky Way is disk shaped. We are moving very very fast around the Milky Way; orbiting the center of the galaxy at a speed of 220 km/second (about 500,000 miles/hour).
3. The Milky Way is very very big. At 220 km/sec, it still takes the solar system 240 million years orbit the Milky Way once.
4. Astronomers have found 4 main arms of the Milky Way (see Figure 1).
5. The Sun is currently between two arms of the Milky Way, the Sagittarius-Carina and Perseus arms (See Figure 1).
6. The visible universe is mostly made of hydrogen and helium.

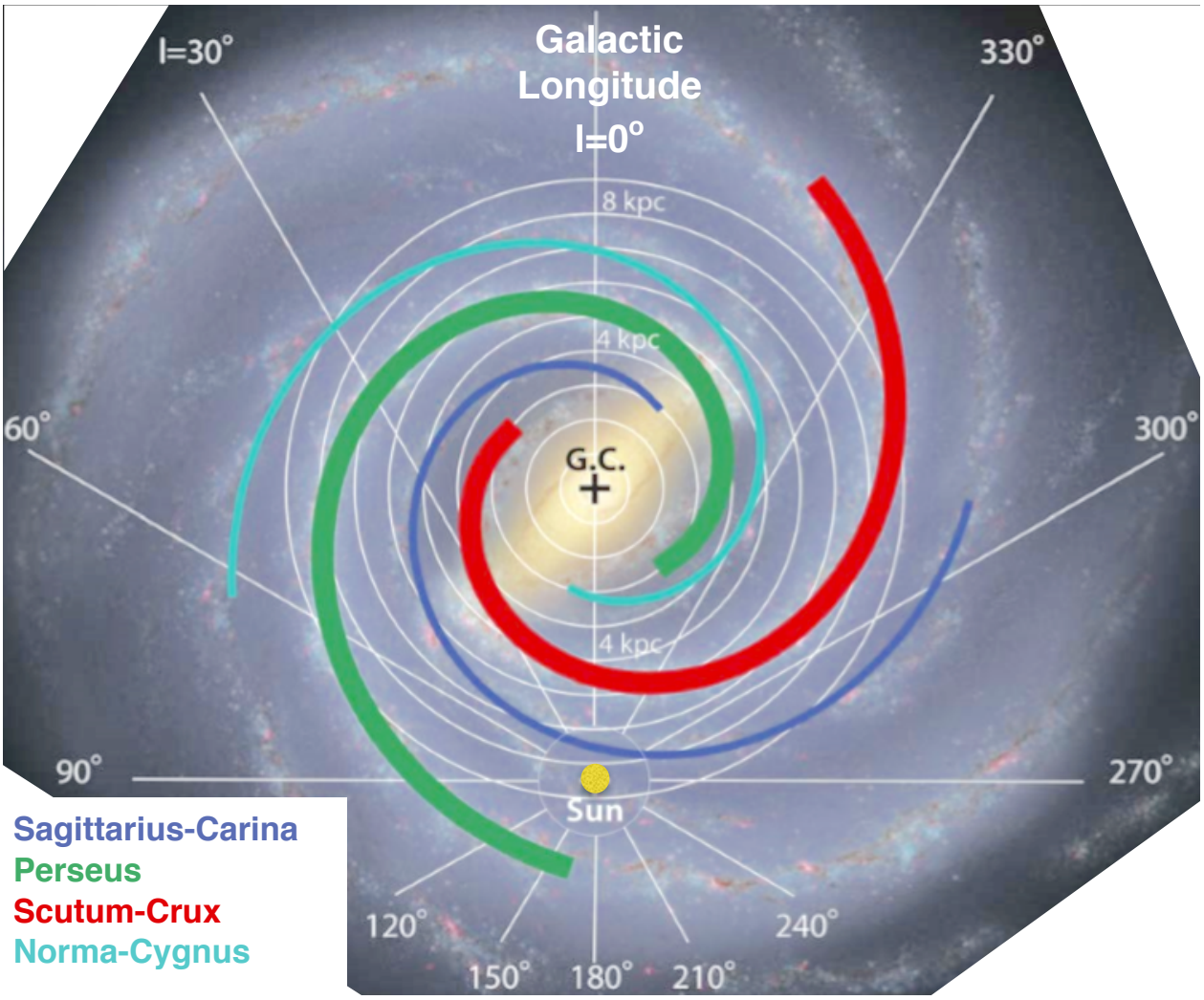

Figure 1: Our place in the Milky Way Galaxy, marked with the 4 main Arms. *The sketch shows we and our solar system are far from the center of the Milky Way. The image was drawn as if we are way above our galaxy. Our galaxy is a disk and the coordinate of the center of our galaxy is at Galactic Longitude, l, = 0. The figure is based on research by Koda, Scoville and Heyer, 2016, Astrophysical Journal, 823, 76.*

7. All neutral hydrogen atoms emit radio waves at exactly the same frequency 1420.4 MHz.
8. The speeds of the arms are measured easily with radio telescopes.
9. You can build your own radio telescope and see the Milky Way Galaxy any time, day or night.

You need to know a little about coordinate angles to understand your observations. **Figure 1** has the Galactic coordinate system. The figure shows the Galactic plane, where the Latitude is

zero. The different directions of the sky show different Galactic Longitudes. Zero degrees Galactic Longitude is the direction of the center of our galaxy and 180 degrees longitude is the opposite direction, out of our galaxy. The plot at right in **Figure 1** show observations out of our Galaxy, in the Longitude Range 168 to 246 degrees. **Figure 1** shows a range of Galactic Latitudes, from Latitude = 0 and moves down, out of the Galaxy to Latitude = -34 degrees. The hydrogen signal weakens as the telescope points away from the galactic plane. We're all moving in a circle around the center of our galaxy, at 90 degrees Galactic Longitude. The Milky Way is a disk, and the most hydrogen emission is at Galactic Latitude = 0, the galactic plane. We're moving round the center of the galaxy, and our direction is marked with a yellow arrow. The Earth is tilted at an odd angle relative to our galaxy, and the North Pole is roughly where the blue arrow points. Actually, our north pole is pointed a little out of the plane of our galaxy, but for now, the blue arrow is close enough. (Our north pole direction is actually Galactic Longitude = 123 degrees, Galactic Latitude = 27 degrees.)

The graphic in **Figure 2** was drawn by Robert Hurt, (http://www.spitzer.caltech.edu/mission/profile/50-Robert-Hurt), sketching our position relative to the center of our galaxy. This plot shows what we think our galaxy looks like, if we were viewing the galaxy from far, far above.

The point of this memo is to motivate you to build your own observatory, and the plot on the right side of **Figure 1** shows how easy it is to see our galaxy with a radio telescope. This clear signal is from the Perseus Arm of our galaxy, and took only 9 minutes of observations with a home-built telescope and this software. In order to make sense of the data, you need to know the direction the telescope was pointing. For all these observations the telescope was pointed due south, Azimuth = 180 degrees. I moved the telescope, by hand, in elevation (that is up and down) from 90 degrees, straight up, down near the horizon, 10 degrees elevation. Each observation was actually only about 30 seconds long, with 20 seconds between observations for me to run out and tilt the telescope to a new elevation.

Conclusion

This memo has described a new GRC design for astronomical observations that allow sensitive observations of the Milky Way. It takes a while to learn how to use GRC and to build your own radio telescope, but taking these steps allows you to see the Universe from your own back yard.

The telescope and software are sensitive enough to see our Galaxy. With 10 minutes of observations, you can start to discover our galaxy. Give these commands a try with your own telescope and collect your own observations of the Milky Way!

10 Interesting facts about the Milky Way

http://www.astronomytrek.com/10-interesting-facts-about-the-milky-way-galaxy/:

1: All Naked-Eye Stars are in our Milky Way

It isn't that long ago that we used to think of the stars as light leaks in a black curtain, just a little further than we could reach, and heaven was on the other side. In actual fact, all the stars we can see in the night sky with the **naked eye**, which is around 9,096 or 4,548 from each hemisphere, are contained within our own Milky Way galaxy. Obviously the biggest concentration of stars we can see lie in the direction of the Milky Way's galactic plane and central bulge, which unfortunately is impossible to see due to widespread light pollution, unless viewing from rural areas on a clear, moonless night.

2: The Milky Way Is Vast

The Milky Way is an estimated 100,000 light-years in diameter and contains up to 400 billion stars, including our own Sun. In spite of such a huge number of stars, the distance between Earth and even our nearest star system, **Alpha Centauri**, is vast. Needless to say, comprehending

such astronomically large numbers and sizes isn't easy. Can you imagine 186,282 miles, for instance? Of course you can't, and yet light travels that far in a single second, or 5.88 trillion miles in a year. To put things into some kind of perspective, if you were to count at a rate of one per second, it would take about 11 and a half days to reach just one million. Alpha Centauri, our nearest star apart from the Sun, is 25.6 trillion miles (4.3 light-years) away – good luck imagining! Even with the best technology we can currently muster it would take centuries to reach our nearest star. The Space Shuttle, for instance, would take around **165,000 years** to reach Alpha Centauri, while the Voyager-1 spacecraft which has now left our solar system will not pass other stars for 40,000 years.

3: Just One Of Many Galaxies

The point being that we're really not good at large sizes! The ancient Greeks, for instance, believed that our solar system represented the whole universe, with the Sun, Moon, planets, and fixed stars revolving around the Earth on a daily basis. In fact, Archimedes estimated the whole universe to be around the equivalent of two light-years across, which is far cry from its actual distance of about 14 billion light-years. Size is so elusive that it wasn't until 1923 that **Edwin Hubble** was finally able to prove that our galaxy was not the whole universe, and that in fact there were hundreds of billions of galaxies beyond our own. According to most recent estimates based upon Deep-field images from the Hubble Space Telescope, the number of actual galaxies in the universe could be more than 2 trillion.

4: Classified As A Barred Spiral Galaxy

The **Milky Way** is a spiral armed galaxy, and as is typical for about sixty-seven percent of those, ours is barred. It is suspected that such bars are the consequence of a galaxy drawing gas from its spirals into its heart, but as the density of the bars increase over the millennia their own gravity destroys them resulting in spirals without bars. It seems to be part of a middle-aged spiral galaxy's normal life cycle to have bars for a while. Some spiral galaxies form by brushing past other galaxies. Their gravities shred their globular shapes and leave long trails of stars that wrap around the remaining large bodies of stars. Often that is the end of it, with their relative speeds so high that they will never interact again. Sometimes there is enough attraction between them that they condense to form a single galaxy. While the above instance is not rare, most spirals are explained by one or both of these theories. You can look at them at your own convenience. The Density Wave Theory, which explains Saturn's rings,

explains some spirals, while the SSPSF model explains many others, but the language and mathematics in the latter may be difficult to digest. In any case, the Milky Way has grown by cannibalizing and absorbing other smaller galaxies that it has come into contact with over millions of years, including dwarf galaxies.

5: On A Collision Course With Andromeda

Interestingly, two galaxies could pass right through each other and have no collisions despite their billions of stars. In actual fact, that scenario is rather more likely than an actual collision because of the vast distances between objects, which is a bit of a relief since we and the **Andromeda Galaxy** are headed for a meeting in the far future. At present, the Milky Way and Andromeda galaxies are approaching each other at a rate of up to 140 kms/s, giving them a meeting point of 4 billion years from now.

6: Black Hole Located At Its Centre

Of course, all this matter heading for the heart of the galaxy has to go somewhere. The oldest star in our galaxy is about 13.82 billion years old, forming just shortly after the Big Bang, which means a lot of time has passed, and a lot of matter has gone tumbling into the centre of the galaxy. There awaits a supermassive **black hole** called Sagittarius A, situated 26,000 light years away from Earth with a mass equivalent to 4.1 million Suns, and a source of intense radio waves.

7: Galactic Year Last 240 Million Years

A galactic year lasts between 225 and 250 million years in our part of the galaxy, since rotation speeds alter depending on location. The best estimate for ourselves appears to be in the 240 million year range, since we're about two-thirds of the way out on the Orion Arm of our galaxy.

8: A Star Maker

With between 100 and 400 billion stars in the Milky Way galaxy, and enough interstellar dust to make 100 billion more, we're not likely to run out of stars any time soon. There is a distinct advantage to having so many **stars**. Current theories of stellar formation seem to indicate that most stars will have planets.

9: Milky Way Could Contains Millions Of Planets

Planets and each sun will have a "Goldilocks" zone. In other words, it's possible that **most stars will have a planet** (or two) that will fall in the habitable zone for life where it's not too cold and not too hot — it's just right. It could have liquid water, if it's solid; even if it's a gas giant it could have water in the atmosphere, so that something organic could float and live, despite the lack of "surface".

10: Frank Drake And Alien Civilizations

Drake was a *radio* astronomer who was intrigued by the notion of extraterrestrial life communicating deliberately (or accidentally) by radio. He set up a conference and created an equation to stimulate discussion among the attendees. It was never intended to represent reality, but to help people consider just what we need to know in order to seek other life in the galaxy. Some elements we know and can compute; others are "best guesses".

Either way, all the equation shows is that there might be hundreds or even thousands of civilizations in our galaxy. But because civilizations rise and fall over time, they don't all exist simultaneously, and most will be nomadic or agrarian, but not technologically capable. If there are technological civilizations, they should number about 43 (arguable, but as good a guess as any) at this point in galactic evolution. With fairly even but random distribution they are probably about 40+ light years apart. Unless we're particularly lucky, we probably don't have a nearby neighbor.

In fact, assuming we're average (we don't know enough to presume anything else) that means there are 21 civilizations that are less capable than us, and 21 that are more capable than us.