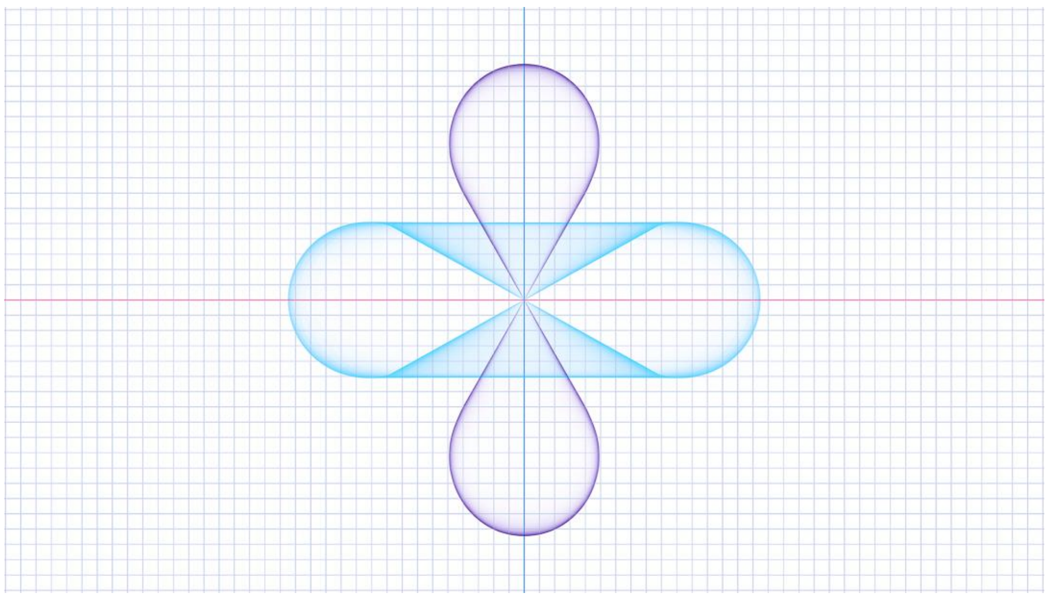
# Understanding Revealed Cosmology Through Visualization

## Matching Stellar Observations with Revealed Universe Architecture



Science Symposium 2022

# Understanding Revealed Cosmology Through Visualization

## Matching Stellar Observations with Revealed Universe Architecture

**David Neufer**

ABSTRACT The cosmology of the Urantia Papers is presented on such a grand scale that it can be challenging to take in through the narrative alone. With advanced computing power and software, we can more readily graphically represent revealed concepts and thus more easily comprehend the given descriptions of Paradise Isle, the central universe, space levels, space respiration, and force circulations. A new and evolving 3D Master Universe Model can become a framework for scientists and Urantia scholars to build upon by incorporating current and historical astronomical observations.

## INTRODUCTION

The Urantia Book [1], also known as the Urantia Papers, is the primary source for this article.

Models, be they of planetary orbits of solar systems or the three-dimensional structures of the spike proteins, help us understand relationships. We model particles, molecules, structures, organisms, planets, galaxies, and even universes. The word model comes from the Latin modulus, which means "a measure." In English, the term was first used in the 16th century to note plans for a building. [2] By definition, a model is an informative representation of something. [2] For this paper, the authors present a three-dimensional computer-generated model of revelatory cosmology as described in The Urantia Book. [1] Construction of the Master Universe Model (MUM) was started in 2019 by David Neufer.

Revelation students have modeled concepts in their minds to aid with understanding the book's relationships, and they have drawn diagrams on convenient surfaces to illustrate discussion points for each other. Serious scholars have been modeling more complex representations since the book's publication in 1955. (See appendix A for a partial list).

The Master Universe Model is built from the center outwards. At the center is the Eternal Isle of Paradise. All other objects, pathways, and conditions surround it. Though the MUM includes hundreds of thousands of objects, many have not yet been included. (See *Future Studies*)

In addition to illustrating revealed cosmology, the MUM lets us superimpose current and historical astronomical data. In this way, we can unify revealed concepts with evolutionary information.

The MUM is evolving. In the following years, we will add new scientific details. Currently, we have positioned 3500 stars; it will eventually be possible to include millions of stars, galaxies, galactic walls, and voids. And the model will change as our understanding of revealed concepts grows.

This paper presents visualizations from this model. We hope to demonstrate a reasonable method for aligning known stellar observations with revealed universe architecture.

## MATERIALS AND METHODS

MUM uses Blender software, "a free and open-source 3D creation suite". [3] Star data is provided by "3D Star Map," a Blender add-on. [4] The add-on's developer, Jumping Puzzle, uses star data from SIMBAD (the Set of Identifications, Measurements, and Bibliography for Astronomical Data) maintained by Université de Strasbourg/CNRS. [5] Currently, this database has 13,247,040 identified objects, including stars, galaxies, nebulae, quasars, exoplanets, clusters, nova, and black holes. 3D Star Map presents a small but representative sample of this data.

Visual information from the MUM can be presented live using 3D software. Images and videos are now being rendered from this model. In the future, the model can be incorporated into an informational app, similar to astronomy and anatomy educational apps. It can even be the basis of a virtual reality experience.

## ASSUMPTIONS

Where information is not stated or subject to interpretation, assumptions are made. These are some of them:

1. Cosmological measurements are in light-years (LY). 1LY=5.88 trillion miles. (6)
2. The "plane of creation" and the galactic plane are coplanar.
3. The "plane of creation" bisects pervaded space horizontally.
4. The galactic plane's poles are pivoted 180° for the overlay of star data.

5. Each space level is 100 times the size of the preceding one. MUM's decimal (base 10) pattern finds its origin in Paper 12. This 1-100 sizing is extrapolated from Paradise Isle out through to the outer space levels. 12:1.14-16,32:2 [1], [7]
6. The E/W diameter of Paradise is one Paradise width, abbreviated as "one par." The 1-100 scale from #5 appears to indicate that one par equals about one light-year.
7. "Mother force" lines are modeled on our current understanding of magnetic force lines.
8. The universes expand and contract 10% from a mid-point due to space respiration.
9. In space level cross-sections, the angles used to show midspace, pervaded space, and unpervaded space are based on 30° increments, like the hour placements on a 12-hour clock.
10. The superuniverse level is about 1 million light-years across. Its transverse diameter varies and depends on orientation and space respiration. [1] [7]
11. The distance from the Sun to Paradise center is deduced to be between 450k to 500k ly. The MUM places the Sun at 450 ly from the center. [1] [7]

DISCUSSION AND GALLERY

The revolutions of starry systems proceed as they do, independent of an observer's position. As a way of unifying stellar observations, astronomical mapping conventions decide on a fundamental plane, on which way is up, and on which way is clockwise. To coordinate these observations with revealed cosmology, we will examine both data types, observed and revealed, then decide which polar arrangement is consistent. We do this by looking at Sagittarius A; the Cygnus sun-forming region; and M31 – the Andromeda nebula (or Galaxy.)

This paper will tell its story mostly with pictures. These views from the Master Universe Model include illustrative quotes from The Urantia Book and other explanatory information when needed. As a starting point for understanding the cosmos (or anything else,) it is wise to begin at the Eternal Isle of Paradise.

# Paradise Isle

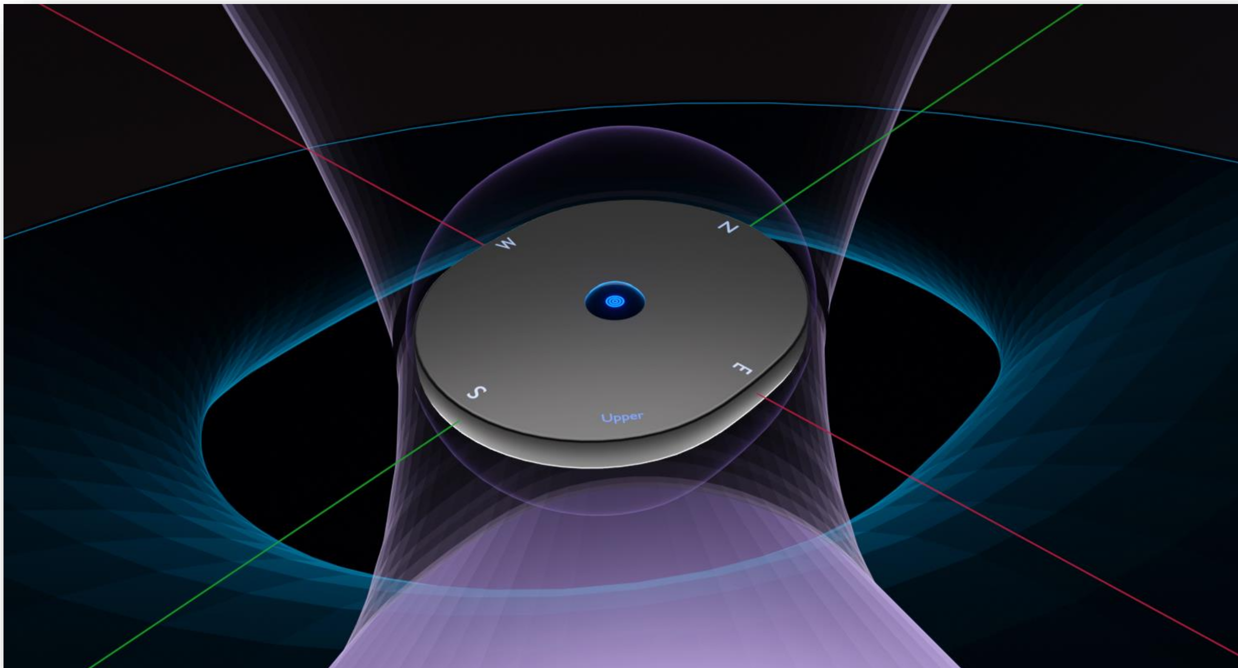



Figure 1. Paradise Isle – Inner terminus of the master universe.

"At the heart of this eternal and central universe is the stationary Isle of Paradise, the geographic center of infinity and the dwelling place of the eternal God."

0:0:5 [1]

# Paradise Isle Dimensions

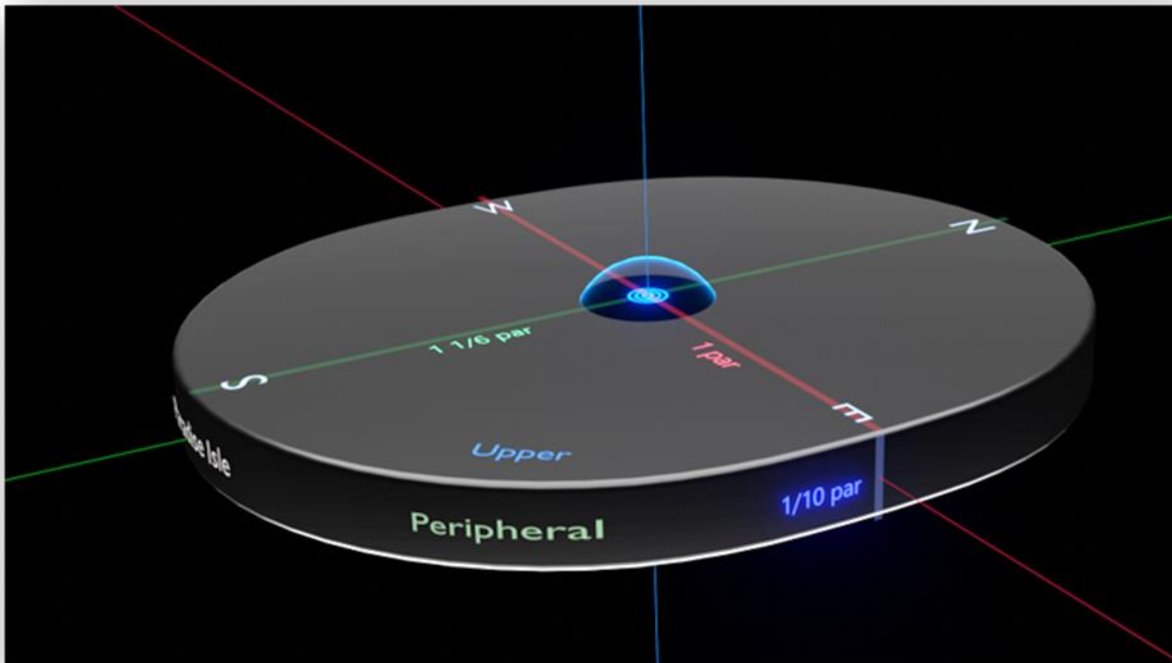



Figure 2. Paradise dimensions

"In form Paradise differs from the inhabited space bodies: it is not spherical. It is definitely ellipsoid, being one-sixth longer in the north-south diameter than in the east-west diameter. The central Isle is essentially flat, and the distance from the upper surface to the nether surface is one tenth that of the east-west diameter."

11:2.2 [1]

# Mother Force of Space


Figure 3. Mother force directory

"The inner zone of this force center seems to act as a gigantic heart whose pulsations direct currents to the outermost borders of physical space. It directs and modifies force-energies but hardly drives them.

11:5.5 [1]

# Mother Force of Space

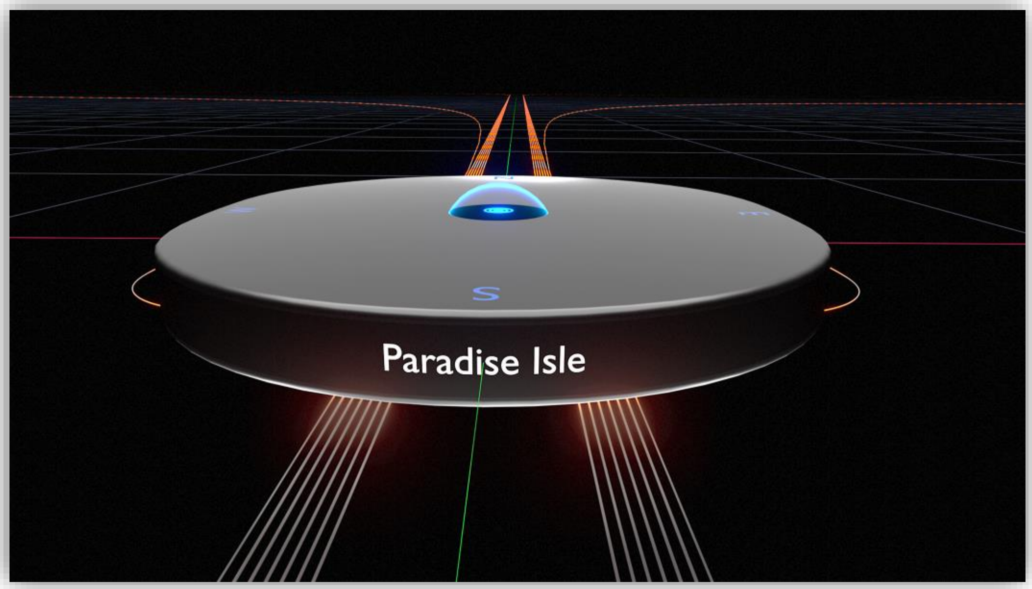



Figure 4. Mother force at Paradise

"The reality pressure-presence of this primal force is definitely greater at the north end of the Paradise center than in the southern regions; this is a uniformly registered difference. . ."

". . . The **mother force** of space seems to flow in at the south and out at the north through the operation of some unknown circulatory system which is concerned with the diffusion of this basic form of force-energy. "

11:5.5 [1]

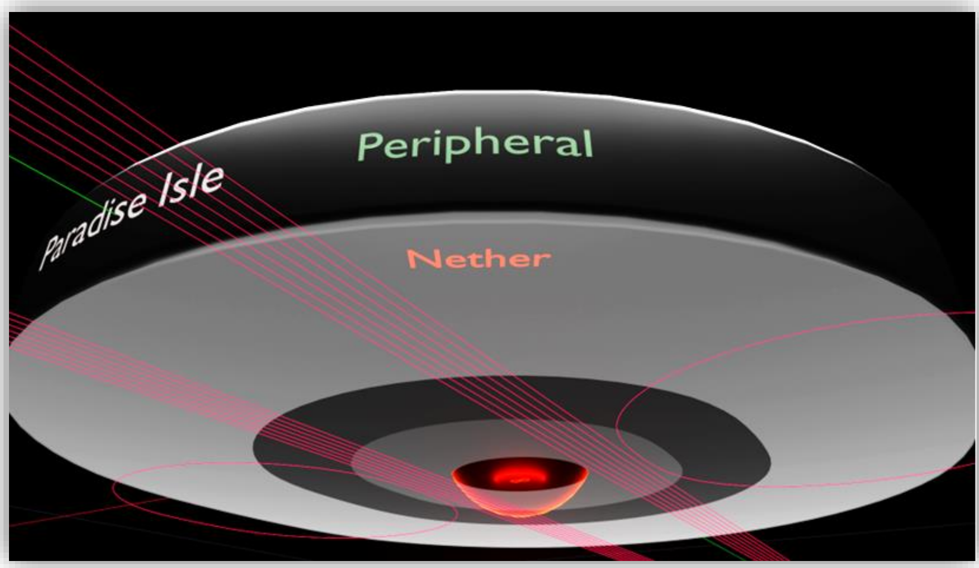



Figure 5. Mother force at Paradise

# Generic Space Level


Figure 6. Side view of a space level.

“The relatively quiet zones between the space levels, such as the one separating the seven superuniverses from the first outer space level, are enormous elliptical regions of quiescent space activities. ... You may visualize the first outer space level, where untold universes are now in process of formation, as a vast procession of galaxies swinging around Paradise, bounded above and below by the midspace zones of quiescence and bounded on the inner and outer margins by relatively quiet space zones.”

11:7:7 [1]

# Generic Space Level


Figure 7. Overhead view of a space level.

"A space level thus functions as an elliptical region of motion surrounded on all sides by relative motionlessness. Such relationships of motion and quiescence constitute a curved space path of lessened resistance to motion which is universally followed by cosmic force and emergent energy as they circle forever around the Isle of Paradise."

11:7.8 [1]

# Comparing the Galactic Coordinate System with Absolute Direction

| Galactic Coordinates | Absolute Direction |
| --- | --- |
| Established in 1959 | Published in 1955 |
| Sun-centered | Paradise-centered |
| Sgr A indicates horizontal zero-point | Sgr A indicates direction to Paradise Center |
| Incremented 0° to 360° | Uses cardinal directions N, S, E, W |
| North and South Poles | Upper and Nether Regions |

*Both systems share a fundamental plane*

Figure 8  Comparison table

a) The coordinates of the MUM are based upon *Absolute Direction* (AD) – a concept described in The Urantia Book. [1]

b) The MUM incorporates Stellar locations whose vectors are numbered according to the Galactic Coordinate System (GCS) established by the International Astronomy Union. [9]

c) AD and GCS share a fundamental plane. However, rotating the GCS poles along an axis formed by the Sun and Sagittarius A (Sgr A) yields star locations and circulations that agree with revealed concepts.

# Galactic Coordinate System

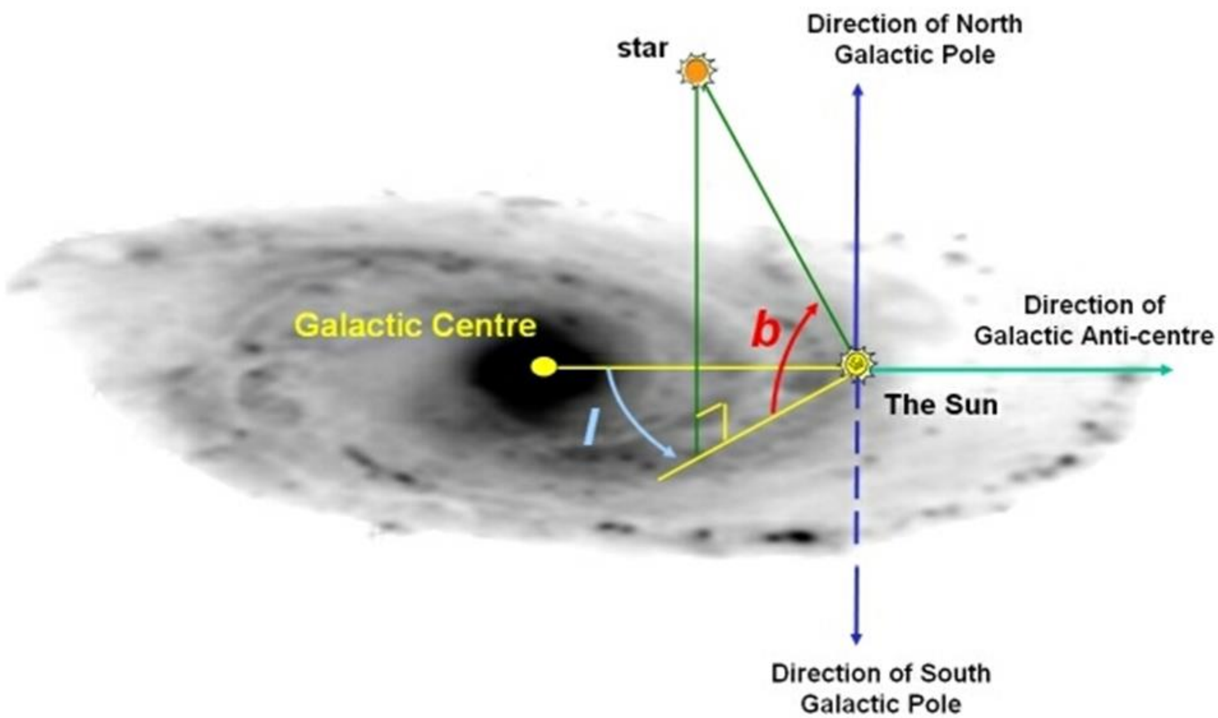



Figure 9. Galactic Coordinates Graphic [9]

The GCS "is a celestial coordinate system in spherical coordinates, with the Sun as its center, the primary direction aligned with the approximate center of the Milky Way Galaxy, and the fundamental plane parallel to an approximation of the galactic plane but offset to its north. It uses the right-handed convention, meaning that coordinates are positive toward the north and toward the east in the fundamental plane. [10] The approximate center of the Milky Way is Sagittarius A." [10]

The GCS was established in 1959 by the International Astronomical Union, replacing the older equatorial system employed previously. [10] This is to say, though logically reasoned, the decision to make the system sun-centric and the designation of polarity, is an arbitrary convention accepted by astronomers to offer a standardized method to report observations. Standardized methods allow humans to communicate. An example of this is the worldwide use of the metric system for measurement.

# Absolute Direction

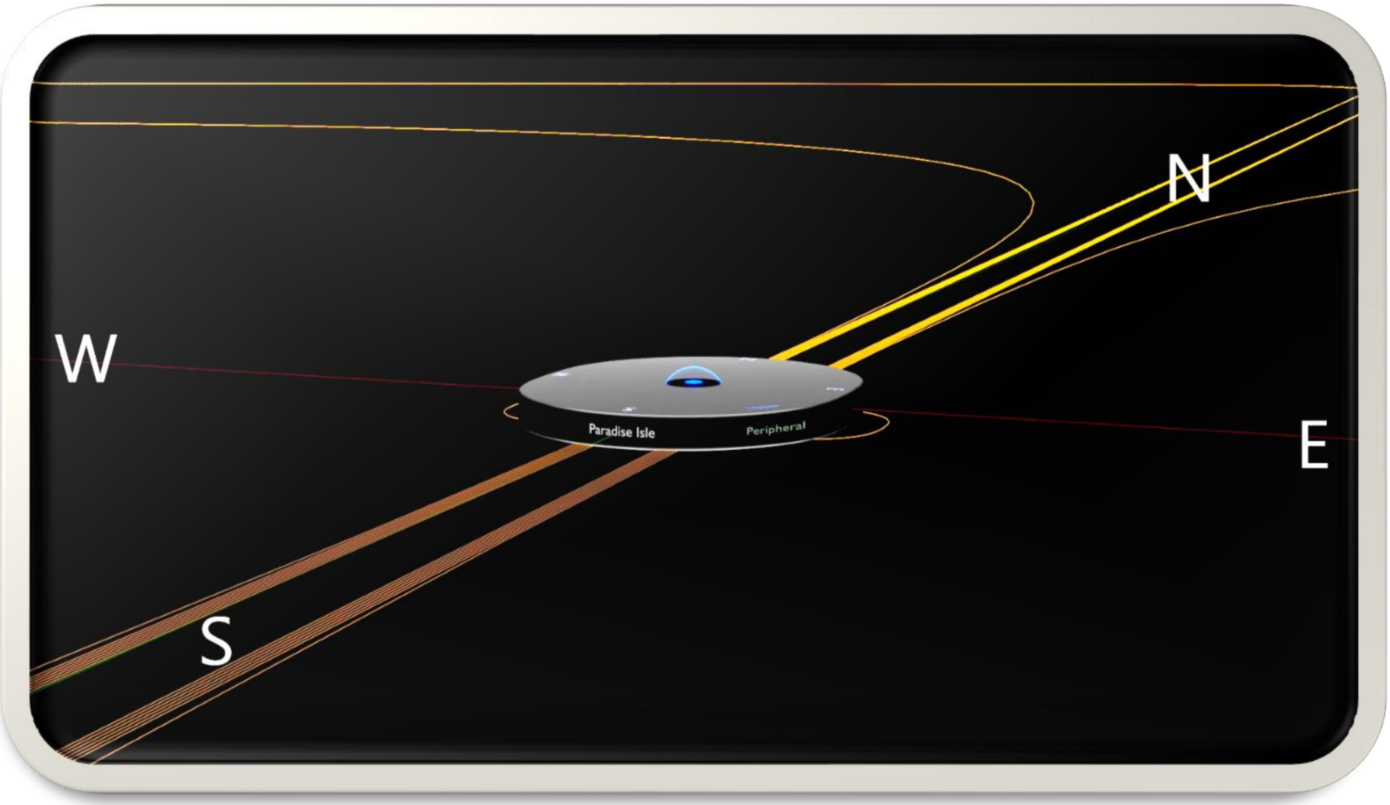



Figure 10. Incoming and outgoing mother force.

"[Paradise Isle's] differences in dimensions, taken in connection with its stationary status and the greater out-pressure of force-energy at the north end of the Isle, make it possible to establish **absolute direction** in the master universe."

11:2.3

# Fundamental Planes

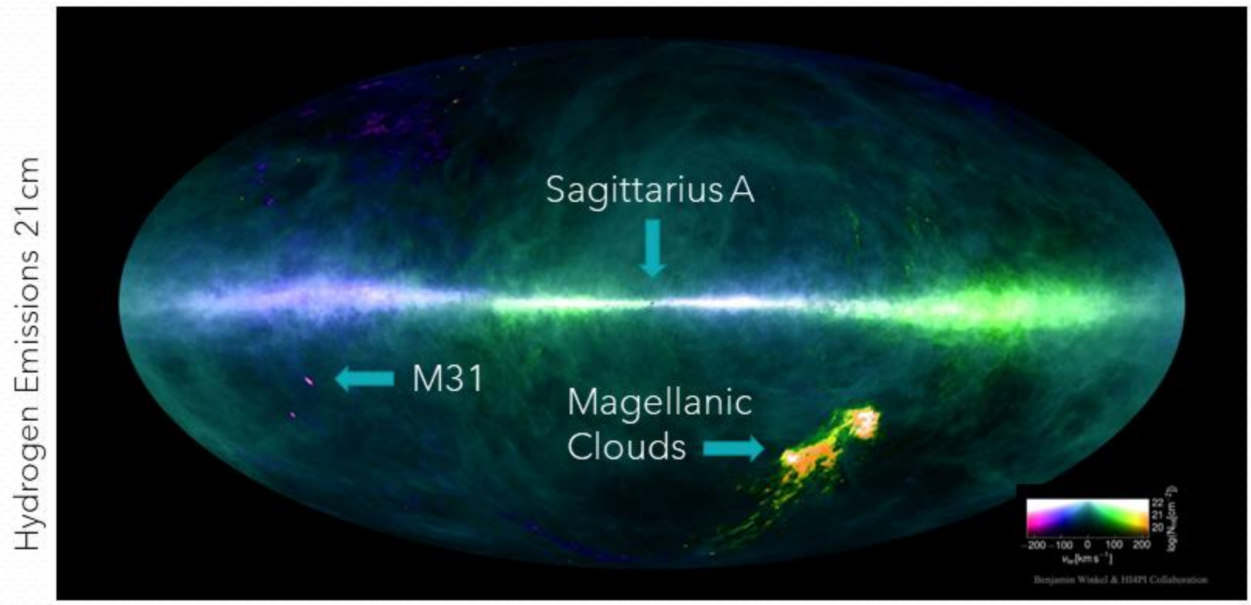



Figure 11. Galactic Coordinates - Fundamental Plane [11]

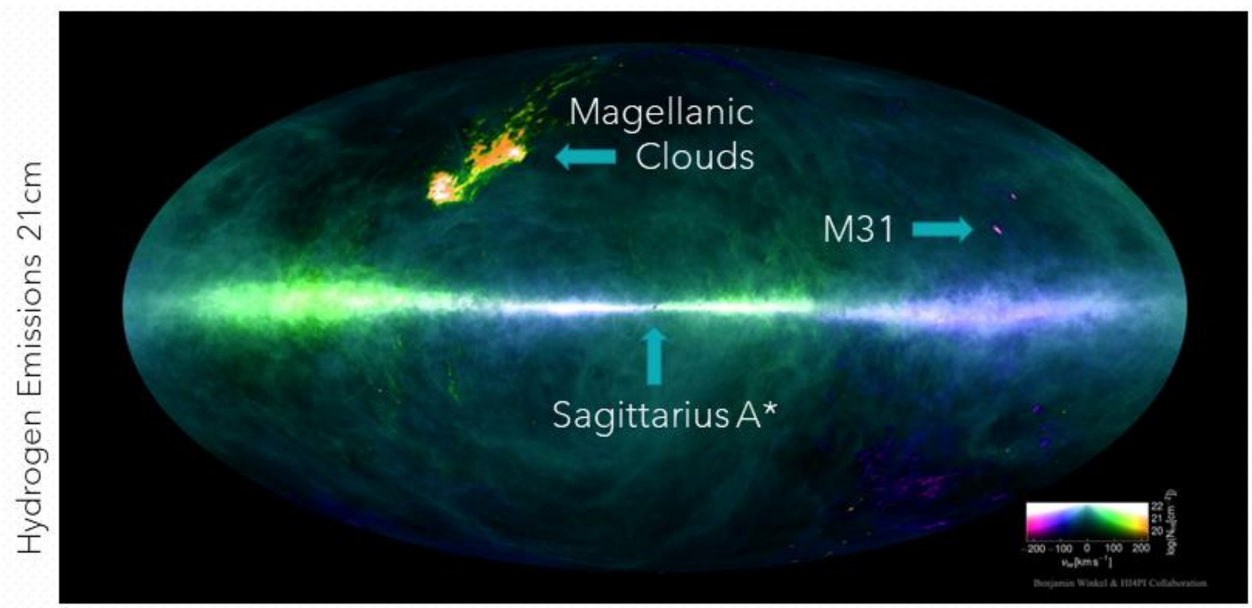



Figure 12. Absolute Direction - “Plane of Creation” [11]

These images show how the GCS fundamental plane pivots 180° on the Sun-Sgr A axis to form the plane of Absolute Direction. Following are examples of AD applied to Cygnus and M31.

# Cygnus?

## Sun-forming Nebula (Revealed)

"A sun-forming nebula just north of the borders of Orvonton, but within the superuniverse space level, has already given origin to approximately forty thousand suns..."

UB 15:4.5

NASA-IPAC-MSX

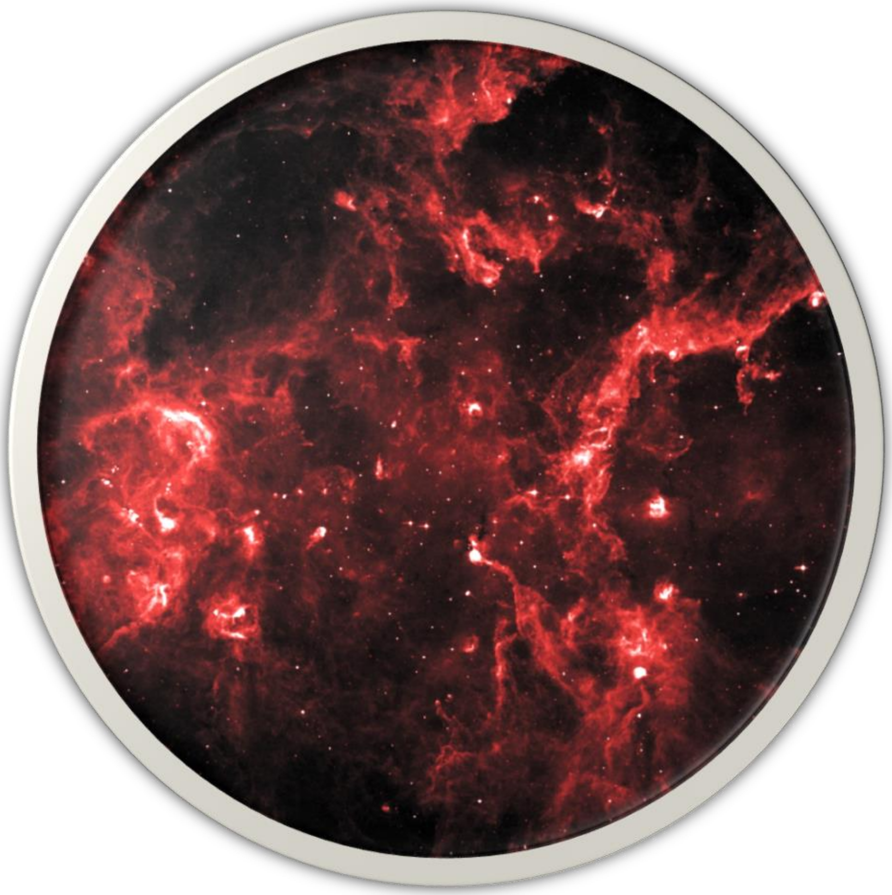


Figure 13. Cygnus [12]

# Cygnus

## Sun-forming Nebula (Observed)

“The Cygnus-X complex represents the **most powerful** star-forming region at less than 2 kpcs [6500 ly] from us…“ [13]

“Its core, Cygnus OB2, represents the **most obvious example** of recent star formation…” [13]

NASA/JPL-Caltech/J. Hora (Harvard-Smithsonian CfA)

Figure 14. Cygnus [14]

# Cygnus, Sun, & Sgr A

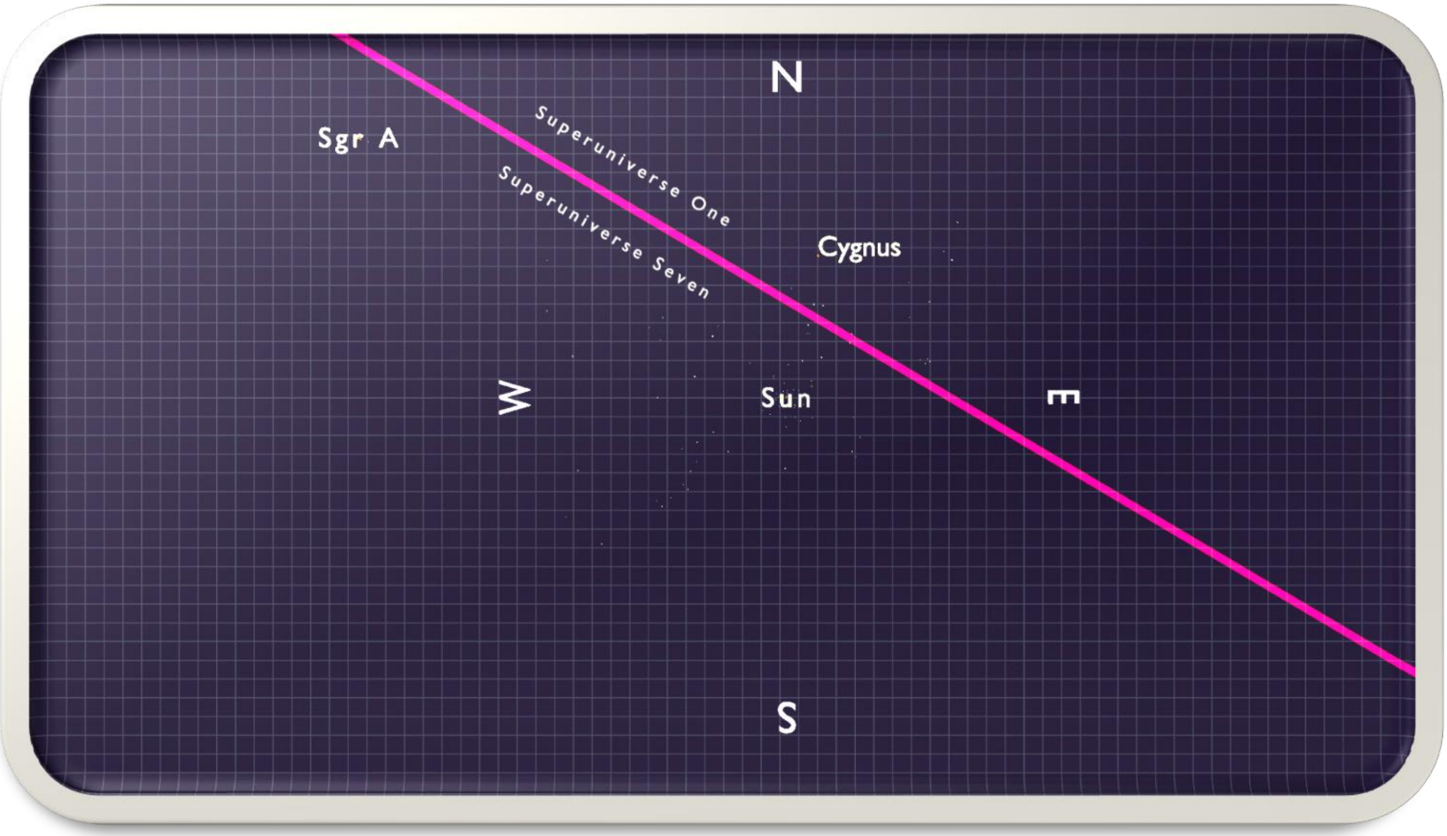



Figure 15. Placement of Cygnus in Superuniverse One using Absolute Direction coordinates.

Evidence suggests that Cygnus is the “sun-forming nebula just north of the borders of Orvonton” - superuniverse seven. Using Absolute Direction, Cygnus is found to be north of the Sun. We are told that the nebula is “within the superuniverse space level,” so it is likely that this active region is found in superuniverse one which “swings almost due north.” [1]

The Galactic Coordinate System is centered on the Sun and only applies to one star. Absolute Direction originates at Paradise Isle but can be applied to any sphere in the master universe.

# M31 Blueshift vs. Redshift

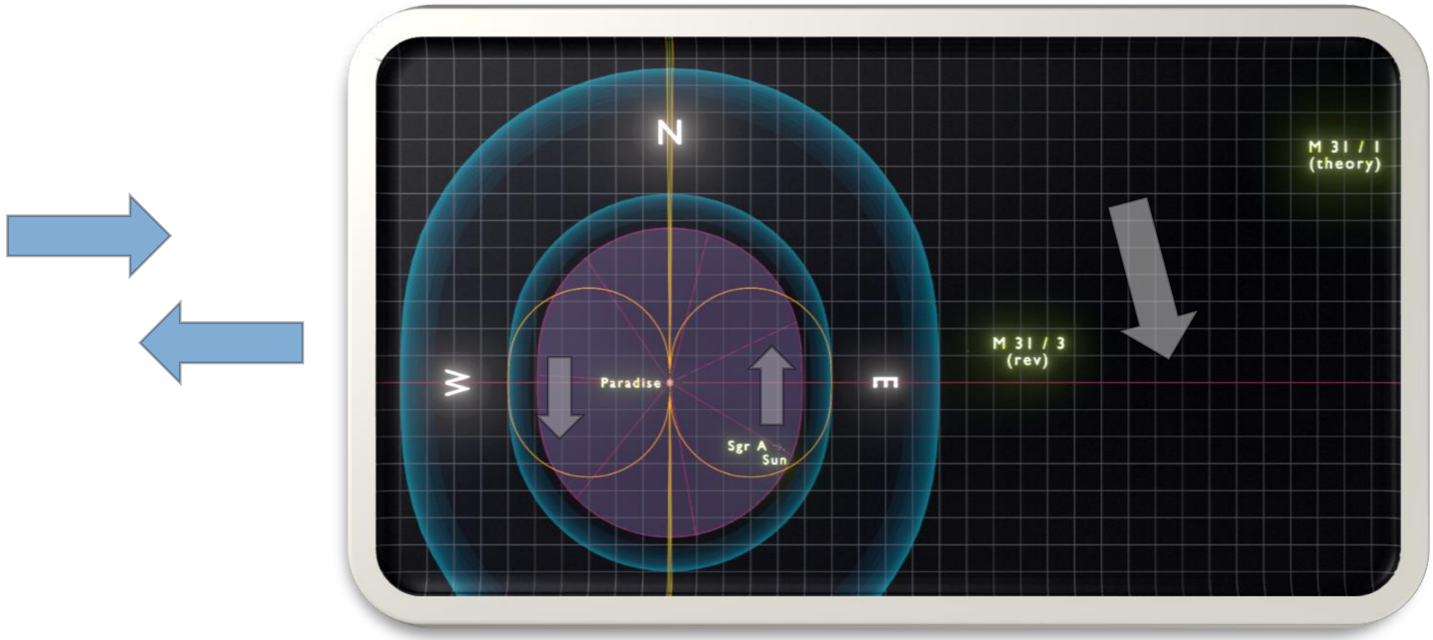



Figure 16. Placement of Andromeda (M31) using Absolute Direction. Note that the Sun and M31 are approaching each other on their separate paths. (Andromeda has a measured blueshift.) [15]

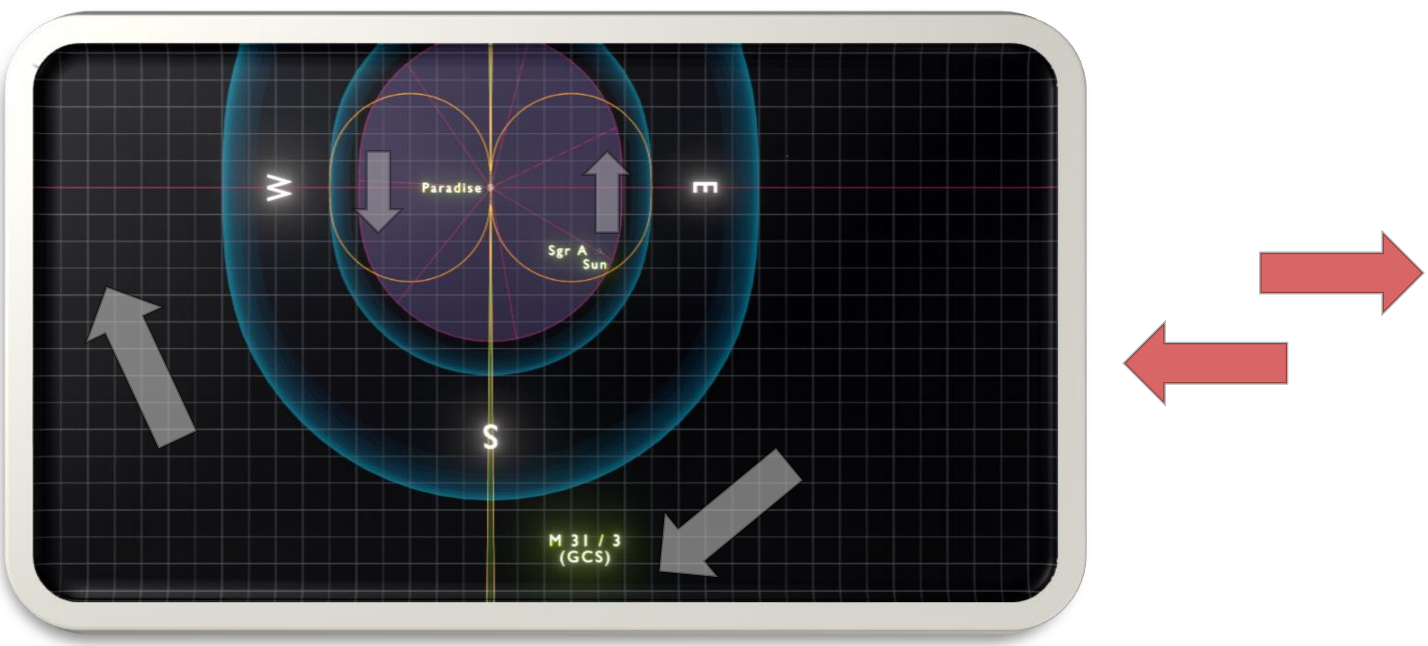



Figure 17. Placement of Andromeda (M31) using the Galactic Coordinate System. Note that with the GCS, the Sun and M31 are moving away from each other and likely would redshift.

See Appendix B for more about Andromeda's distance.

# FUTURE STUDY

Enhance the model with the placements of:

Voids

The zone of avoidance

Galaxy filaments

Telescope discoveries

Mother force circuits

Deeper examination of related matters:

Fermi Bubbles

Antigravitational Lensing

The Speed of Space

# FUTURE STUDY

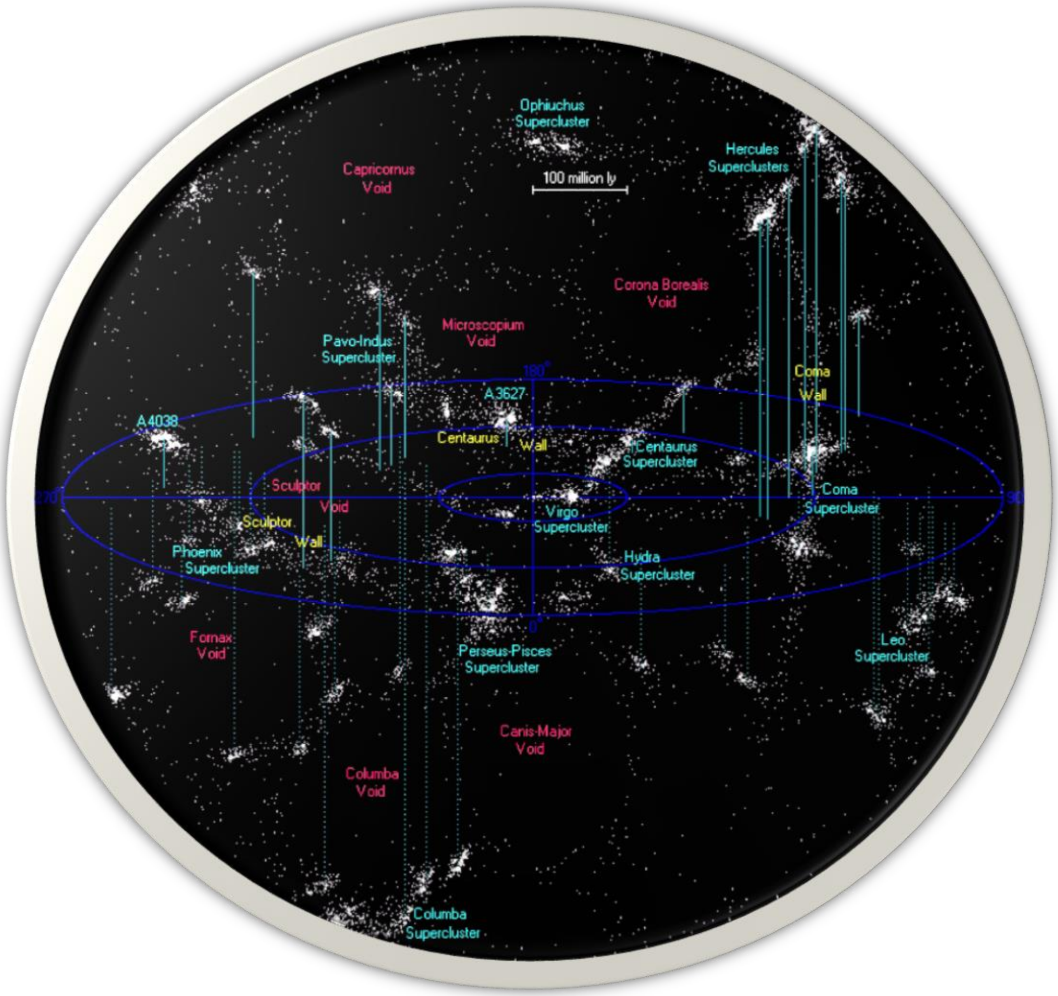



Figure 18. The universe within 200 million light-years showing the nearest galaxy walls (horizontal lines + yellow names), superclusters (teal), and voids (red). [16]

The Master Universe Model scales from 1 light-year to over 200 trillion light-years spanning seven levels. We can attempt to place the above universe structures at appropriate space levels into their regions of “lessened resistance to motion.”

## CONCLUSION

The authors acknowledge the diversity of viewpoints concerning the precise placement of objects and pathways in the master universe surrounding the Eternal Isle. We intend that the Master Universe Model (and this paper) provide Urantia students with a starting point for visually understanding concepts, not with the last word about them. Some will find this vision entirely reasonable; some reasonable in part; and some, hopefully not many, altogether unreasonable.

The presenters of the Urantia Papers provide us with a spectrum of details about the contents of the master universe. However, they did not present pictures. The images are left to be created in the minds of the readers. And it will always be true that the best way to understand the Urantia Papers is to read them. And then, to reread them.

As this model evolves, some will likely dispute the proposed shape of Paradise Isle. Some will find the size of Orvonton to be too small. Other points of issue can be anticipated. While we have endeavored to be faithful to the text and follow the patterns and architectural guidance presented therein, any cosmological model, be it revelatory or evolutionary, should be thought of as "proposed."

The revelators are the first to admit the things they do not know. The universe models in mansion world museums will blend the observations of Uversa star students with theories about regions where personal beings do not tread.

> "Through the realization of truth the appreciation of beauty leads to the sense of the eternal fitness of those things which impinge upon the recognition of divine goodness in Deity relations with all beings; and thus even cosmology leads to the pursuit of divine reality values—to God-consciousness."
>
> 56:10:8 [1]

## ACKNOWLEDGMENTS

**Marjorie Ray** provided supreme assistance and support in the assembly of this paper and the accompanying video. Her vast experience in the field of science and education contributed greatly to the work. She provided her voice, her guidance, and most importantly, her friendship, to make the process pleasant and fruitful from start to finish.

Also, sincere thanks to the other God-knowing friends who have offered time, help, and advice through the challenging course of cosmic mapmaking. Some are:

**2022 Science Symposium Team**

**Luigi Bartolomeo**

**Columbus, Ohio Study Group**

**Richard Jernigan**

**Jumping Puzzle**

**Rick & Susan Lyon**

**Ray Mohrey**

**NY/Penn Study Group**

**Steve Sawyer**

**Geoff Taylor**

**Gary Tonge**

**Technology by:**

blender Davinci Resolve PowerPoint Photoshop

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APPENDICES

Appendix A - Partial list of Urantia Book models. (Alphabetical order)

**Tom Allen**, The Great Debate on the Scale of Orvonton: A Critical Study of Urantia Book Cosmology

**Richard Bain**, video (2011), Modern Astronomy and the Urantia Book
https://www.youtube.com/watch?v=GegBhg-ztNQ

**Frederick L. Beckner** (2002), Stars, Galaxies, Superuniverses, and the Urantia Book
http://www.squarecircles.com/articles/pdf/StarsGalaxiesSuperuniversesUB.pdf

**John Causland,** video (2014), Reconciling Urantia Book Cosmology with Modern Astronomy
http://www.ubastronomy.com/

**Sergey V. Chupin** (2009), Cosmology of Uversa, Urantia and the Big Bang Myth
http://www.sciteclibrary.ru/texsts/eng/stat/st3303eng.pdf

**Norm Du Val** (1966), How Large is Orvonton, Really?
http://urantia-book.org/archive/studyaid/orvonton.html

**Dave Hansen**
https://m.youtube.com/results?sp=mAEA&search_query=Creation+tour+urantia+book+master+universe

**Richard Jernigan**, Urantia, Nebadon, and the Master Universe on Vimeo

**Dan Massey** (1979), Is the Milky Way Orvonton?
http://urantia-book.org/archive/science/milkyway.htm

**Nigel Nunn**, https://www.youtube.com/playlist?list=PLujf81__tQbQ_tAoVrvr6xOPm4XkZUStU

**George Park**, Proving Divine Providence is Responsible for Universe Evolution:
Scientific Confirmation of the Plane of Creation Revealed in The Urantia Book
June 2-5, 2016 Science Symposium, Chicago, Illinois

**William S. Sadler, Jr.,** A Study of the Master Universe

**William S. Sadler, Jr.,** Appendices to a Study of the Master Universe

**Gary Tonge,** video (2010), Journey Through the Universe – Urantia Book
https://www.youtube.com/watch?v+9CkbbohKDoY

Appendix B

## Selections from “The Universe” by Isaac Asimov about the history of Andromeda distance theories


ISBN: 0-8027-0655-X

Page 89-92

### The Andromeda Galaxy

The matter of the novae entered the problem of the Andromeda Nebula when, in 1885, one appeared in the central portions of the nebula. For the first time, a prominent star was seen in connection with the Andromeda Nebula.

There were two possibilities here. The star might exist between the Andromeda Nebula and ourselves and be seen in the nebula only because that object was in the line of sight. In that case, the star and the nebula would have no true connection. The second possibility was that the Andromeda Nebula was made up of stars too dim to be seen and that one of them had flared up into a nova and had become visible in a telescope.

If the latter were the case, it might be possible to determine the distance of the Andromeda Nebula if one assumed that novae always reached about the same peak of luminosity. In that case, variations in apparent brightness would be caused entirely by a difference in distance. If the distance of any nova could be determined, the distance of all the rest could then be calculated. The opportunity came with a nova that appeared in the constellation Perseus ("Nova Persei") in 1901. It was an unusually close nova and its distance was estimated by parallax to be about 100 light-years.

The nova that had appeared in the Andromeda Nebula, referred to now as "S Andromedae," reached only the seventh magnitude at its peak (so that it would never have been visible without a telescope) as compared with a magnitude of 0.2 reached by Nova Persei. If the two novae had indeed attained the same luminosity, S Andromedae would have to be some sixteen times as distant as Nova Persei to account for the difference in brightness. It was argued in 1911, then, that the distance of S Andromedae was 1600 light-years.

If S Andromedae were indeed part of the Andromeda Nebula, that meant the nebula, too, was 1600 light-years distant. If S Andromedae were merely in the line of sight of the nebula, the latter would have to be beyond the nova and even more than 1600 light-years from us. In either case, the nebula was at least 800 times as far from us as had been calculated from the apparent parallactic data obtained in 1907. If the nebula were 1600 light-years distant, it had to be quite large to seem as large in our telescopes as it does. It could scarcely represent a single planetary system in the process of formation as Laplace had supposed. Still, one could not yet accept the Kantian view either. Even at 1600 light-years, the Andromeda Nebula had to be merely a feature of the Galaxy.

This line of argument assumed, however, that S Andromedae and Nova Persei actually reached the same luminosity. What if this assumption were not valid? What if S Andromedae were actually much more luminous than Nova Persei ever was? Or much less luminous? How could one tell?

The American astronomer Heber Doust Curtis (1872 1942) believed that the one way of deciding this matter was to search for more novae in the Andromeda Nebula. What could not be judged in the case of one specimen might become clear in the comparative study of many. He therefore tracked down and studied a number of novae in the Andromeda Nebula, and found himself able to make two points.

First, the number of novae located in the nebula was so high (about a hundred have been detected so far) that there was no possibility that they were not associated with the nebula. To suppose that all those novae just happened to spring up among stars located in the line of sight between ourselves and the nebula was ridiculous. Such a fortuitous concentration of novae was com pletely unlikely. This further implied that the Andromeda Nebula was not merely a cloud of dust and gas passively reflecting sunlight. It had to consist of numerous stars-a very large number indeed to have so many novae (a very rare type of star) appear among them. That such stars could not be made out even by large telescopes argued that the nebula was at a great distance. Secondly, all the novae observed in the Andromeda Nebula after 1885 were far dimmer than S Andromedae had been. Curtis suggested in 1918 that these other novae should be compared with Nova Persei, and that S Andromeda was an exceptional, extraordinarily bright nova.

If the ordinary novae in the Andromeda Nebula were set equal in luminosity to Nova Persei, then the distance that would account for the unusual dimness of the former would have to be in hundreds of thousands of light-years, at the very least. Such a distance would also account for the fact that the nebula could not be resolved into stars. At such a distance, individual stars were simply too faint to be made out - unless they brightened enormously, nova-fashion.

But if the Andromeda Nebula were indeed at such a distance, it must be far outside the limits of the Galaxy and, to appear as large as it does, it must be a huge conglomeration of a vast number of stars. It was indeed an island universe of the type Kant had once described. Curtis' conclusion was by no means accepted by other astronomers, and even Shapley was opposed to him.

Entering the lists, however, was the American astronomer Edwin Powell Hubble (1889-1953). It seemed clear to him that the argument from novae would always seem inconclusive since not enough was known about them. If, however, the Andromeda Nebula were actually an island universe, then perhaps a new telescope-more powerful than any available to nineteenth-century astronomers-might settle the issue by revealing the individual stars in the nebula. From the ordinary stars, far less mysterious than the novae, it might be possible to draw firmer conclusions concerning the nebula. In 1917, a new telescope (the "Hooker telescope" made possible by the donations of John D. Hooker of Los Angeles) had been installed on Mt. Wilson, just northeast of Pasadena. It had a mirror that was an unprecedented 100 inches in diameter, making it by far the most powerful telescope in the world (and it was to remain the most powerful for a generation).

Hubble turned the Mt. Wilson telescope on the Andromeda Nebula and succeeded in making out individual stars on the outskirts. That was the final settlement of one problem: the nebula consisted of stars and not of gas and dust.

By the end of 1923, Hubble was able to identify one of the stars as a variable showing all the characteristics of a Cepheid. He located other Cepheids soon after. This was exactly what he needed. Shapley had by then worked out the Cepheid yardstick so that the period of variation of the Cepheids in Andromeda could tell Hubble at once the actual luminosity of those stars, provided one could assume that the same laws governing Cepheids in the Galaxy and the Magellanic Clouds also governed them in the Andromeda Nebula.

Once the luminosity of the Cepheids in the Andromeda Nebula was determined, one could then calculate their distance from their apparent brightness, therefore, the distance of the nebula. Hubble calculated this distance to be approximately 800,000 light-years.

By the mid-1920s, then, the matter was settled, and it has not been questioned since. The Andromeda Nebula is not a member of the Galaxy but is located far beyond its bounds. It is a vast and independent conglomeration of stars, an island universe indeed. Kant was right; Laplace was wrong.

Hubble therefore spoke of the Andromeda Nebula as one of a class of "extra-galactic nebulae," to be distinguished from the ordinary "galactic nebuiae" such as that in Orion. Shapley, now converted to the new view, felt such terms to be inadequate. The Andromeda Nebula was not to be compared with the Orion Nebula even by terminology, but only with the Galaxy. The Andromeda Nebula was another galaxy. its own right, and Shapley suggested that all such bodies be termed "galaxies."

Today, therefore, we speak of the "Andromeda galaxy." We distinguish our own galaxy either by giving it a definite article and a capital, "the Galaxy," as I have been doing in the last few chapters, or by calling it "the Milky Way galaxy."

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Page 203-208

**The Cepheid Yardstick Revised**

The distances worked out for the far-off galaxies were based on the comparison of their apparent brightness with that of near-by ones whose distance was in turn determined by the Cepheid yardstick. And of the nearby ones, the distance determination was most certain and reliable, it seemed, for the Andromeda galaxy. If the distance of the Andromeda galaxy was wrong, then all the distances were wrong; the entire scale of the Universe was wrong.

And by 1950, the uncomfortable feeling was growing that the determination of the distance of the Andromeda galaxy was indeed in error. If Andromeda was at a distance of 800,000 light-years, as the Cepheid yardstick seemed to indicate, certain peculiarities showed up. For one thing, the Andromeda galaxy seemed to be considerably smaller than our own Galaxy, perhaps only a quarter as large. There was no crime in this, taken alone, but all the galaxies whose size could be estimated seemed to be considerably smaller than our Galaxy.

One might argue that some one particular galaxy had to be larger than all the others, and we just happen to be living in that one. And yet why should our Galaxy be so much larger? Whatever process formed the galaxies produced them in a wide range of sizes. No one could argue with the fact that the Galaxy was far larger than the Magellanic Clouds, and that the Andromeda galaxy was far larger than its satellites, M32 or M33. But there were numerous members representing every portion of the range; no single galaxy was unique in size, either at the large or the small end of the scale-except our own. Our Galaxy stood alone, far larger than the rest.

Furthermore, our Galaxy was the wrong shape to be so large. Where galaxies could be compared directly, it was always the elliptical galaxies particularly the spheroidal ones classified as EO-that were the giants. Why should the largest of all, our own Galaxy, be a spiral?

What was worse still was that our Galaxy was not only larger all together, but that its component parts were larger and brighter than the analogous component parts in other galaxies such as the Andromeda.

For instance, the Andromeda galaxy has a halo of globular clusters about its center, just as our own Galaxy has (see page 58). The number of globular clusters, their appearance, and their distribution, are all very similar in both cases. One could, how ever, begin with the apparent brightness of the individual globular clusters of Andromeda and, considering them to be at a distance of 800,000 light-years, work out what their actual luminosity must be. It turns out that the globular clusters of Andromeda are less than a quarter as bright, on the average, as our own globular clusters are, and only about half as wide in diameter. Even individual stars showed the same effect. Ordinary novae, appearing in Andromeda, usually attained considerably less lumi nosity than novae in our own Galaxy did, allowing for an 800,000 light-year distance.

To suppose that our own Galaxy was not only a giant among galaxies, but that it was made up of globular clusters that were giants among globular clusters, and of stars that were giants among stars, was asking too much. It looked almost as though we were looking at the Andromeda galaxy (and, therefore, at the other galaxies, too) through a diminishing glass that was reducing everything about it in size. Since everything about the Andromeda galaxy was determined on the basis of its distance, the question had to arise as to whether that distance might not be wrong. Since the distance, as accepted in 1950, depended, in turn, on the Cepheid yardstick, the question had to arise as to whether there might not be something wrong with the Cepheid yardstick. Baade, in the early 1950's, addressed himself to this question. He reasoned that the stars of the Magellanic Clouds and of the globular of our own Galaxy were of Population II (see page 179), the generally smaller and stabler of the two populations. It had been Population II Cepheids, therefore, that had been used to set up the period-luminosity law in the first place, and it had been those which had been used to determine the scale of our Galaxy and the distance of the Magellanic Clouds.

However, the Cepheids that had been used to determine the distance of the Andromeda galaxy (and therefore, indirectly, of all the far-off galaxies) had been those of the spiral arms of the Andromeda because the giant blue-white members of the Population I stars in those arms had been the most easily seen at Andromeda's vast distance. Could it be that the Population I Cepheids of the spiral arms of Andromeda did not follow the same period-luminosity law followed by the Population II Cepheids that Leavitt and Shapley had worked with?

Certainly, there seemed to be considerable difference between the two types of Cepheids. The Population II Cepheids included a considerable number with particularly short periods running from an hour and a half to a day, whereas such periods were quite rare among the Population I Cepheids, where periods of several days to several weeks were much more common. Sec ondly, the Population II Cepheids were, on the whole, smaller and dimmer than the Population I Cepheids. This second difference was masked by the fact that the Population I Cepheids in our own Galaxy, located in the dusty spiral arms, were dimmed and reddened by the interstellar dust by an amount that had not been properly allowed for.

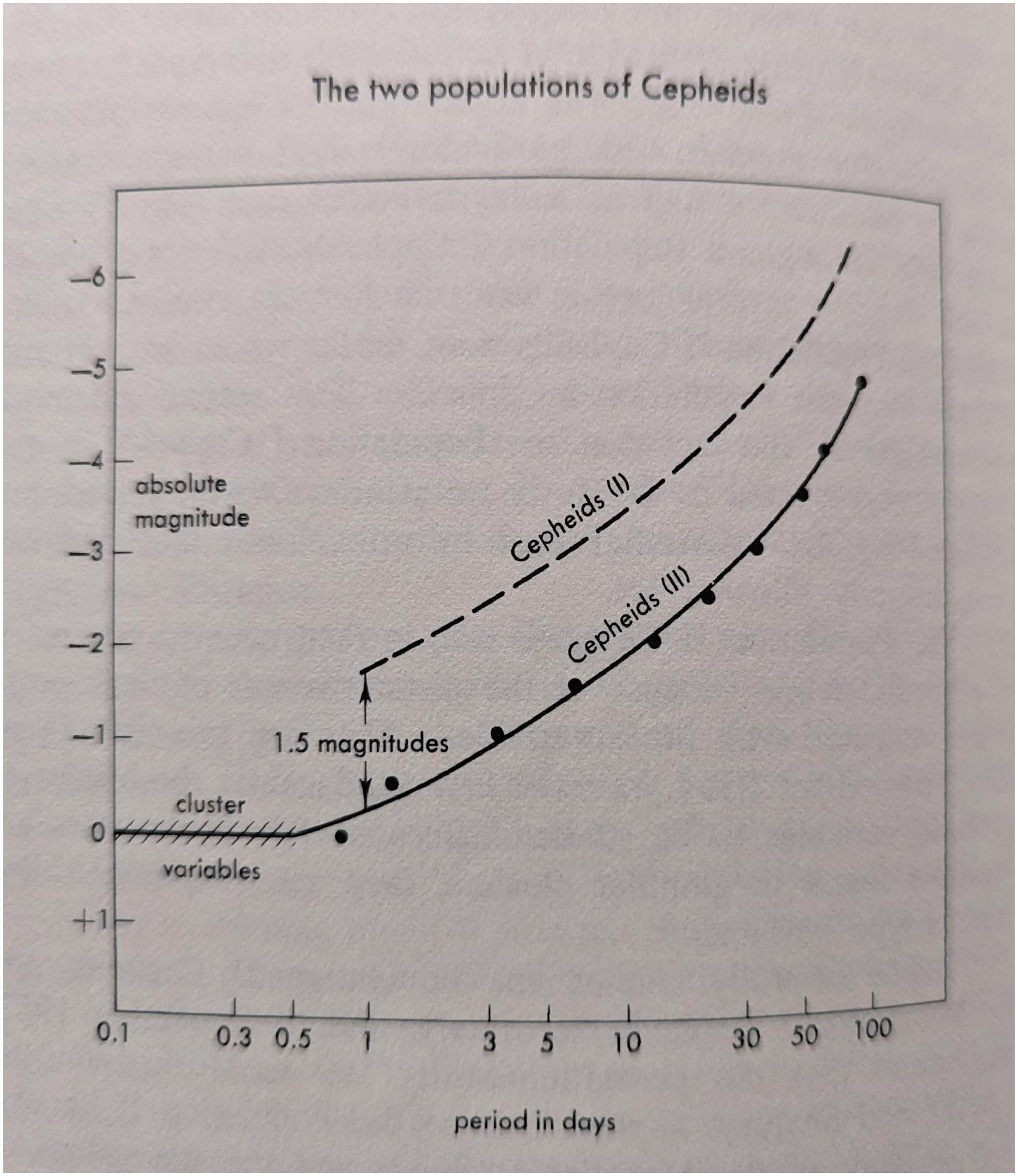
The Population II Cepheids are, in fact, even in possession of a special name because of the distinctiveness of their properties compared with other variables. They are the "RR Lyrae stars," named for RR Lyrae, the first (and nearly the brightest) of these variables to be studied. Because RR Lyrae stars are regularly found in globular clusters, they are sometimes called "cluster-type variables."

Baade carefully studied the Population II Cepheids and the Population I Cepheids separately, and in September 1952, announced that the period-luminosity law as worked out by Leavitt and Shapley, applied only to the Population II variety. The distance of the Magellanic Clouds and the dimensions of our Galaxy were therefore correct. The Population I Cepheids, however, followed a somewhat different relationship and for a given periodicity were a magnitude or two brighter than would have been expected from the ordinary relationship used by Shapley.

Let us see what this means. Suppose we observe a distant Cepheid with a period that yields us an absolute magnitude of -1. This means that if it were 32.5 light-years (10 parsecs) from us, it would appear to have a magnitude of -1. To be reduced from 1 to its actual magnitude of something like 20, it would have to be some 24,000 times more distant than 32.5 light-years -or 800,000 light-years away.

But suppose it turned out that, using Baade's new period luminosity scale for Population I Cepheids, the particular Cepheid under study had an absolute magnitude of -3 rather than-1. It would then be more than six times as bright as had been thought.

**The two populations of Cepheids**



In order to reduce such a six-times-brighter star to a magnitude of about 20, it would have to be placed correspondingly farther off-58,000 times more distant than 32.5 light-years, or nearly

2,000,000 light-years away. By using the revised Cepheid yardstick and adding some additional refinements that now appear necessary, the Andromeda galaxy is today thought to be some 2,700,000 light-years away. All other galaxies beyond the Andromeda must be moved correspondingly.

This removed, at once, all the uncomfortable uniqueness of our Galaxy. If Andromeda is 2,700,000 light-years away (rather than 800,000) and still appears as large and as bright as it does in a telescope, it must be much larger and brighter in actual fact than had been supposed in the days when the shorter distance was accepted.

Nowadays, the Andromeda galaxy is accepted as being some what larger than our Galaxy. The Andromeda is as much as 200,000 light-years across and contains as many as 300,000,000, 000 stars. Moreover, its globular clusters, which are also farther away than had been thought, are now seen to be larger and brighter than they had been considered as large and as bright, in fact, as our own globular clusters. The novae in the Andromeda are also as large and as bright as those in our own Galaxy. Further more, all other galaxies are now seen to be larger and brighter than had been thought, and many of the spirals rival our Galaxy in size, while some spheroidal galaxies may be ten to thirty times as large.

Our Galaxy remains a giant galaxy, but it is no longer unique, no longer a one-of-a-kind monster. The 135-billion-star Milky Way Galaxy fits well in a Universe that contains galaxies varying in star number from 10- to 5000-billion.

Since this new scale of distance has removed the most serious peculiarities from the galactic scene, astronomers are hopeful that they now have the scale about right. Certainly in the years that have passed since Baade's correction, nothing has happened to shake this faith. In fact, since Baade's death in 1960, astronomers such as the Russian-American Sergei Illarionovich Gaposchkin (1898 ) have continued analyzing the photographs of Andromeda taken by Baade, using the 200-inch telescope, and have

confirmed his work completely. The new scale of distance has not, of course, affected the red-shift determinations. These determinations are independent of distance. The Virgo cluster of galaxies is receding from us at a rate of 710 miles per second whatever distance we determine for it. From the brightness of its brighter members, as compared with the brightness of the Andromeda galaxy, it is still 16.5 times as far away as Andromeda.

But now that the accepted distance of Andromeda has been tripled, so must the accepted distance of the Virgo cluster. It must now be considered at a distance of 2,300,000 X 16.5 light-years or something like 38,000,000 light-years away, rather than merely 13,000,000.

To determine Hubble's constant, we divided the velocity of recession of a galaxy or cluster of galaxies by the number of millions of light-years it is distant from us. Instead of dividing 710 by 13, we must now divide it by 38, so that Hubble's constant comes out to be 18.5 rather than 55. If anything, this still probably errs on the side of conservatism. Let us therefore set the value of Hubble's constant at 15.

To determine the distance at which a galaxy must be receding at the speed of light, let us once again use the equation: $D = V/k$, setting V equal to 186,282, and k, this time, at 15. It turns out that D equals 12,500 and we can therefore say that a galaxy at a distance of 12,500 million light-years, or 12.5 billion light-years, can no longer be detected. That is the limit of the observable Universe, or the "Hubble radius."

To put this another way, we can say that the diameter of the sphere of the observable Universe (with ourselves at the center) is 25 billion light-years. - a diameter nearly four times that, thought correct as late as 1950.