Galaxy Structure Role-Play

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1 The Puzzle

Imagine that you live on the planet Klovia, in a distant universe, which may or may not bear much resemblance to ours. Klovia is remarkably similar to the Earth, and it sits in a solar system remarkably similar to our own. What lies beyond this solar system is less well understood...

You know about stars: how they are powered, and the approximate distances to them. Your current cosmology states that the universe is full of an endless progression of stars stretching to infinity, pretty evenly spaced, with roughly 4 light years between neighbours.

Unfortunately, some uncomfortable new information is coming to light that casts doubt on this tidy theory. Your job today is to try and gather all this information together, and see if you can come up with a theory that fits all the data.

Star Mappers

You are a group of amateur astronomers, and you've spent the last ten years mapping the sky, drawing beautiful charts of everything you can see with the naked eye.

You've recorded the positions, colours and brightnesses of the 5,000 stars visible to the Klovian eye. These stars are pretty evenly distributed around the sky, as you would expect. Some constellations contain more bright stars than others, but by-and-large it averages out.

Rather different is the famous, and unexplained "Milky Braid", a band of diffuse white light that crosses the sky. You've mapped this "Milky Braid", and you show that it completely circles the sky in a great circle. At any given time, from and particular point on Klovia, you can only see half of it, but the full braid goes all the way, 360 degrees, around the sky.

All parts of the "Milky Braid" appear to be of roughly equal brightness: it isn't brighter in some directions than others (though on small scales is does appear somewhat mottled). It's quite faint: you can only really see it when all three moons of Klovia are below the horizon.

The "Milky Braid" isn't a single band all the way around the sky. In many places it breaks up into several independent threads, separating from each other and then rejoining. Indeed, three pieces of it seem to have broken off, and drifted into different regions of the sky. Apart from these three pieces, however, all the "braids" stick fairly close together, lying within a band about 10 degrees thick on the sky.

Star Counters

You work for the Galactic Patrol Skywatch Observatory, high in the mountains of Zabriska. Using your powerful telescopes, you have zoomed in on several small areas of the sky, and taken deep, long exposure photographic plates of them. You've then spent many hours poring over the plates, counting the stars upon them.

Most of your plates are pretty much the same. You pick up stars up to 10,000 times fainter than the Klovian eye can see. Your plates cover 0.03 square thargs of area, and on most, you will see around 3,000 stars.

Plates taken pointing at different parts of the "Milky Braid" (a mysterious band of faint diffuse light running across the sky), show a very different picture. The milky glow appears to be caused by very large numbers of stars: you count around 50,000 stars on each plate, packed so closely together that you can barely separate them on the plate. These stars usually appear fainter than the stars seen in other regions of the sky.

There are gaps in the "Milky Braid", between the different braids. When you take pictures in these gaps, you only find between 2,000 and 10,000 stars on each plate.

Spiral Nebula Experts

If you take long-exposure photographic plates with a big telescope, stars are not all you see. Very often, you see tiny fuzzy spiral shaped objects. These mysterious things are known as spiral nebulae.

You have become fascinated by these little spirals. You work at the Velantia National Observatory, and using your 1m telescope, you have searched the sky for more examples of these spiral nebulae.

You find them in most parts of the sky, but curiously enough, you find few if any close to the "Milky Braid". Within about 10 degrees of the Braid, you've not found any spiral nebulae, and between 10 and 20 degrees away, their numbers are seriously reduced. Elsewhere in the sky, these spiral nebulae seem to be pretty randomly distributed.

You've decided to call this zone without spiral nebulae the "Zone of Avoidance".

The spiral nebulae vary enormously in size and brightness. They seem to be flat, disk-like structure: sometimes you see them edge on, and they look like tiny lenses. They may have one tightly-wrapped spiral arm, but most have two or even three spiral arms. Several have bright blue dots in their centres.

What are they? The most popular theory at present is that these are newly forming solar systems. You could be looking at the protoplanetary disk, forming planets around young stars.

Fuzzball Experts

When you look at most regions of the sky with your powerful 2m telescope (you work at Manarkan Stardrop Observatory), most of what you see are stars. In-between the stars, however, are a number of circular fuzzy blobs. You have devoted your lives to studying these strange fuzzballs.

Most of these little fuzzy round blobs are too small and faint for you to pick out details, even with your giant telescope. A few of them, however, are much larger, and when you take detailed pictures of them, they break up into thousands of stars. It appears that these largest fuzzballs are dense clusters of stars. You estimate that each fuzzball may contain as many as a million stars. Most of these stars are squashed into the central regions, but some are much further out, giving the cluster its fuzzy appearance, as viewed through a moderate sized telescope.

The faint fuzzballs can be found in most parts of the sky. They seem to avoid the "Milky Braid": you see few if any within 20 degrees of the braid. Elsewhere, they seem to be quite randomly distributed, with no obvious pattern.

The larger fuzzballs, however, are mostly concentrated in one part of the sky: the constellation of the Celestial Slug, and neighbouring constellations. Over 80% of all bright fuzzballs lie in this region of the sky (though there are a few bright fuzzballs in other regions). The "Milky Braid" runs through this constellation. You only find one fuzzball in the Milky Braid, but most of them lie just one side or another of it.

Recently, you've been taking pictures of some of the Slug fuzzballs, and you've noticed that a few of the stars within them seem to vary in brightness. They peak in brightness every two hours, and at their peak, they all get to magnitude 13.1. You have now seen stars like this in 12 fuzzballs in this region of the sky.

Parallax Observers

The most fundamental problem in all of astronomy is measuring distances. Let's say you see a dot of light. How far away is the damn thing? How could you possibly tell?

You've been working for ten Klovian years on this difficult problem, and you think you have it licked. You know how far Klovia is from its sun: 2.2×10^{11}m. You measured this by bouncing radio pulses off the other planets in the Klovian solar system, at different points in their orbits.

What you did then way carefully photograph regions of the sky at six Klovian month intervals. This means that Klovia was on opposite sides of its Sun when the pictures were taken. You look for stars that appear to have slightly changed their position, over this six month period. Six months later still, they should have moved back to their original place.

This apparent wobble, you hypothesise, is caused by the motion of Klovia. As you orbit your sun, you are looking at these stars from a slightly different angle, hence their slight apparent change in position.

You have been intensively studying a nearby cluster of stars, called the Boskonies. This group of 120 bright stars is a famous sight for star watchers all over Klovia, because seven of the stars pulse in brightness. Each star pulses once every two hours. At their peak, each star is magnitude 2.3, dropping to a barely visible 5.7 an hour later. At different stars brighten and fade, the whole pattern of the Boskonies seems to change: Klovian sailors have used these changing patterns to set their clocks for hundreds of years.

You have been measuring the size of the wobble in the positions of the stars in the Boskonies for five years now. All the stars seem to wobble every six months by the same amount: 14.5 micro-degrees. You are guessing that this means they are all at the same distance from Klovia.

Radio Observers

Unlike the other Klovians at this conference, you are not astronomers. No, you are radio engineers, and proud of it. You work for the Arisian Institute for Radio Physics. You spend your time building giant dishes, which pick up and analyse radio signals, both from space and from the ground.

Recently, a theoretical physicist working with you pointed out that Hydrogen gas should emit strongly at a wavelength of 21cm. This emission is triggered when the electron in a hydrogen atom flips its direction of spin.

You tuned your radio receiver to 21cm, and sure enough, you detected a very strong signal coming from space. But not from everywhere in space. You only detect this emission when you point your receiver at the "Milky Braid". In fact, only at the central 3 degrees of the Braid. Curious!

Furthermore, the wavelength of the radiation isn't always precisely 21cm. In most directions, the wavelength is 21cm, but some funny things are detected when you point your receiver at the part of the braid that passes through the constellation of the "Celestial Slug".

At one position within this constellation, the emission seems to be smeared over a wide range of wavelengths, extending 3.5mm above and below 21cm. You call this the "Wow" position. Immediately on either side of the "wow" position, both north and south along the braid, you only detect emission at 21cm. But 17 degrees north of Wow (along the braid), in the adjacent constellation of the "Cosmic Earthworm", you detect emission at two quite distinct frequencies: 21cm and 21.015cm. 17 degrees south of wow along the braid, in the constellation of the "Star Slime", you detect emission at both 21cm and 20.985cm. Very curious.