A Dynamic Model of the Grand Universe

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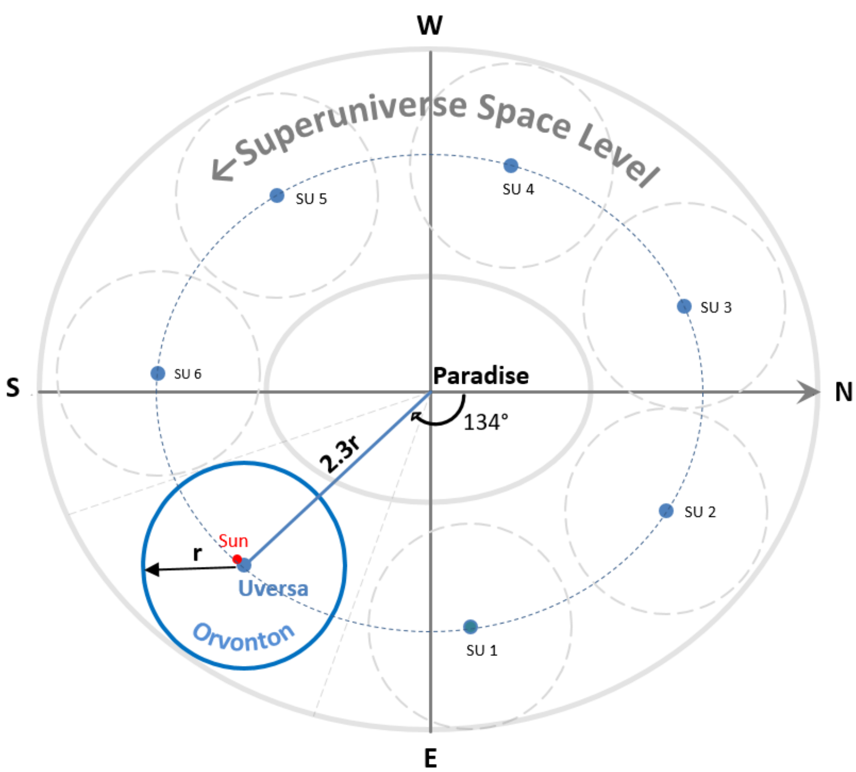
Ex. 1 Overhead View of the Plane of the Grand Universe



The Urantia Book contains a unique and beautiful cosmology. The galaxies of the universe are organized in concentrically arranged elliptical space levels which revolve about the Isle of Paradise, the dwelling place of God. Our Milky Way galaxy is part of Orvonton, one of seven superuniverses found in the superuniverse space level shown in Exhibit 1. Uversa is the headquarters world of Orvonton and is at the rotational center of our superuniverse. From the geometry of the superuniverse space level, the distance from Uversa to Paradise is 2.3 times the radius of Orvonton, since each superuniverse occupies one-seventh of the space level. Is there some cosmic structure we can see through our telescopes that matches this ideal model of the grand universe?

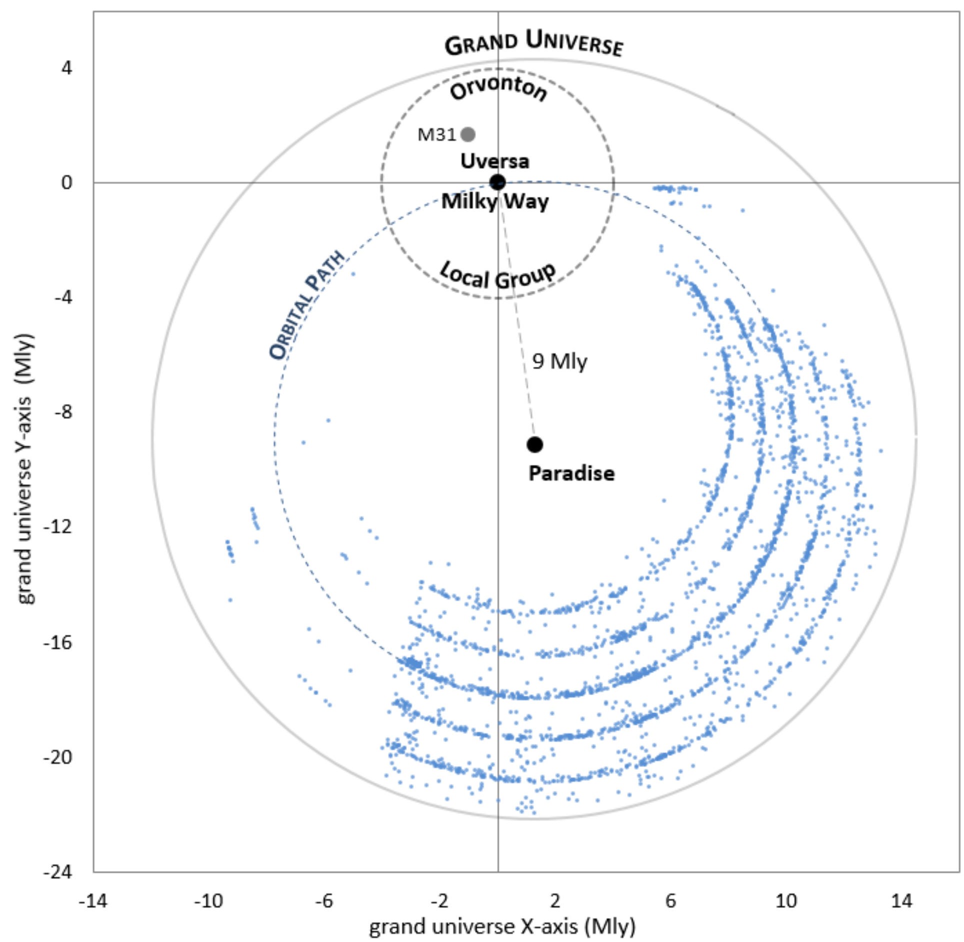
Recent advances reveal a ring-like structure which is 26 million light-years (Mly) in diameter. This circular arrangement of galaxies appears to match the form and size of the superuniverse space level, if Orvonton is a structure called the Local Group. This paper gives a brief overview of this cosmic structure, which is considered in depth elsewhere. The main focus is upon the organized motions of galaxies within 135 Mly, an area of investigation astronomers refer to as the local velocity field. Over the last few decades, half a dozen motions have been identified which characterize the kinematics of galaxies within this region. Of these, only the sun's motion about the Milky Way is explained by gravitational revolution.

Gravitational revolution is the unifying characteristic of the grand universe model. Is this revealed model consistent with these identified motions in the local velocity field? More specifically, are the two cosmic structures tentatively identified as Orvonton and the superuniverse space level able to explain the origins, directions, and amplitudes of these local field velocities? The grand universe model appears consistent with these cosmic structures and with these local field velocities. It is able to systematically explain both in terms of gravitational revolution about Uversa and Paradise.

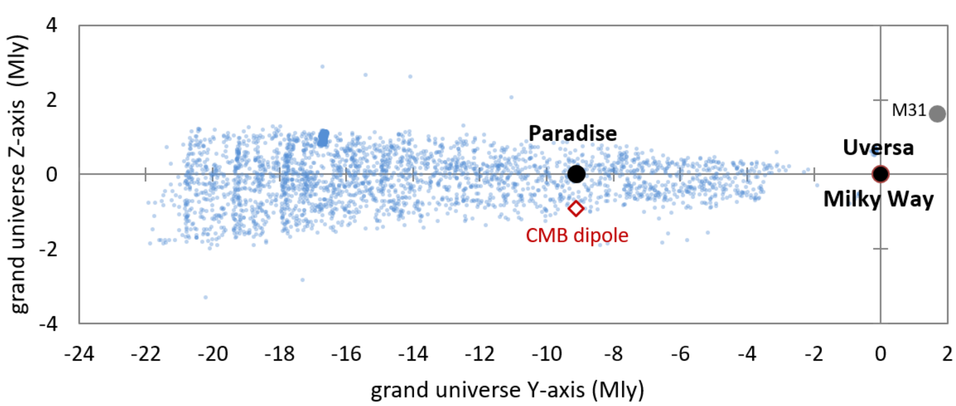
1. The Superuniverse Space Level

Numerous statements suggest that Orvonton is what astronomers call the Local Group of galaxies, [4] which was first identified in the 1930s by Edwin Hubble. The maximum estimated radius of the Local Group is 4 Mly. If Orvonton is the Local Group, the model predicts the distance to Paradise is 2.3 times 4 Mly or 9.2 Mly. Given this predicted radius for Orvonton, the other six superuniverses should be found well within 36 Mly of us. There is, in fact, a circular structure within this region of space that matches this description and includes the Local Group.

Ex. 2 Overhead View of the Galaxies in the Plane of the Grand Universe



Ex. 3 Side View of the Galaxies in the Plane of the Grand Universe



Overhead and side views of this cosmic structure are charted in Exhibits 2 and 3. This planar structure is contained within a radius of 23 Mly or 7 megaparsecs (Mpc; 1 Mpc equals 3.26 Mly). The distance to the center of this circular structure is 9 Mly, which is in good agreement with the size difference between Orvonton and the superuniverse space level. This scale relationship structurally corroborates the hypothesis that Orvonton is the Local Group.

Several thousand galaxies are found within this annular structure, which is tilted 61° to the galactic plane, the plane of the Milky Way. The details on how this structure is identified are given in a 2013 work by the author. [8] This work also explains the construction of the spherical coordinate system based upon the gravitational plane of the grand universe. An overview of how this cosmic structure is aligned with other space levels in the plane of creation is presented in a 2016 paper. [9] By coincidence, this planar concentration of galaxies is tilted slightly less than 1.5 degrees to the earth's equatorial plane, also called the celestial plane. In the grand universe coordinate system, Paradise has a longitude of $\alpha = 278$ and a latitude of $\beta = 0$. In the galactic coordinate system, which is based upon the plane of the Milky Way, this transforms to a longitude of $l = 259.0$ and a latitude of $b = 52.9$. (Appendix A gives the formulae for transforming galactic into grand universe coordinates.) The temperature of the cosmic microwave background (CMB) radiation is warmest in a direction that is 5.7 degrees directly below Paradise. This direction is referred to as the CMB dipole. In the grand universe model this is the direction to the point of space respiration located "just below" Paradise.

This circular structure spans 150° of a circle. The remainder of this structure is hidden behind the dense belt of stars in the Milky Way. This region of the sky is known as the zone of avoidance and extends about 10° above and below the galactic plane. The dashed circle running through the central core of this structure passes exactly over Uversa at the center of Orvonton. This circle is the orbital path of the superuniverse capitals.

The physics of gravitational revolution should cause the highest number of galaxies to occur along this orbital path. In our solar system both the asteroid and Kuiper belts have central cores, where the density of objects is highest. Moving inward and outward from this central core, the density decreases. This diminishing density on either side of these central cores roughly approximates a statistically normal distribution. The distribution of galaxies in this circular structure is consistent with this density profile. One-third of all galaxies are concentrated in the single arc aligned with the orbital path. The galactic density here is 2.5 times greater than it is in the arcs immediately adjacent on either side. This density profile is consistent with a belt of galaxies revolving about a center 9 Mly from us.

In the grand universe (GU) model the Milky Way and the galaxies along this orbital path are revolving about Paradise. This leads to the expectation that there should be little or no relative motion between them and us. The situation is analogous to cities located along the earth's equator. These cities have a velocity of 460 m/s (1000 mph) due to the rotation of the earth, but there is no relative motion between them. Heliocentric redshift measurements for these galaxies show there is no displacement in their spectra; they have no observable motion relative to the sun, which is consistent with the expectation of the model. It is a remarkable fact that the highest galactic density within 36 Mly occurs along a circular arc made up of more than a thousand galaxies which are stationary in the sun's frame of reference. This fact is consistent with the common revolution of these galaxies and the Milky Way about a location 9 Mly distant.

There is substantial structural evidence supporting the hypothesis that this observable structure is the superuniverse space level. If this is true, the GU model should be able to explain the organized motions of galaxies which have been identified within the local velocity field. Before considering how consistent these motions are with the model, it is necessary to briefly review the difference between the expanding motion of space itself and the motions of galaxies within expanding space.

2. The Proper Motion of Space and the Peculiar Motions of Galaxies

The discovery of space expansion comes from an empirical relationship identified by Edwin Hubble in 1929 known as the redshift-distance relation. [3] Hubble discovered that the distance D to a galaxy is directly proportional to the redshift z in its light spectrum, such that $z \propto D$. Redshift means the wavelengths of light become longer, shifting them toward the red end of the light spectrum. The redshift z in the spectrum of a galaxy's light is simply related to the velocity v which causes this redshift by $v = cz$, where c is the speed of light (for a velocities much smaller than c). It was discovered that the redshift-distance relation is constant for all galaxies, so $k = cz/D$, where k is a universal constant called the Hubble constant H_0. This leads directly to Hubble's formula for the proper velocity of space expansion.

$$v_{prop} = H_0 D$$

The current determination of the Hubble constant is $H_0 = 72\ \mathrm{km\ s^{-1}/Mpc}$ (kilometers per second per megaparsec, where 1 Mpc = 3.26 Mly). There are two major causes for a galaxy's observed redshift. [1] There is a Doppler redshift caused by the *peculiar motion* of a galaxy through its local region of space. The second is a cosmological redshift caused by the *proper motion* of space expansion. *Peculiar* and *proper* are technical terms designating two different causes for observed velocities. Doppler redshifts only occur at the moment the light is emitted or observed. Cosmological redshifts only occur during the time between the moments of emission and observation. While light is in transit from a galaxy to an observer, the space between them undergoes a metric expansion, which causes the wavelengths of light to increase in length. Doppler redshifts are only caused by peculiar motions. Cosmological redshifts are only caused by the proper motion of space expansion.

Peculiar motion *through* space matches our intuition of motion, but the proper motion *of* space, its metric expansion, is not intuitive. A common two-dimensional analogy for space expansion is an elastic sheet. Such a sheet can be uniformly stretched outward from its center. Imagine drawing a small circle on the surface of a partially inflated balloon and marking its center with a dot. The surface enclosed by the circle is virtually flat like a sheet, if the circle is small enough. As the balloon inflates, the circle uniformly expands away from the dot at its center, which is the one stationary point on the circumscribed surface. Expansion causes all of the molecules (geometric points) making up the sheet (space) to recede from each other by the same distance over the same time. There is a universal rate of expansion between all molecules in the elastic sheet.

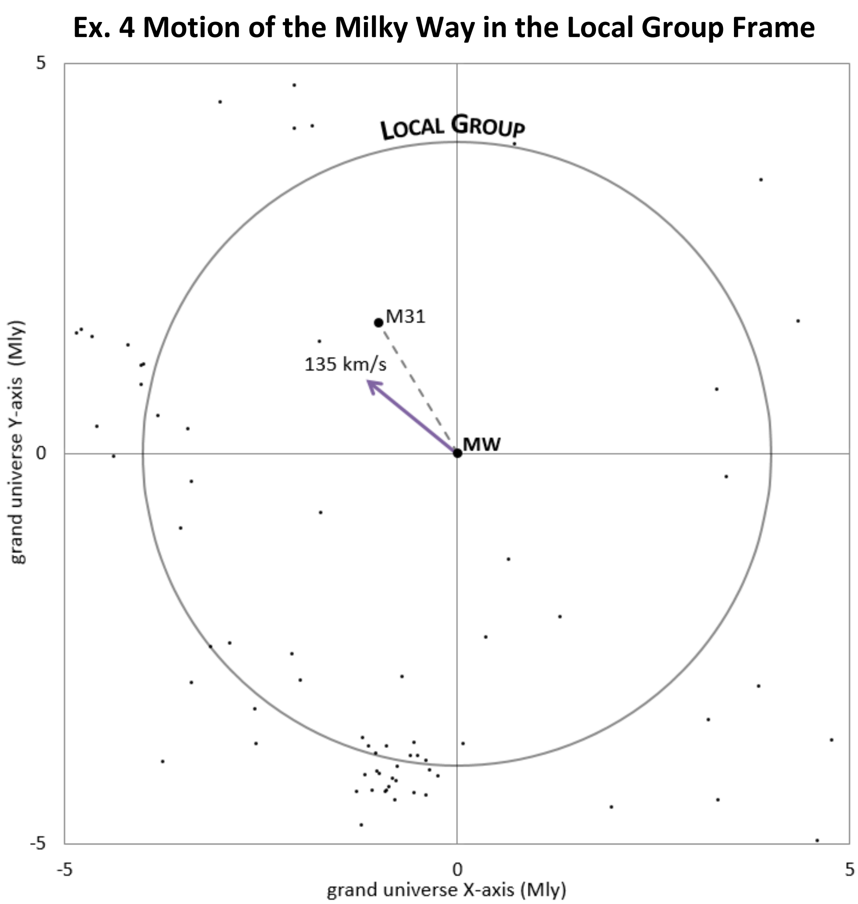
This analogy can be extended to include the cosmic microwave background (CMB) radiation. In the standard model this radiation would be emitted from the circumference of this circle toward the sun's location at the central dot. Over the course of 13.8 billion years, the radius of the circle increases 1100 times. This metric expansion of space causes the wavelengths of the CMB photons to be stretched, until they are 1100 times longer than they were when emitted. This stretching causes the temperature of the radiation to drop from 3000° K to 2.7° K.

At distances greater than a few hundred million light-years, the peculiar velocities of galaxies are relatively insignificant. But within 135 Mly, the region of the local velocity field, peculiar velocities can make a receding galaxy appear much closer or farther away than it actually is. Within this region the distance to the galaxy cannot be reliably determined from its observed velocity v_{obs}. However, if the distance D to a galaxy is known independently of its redshift, its proper velocity v_{prop} can be found with Hubble's equation. Its observed and proper velocities then give its peculiar velocity v_{pec}.

$$v_{pec} = v_{obs} - v_{prop}$$

If subtracting the proper velocity from the observed velocity gives a positive velocity, there is a peculiar receding velocity between us and the galaxy. If the result is a negative velocity, there is a peculiar approaching velocity between us and the galaxy. (By convention, objects approaching each other have negative velocities, while objects receding from each other have positive velocities.)

3. Peculiar Velocities in the Local Velocity Field



The peculiar motion of the earth causes a Doppler shift in the spectra of galaxies. The earth orbits the sun at 30 km/s, which systematically alters all earth-bound measurements of galactic redshifts over the course of a year. To correct this, redshifts are routinely adjusted to be heliocentric, so they reflect what would be measured at the sun. The center of the Milky Way is currently identified with Sagittarius A* (Sgr A*), a radio source that is 26,000 light-years distant. The solar system orbits Sgr A* at 219 km/s. The spectra of galaxies in the direction of this peculiar velocity are blueshifted by 219 km/s, while those in the opposite direction are redshifted. This peculiar motion requires a second correction. The Milky Way moves at 135 km/s in the Local Group frame of reference (Exhibit 4), which requires a third correction. These corrections remove the distortions to galactic redshifts caused by these peculiar motions.

Ex. 5 Peculiar Velocities in the Local Velocity Field (per Tully 2008)

Velocity	*Galactic coordinates*		*Grand Universe coordinates*	
Sun's total peculiar velocity toward the CMB dipole				
$\mathrm{V}_{\mathrm{CMB}}^{\mathrm{sun}} = 371 \pm 1$ km/s	$l = 264.1$	$b = 48.3$	$\alpha = 278.0$	$\beta = -5.7$
Sun's orbital velocity about the Milky Way center				
$\mathrm{V}_{\mathrm{MW}}^{\mathrm{sun}} = 219 \pm 12$ km/s	$l = 87.6 \pm 1$	$b = 2 \pm 1$	$\alpha = 64.8$	$\beta = 47.1$
Milky Way's velocity in the Local Group frame				
$\mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}} = 135 \pm 25$ km/s	$l = 137 \pm 10$	$b = -18 \pm 10$	$\alpha = 140.9$	$\beta = 41.4$
Local Group's velocity in the Local Sheet frame				
$\mathrm{V}_{\mathrm{LS}}^{\mathrm{LG}} = 66 \pm 24$ km/s	$l = 349 \pm 37$	$b = 22 \pm 20$	$\alpha = 349.3$	$\beta = -22.6$
Local Sheet's velocity in the Virgo Supercluster frame caused by the Local Void				
$\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS \leftarrow LV}} = 259 \pm 25$ km/s	$l = 210 \pm 7$	$b = -2 \pm 6$	$\alpha = 209.7$	$\beta = 1.6$
Local Sheet's velocity in the Virgo Supercluster frame caused by the Virgo Infall				
$\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS \rightarrow VCL}} = 185 \pm 20$ km/s	$l = 283.8$	$b = 74.5$	$\alpha = 297.7$	$\beta = 13.8$
Local Sheet's net velocity in the Virgo Supercluster frame				
$\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}} = 323 \pm 25$ km/s	$l = 220 \pm 7$	$b = 32 \pm 6$	$\alpha = 244.4$	$\beta = 9.3$

Acronyms. MW: Milky Way; LG: Local Group; LS: Local Sheet; VSC: Virgo Supercluster; CMB: cosmic microwave background; VCL: Virgo Cluster; LV: Local Void

These motions occurs within the space of the Local Group, which is unlike the space surrounding it. In the standard model of cosmology there is no space expansion within the Local Group. The galaxies in this group are bound together by gravity, and this binding prevents their general dispersion by space expansion. The Local Group is considered an island of non-expanding space in a universal sea of expanding space.

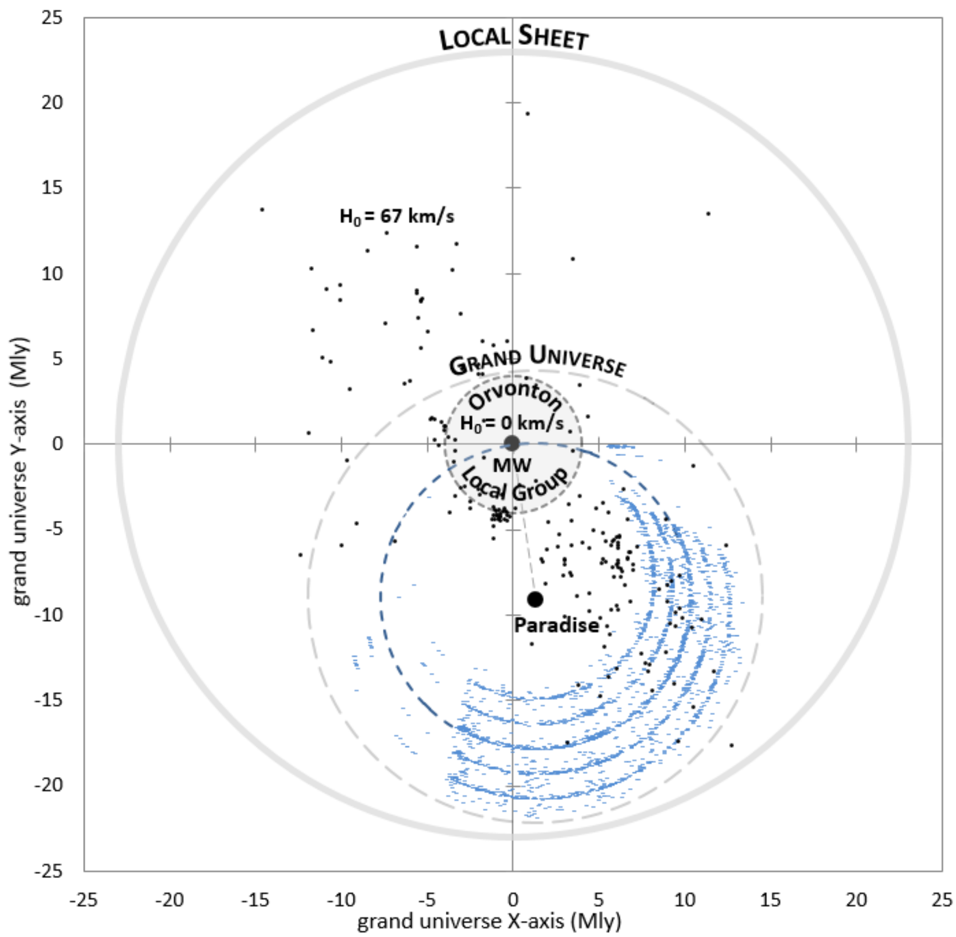
The organized motions of galaxies in the local velocity field are addressed in a 2008 study by the well-known astrophysicist R. Brent Tully. [10] These motions are listed in Exhibit 5. This study analyzes the peculiar motions of 1791 galaxies within 42 Mpc (135 Mly). Each of these galaxies has a redshift-independent distance measurement, which makes it possible to determine their peculiar velocities. Tully identifies the peculiar motions occurring within different frames of reference by performing vector analyses of peculiar velocities within progressively larger regions of space. Theoretically, the peculiar motions of galaxies should be randomly directed, so the vector addition of a large enough sample of peculiar velocities should result in no net motion.

Tully examines the peculiar motions of 40 galaxies in the Local Group and finds their motions are minimized when the Milky Way has a velocity of $\mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}} = 135$ km/s in the general direction of the Andromeda galaxy, which is 2.5 Mly distant. This direction is only 17° from the direction to Andromeda (M31). (see Appendix B for how to find the angle of separation.) Tully remarks that "The offset of the vector of our motion from M31 is sufficiently uncertain that a direct hit on M31 is not precluded." It has been known for a hundred years that there is an approaching motion between the Milky Way and M31. It has long been assumed that a gravitational attraction between the two is the cause. A "direct hit" on M31 would be consistent with this explanation.

Tully reports the recent discovery of a new cosmic structure he calls the Local Sheet, at the center of which he locates the Milky Way. This structure is shown in Exhibit 6. The Local Sheet has a radius of 7 Mpc (22.8 Mly), which is just large enough to completely encompass the superuniverse space level.

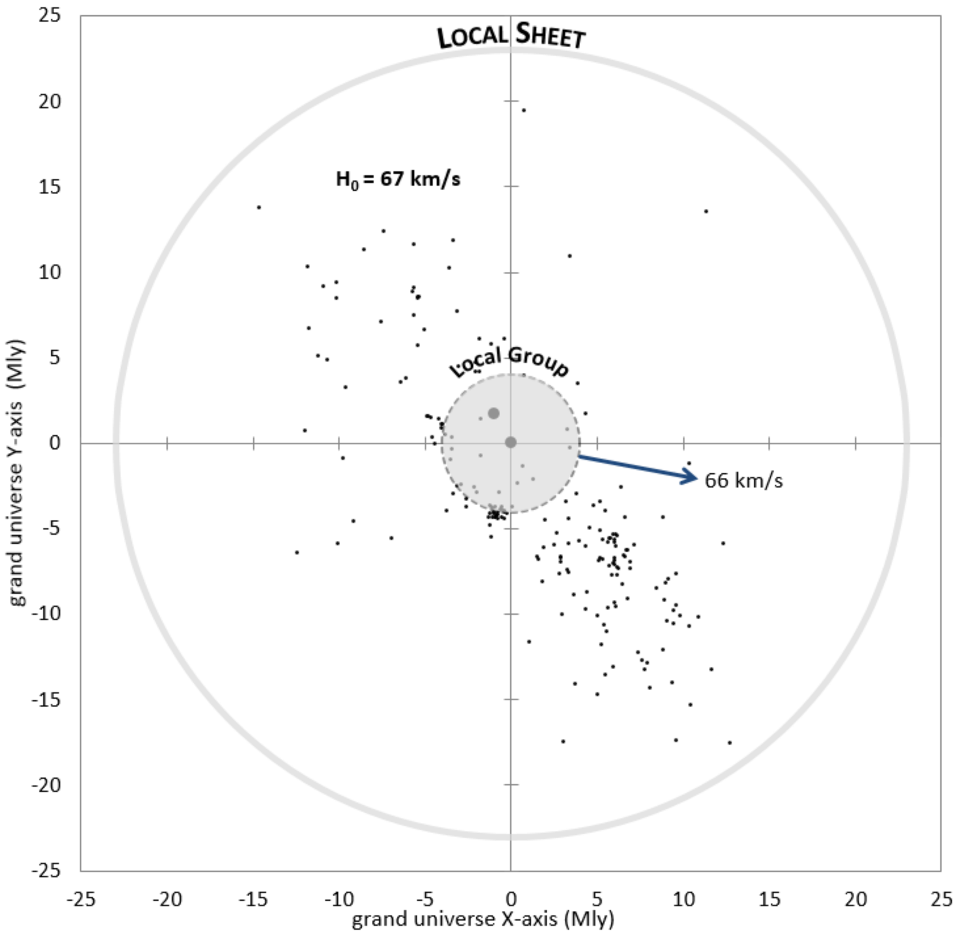
Unlike the static space within the Local Group, space expands within the Local Sheet. There are 158 galaxies outside the Local Group (> 1.1 Mpc or 3.6 Mly) but within the Local Sheet (< 7 Mpc or 22.8 Mly). These galaxies are shown as black dots in Exhibit 6. Tully finds their proper motions are best explained by an expansion rate of $H_0 = 67$ km/s/Mpc. This expansion rate is less than the cosmic rate of $H_0 = 72$ km/s/Mpc. Tully ascribes this lower rate to the higher than average mass density in the Local Sheet. This higher density increases the effects of gravitational forces, which results in "a local retardation of the cosmic expansion."

Ex. 6 The Local Sheet contains all of the Grand Universe



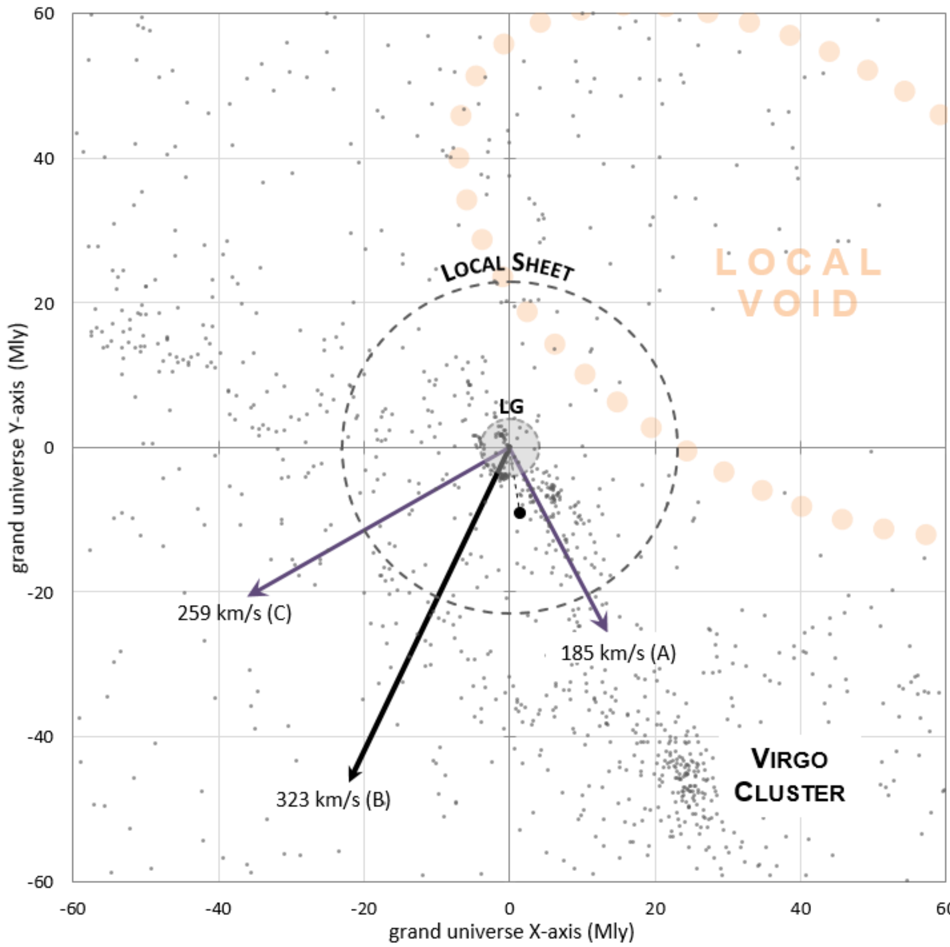
Tully notes that the peculiar motions of the 158 galaxies in the Local Sheet are unusually small, averaging less than 40 km/s. Almost all of their motion is caused by space expansion. This implies that the galaxies in the Local Sheet form a unit. (The grand universe forms a unit.) The small peculiar motions of Local Sheet galaxies are minimized when the whole Local Group moves at 66 km/s within the frame of the Local Sheet. This Local Group velocity of $V_{LS}^{LG} = 66$ km/s is in roughly the opposite direction of Andromeda, as shown in Exhibit 7. This peculiar motion of the Local Group within the Local Sheet frame requires a fourth correction to galactic redshifts.

Ex. 7 Motion of the Local Group in the Local Sheet Frame



The local expansion rate of H_0 = 67 km/s/Mpc distinguishes the Local Sheet (grand universe) from surrounding space. A second characteristic is the low peculiar velocities of galaxies in the Local Sheet, which implies it is a somewhat coherent structure. A third distinguishing feature is "an abrupt break in the amplitude and direction of galaxy motions," which occurs at the border of the Local Sheet. Just beyond 7 Mpc, galaxies no longer have unusually small peculiar velocities of less than 40 km/s. They tend to have receding peculiar velocities of a few hundred kilometers per second away from the Local Void. This region of very low galactic density is shown in the upper right quadrant in Exhibit 8. In the opposite direction galaxies tend to have approaching peculiar velocities of the same amplitude. Tully labels this general pattern in peculiar velocities the "local velocity anomaly." [11] This anomaly at 7 Mpc, where peculiar velocities suddenly jump six fold, can be explained if the Local Sheet is moving at approximately 260 km/s in the general direction of vector (C) in Exhibit 8.

Ex. 8 Motions of the Local Sheet in the Virgo Supercluster Frame



The Local Sheet is considered part of the Virgo Supercluster complex. This supercluster is centered on the Virgo Cluster 54 Mly distant (16.5 ± 0.4 Mpc). This region of space is distinguished from the Local Sheet by its conformance to the cosmic expansion rate of 72 km/s/Mpc. From a vector analysis of the peculiar velocities of 683 galaxy groups (> 1500 galaxies) between 23 and 135 Mly distant, Tully finds the Local Sheet has a peculiar velocity of $V_{VSC}^{LS} = 323\text{ km/s}$, shown as (B) in Exhibit 8, toward a sparsely populated region. This motion can be referred to as the Local Sheet apex. There is no significant concentration of mass in this direction which might attract the Local Sheet and explain this motion. This leads Tully to surmise that the Local Sheet apex "can be decomposed into the components toward the Virgo Cluster and away from the Local Void."

The component toward the Virgo Cluster is known as the Virgo Infall, shown as (A) in Exhibit 8. This peculiar motion was identified in the 1980s. [12] At an expansion rate of

72 km/s/Mpc and a distance of 16.5 Mpc, the Virgo Cluster should have a proper velocity of 1188 km/s. However, its redshift is only 1003 km/s, when adjusted to the frame of the Local Sheet. This leads to the conclusion that the Local Sheet has a peculiar velocity toward the Virgo Cluster of $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}\rightarrow\mathrm{VCL}} = -185$ km/s, since $v_{pec} = v_{obs} - v_{prop}$. Tully attributes this velocity to a gravitational attraction exerted upon the Local Sheet by the Virgo Cluster, which is the consensual explanation.

The second component is the local velocity anomaly. The 185 km/s of the Virgo Infall plus the 260 km/s for this anomaly are able to explain the 323 km/s of the Local Sheet apex. On this premise Tully calculates the exact direction the local velocity anomaly must have in order to explain the apex motion. This direction gives the Local Void vector a velocity of $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}\leftarrow\mathrm{LV}} = 259\,\mathrm{km/s}$, which is shown as (C) in Exhibit 8. Working the other way, the vector addition of the Virgo infall and Local Void vector gives the precise amplitude and direction of the Local Sheet apex. (see Appendix C on vector addition.)

These six motions are clearly identified and explained in Tully's model of the local velocity field. In the GU model the three motions occurring within the Local Sheet frame – $\mathrm{V}_{\mathrm{MW}}^{\mathrm{sun}}$, $\mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}}$, and $\mathrm{V}_{\mathrm{LS}}^{\mathrm{LG}}$ – need to be explained as motions occurring in the Orvonton frame. The three motions occurring within the Virgo Supercluster frame – $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}\leftarrow\mathrm{LV}}$, $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}\rightarrow\mathrm{VCL}}$, and $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}}$ – need to be explained as motions occurring in the grand universe frame and the frame of the first outer space level.

4. The Location of Uversa at the Center of Orvonton

A working model of Orvonton is needed, before considering how motions in the Local Sheet might be explained as motions within Orvonton's structure. Identifying the center of Orvonton is a necessary first step.

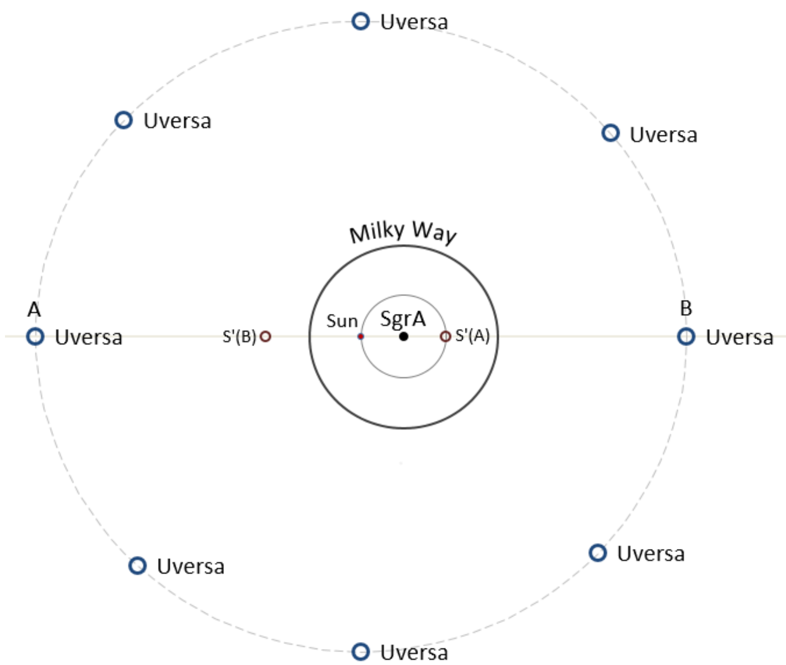
"The vast Milky Way starry system represents the central nucleus of Orvonton." **15:3.1** This appears to place the Milky Way galaxy at the center of Orvonton. But we are also informed, "The Sagittarius sector and all other sectors and divisions of Orvonton are in rotation around Uversa." **15:3.7** There is a strong consensus among students that "Sagittarius sector" refers to either the Milky Way or some subgalactic structure within it. Under either interpretation, the Milky Way revolves about Uversa, and Uversa is something more than 200,000 light-years from us. Uversa is the center of rotation for Orvonton.

From Jerusem, the headquarters of Satania, it is over two hundred thousand light-years to the physical center of the superuniverse of Orvonton, far, far away in the dense diameter of the Milky Way. Satania is on the periphery of the local universe, and Nebadon is now well out towards the edge of Orvonton. From the outermost system of inhabited worlds to the center of the superuniverse is a trifle less than two hundred and fifty thousand light-years. **32:2.11**

Urantia belongs to a system which is well out towards the borderland of your local universe; and your local universe is at present traversing the periphery of Orvonton. **15:1.6**

The sun is 26,000 light-years from Sgr A* at the center of the Milky Way, whose main body has a radius of 50,000 light-years. We are located on "the periphery of Orvonton." The most remote inhabited worlds are 250,000 light-years from Uversa. Uversa is located 200,000 light-years from us. From this information it is possible to map out possible locations for Uversa, as shown in Exhibit 9.

Ex. 9 Locations for Uversa that are 200,000 Light-Years Away



These locations form a circle centered on the sun. If Uversa is at position ***A***, it is ~225,000 light-years from Sgr A*, since we are 26,000 light-years from Sgr A*, and Uversa is 200,000 light-years from us. The most remote inhabited worlds are 250,000 light-years from Uversa, and point S′(A) is at this distance. It takes 240 million years for the sun to complete one revolution about Sgr A*, so the sun will be at S′(A) in 120 million years. Since we are on "the periphery of Orvonton" and we will eventually be at S′(A), this location must also be on the periphery. We can infer from this that the inhabited worlds of Orvonton are within ~26,000 light-years of Sgr A*. This inhabited region is coincident with the structural center of the Milky Way. It also has the highest stellar density and, therefore, the highest potential number of inhabitable planets.

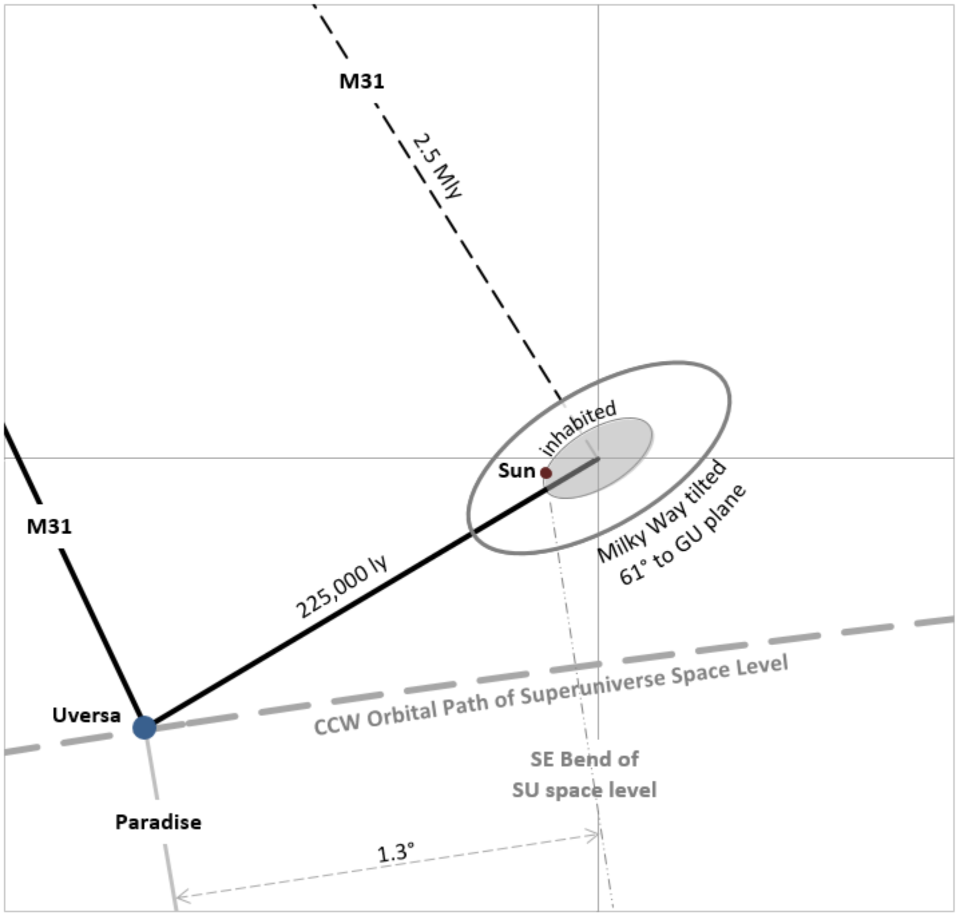
Position $\boldsymbol{A}$ for Uversa seems like the most probable location. However, in the section giving the distance to Uversa it says that Uversa is "far, far away in the dense diameter of the Milky Way." If "diameter" is interpreted in a geometric sense, Uversa would be in the direction of Sgr A*, which would put Uversa at position $\boldsymbol{B}$. But there is a different way to interpret "dense diameter" suggested by a description of the Milky Way.

> Observation of the so-called Milky Way discloses the comparative increase in Orvonton stellar density when the heavens are viewed in one direction, while on either side the density diminishes. **15:3.3**

Instead of indicating the diameter of a circle, "dense diameter" can refer to the dense belt of stars forming the Milky Way in the night sky. The direction to Uversa would then be somewhere along this dense stellar belt arcing around the celestial sphere. This tells us that Uversa has a galactic latitude that is not far above or below the galactic plane; Uversa is more or less on the galactic plane. Uversa also revolves about Paradise in the gravitational plane of the grand universe, and we can observe something which matches the descriptions of this cosmic structure. If Uversa is on both the grand universe and galactic planes, it must be located where these planes intersect. There is an angle of 61° between these two planes. The ascending node for the grand universe plane is where it crosses from below to above the galactic plane. This ascending node occurs at $\alpha = 212.9$, $\beta = 0$ in grand universe coordinates and $l = 212.9$, $b = 0$ in galactic coordinates. The descending node is 180° from this at $\alpha = l = 32.9$. Uversa must at one of these two nodes.

Relative to Paradise North (Exhibit 1), Orvonton has "not long since (as we reckon time) turned the southeastern bend of the superuniverse space level." **15:1.5** Uversa passed this southeastern bend some time ago. "Today, the solar system to which Urantia belongs is … just now advancing beyond the southeastern bend." **15:1.5** The sun is at the southeastern bend which Uversa passed about 240 million years ago. From our perspective, Uversa is in a clockwise direction from Paradise North. So, the direction to Uversa is toward the ascending node at $\alpha = 212.9 \pm 5, \beta = 0 \pm 5$. The margins of error are included, because "in the dense diameter of the Milky Way" implies a general direction, instead of a precisely defined one. At this location the angle from the sun to Uversa to Sgr A* is 3.7°. This is close to the angle of zero degrees, which is what we would expect, if Uversa is located at position $\boldsymbol{A}$ in Exhibit 9.

Ex. 10 Uversa is Located on both the Grand Universe and Galactic Planes



Orvonton has been identified as the Local Group. However, the arrangement of the galaxies in the Local Group conforms poorly to what we might expect. The Milky Way and Andromeda are 20 times larger than the next largest galaxy in the Local Group, the Triangulum galaxy. The Large Magellanic Cloud is the fourth largest galaxy and is 1/100th the size of the Milky Way or Andromeda. All of the other galaxies are smaller than this. A majority of the galaxies in the Local Group are satellites of Andromeda, and most of the rest are satellites of the Milky Way. The Local Group essentially consists of the Milky Way and Andromeda and their associated satellite galaxies.

The organization of the Local Group differs significantly from the ideal configurations which can be imagined from different sets of statements in the book. However, the gravitational dynamics of Orvonton are only consistent with the Local Group. This gravitationally bound structure is the only thing which might possibly revolve about Uversa. Additionally, Andromeda travels with the Milky Way wherever it goes, and everything that moves with the Milky Way must be part of Orvonton. These dynamic considerations are given precedence over the apparent nonconformance of the Local Group with any preconceptions about how the galaxies of Orvonton should be organized.

5. The Center of Mass for the Local Group

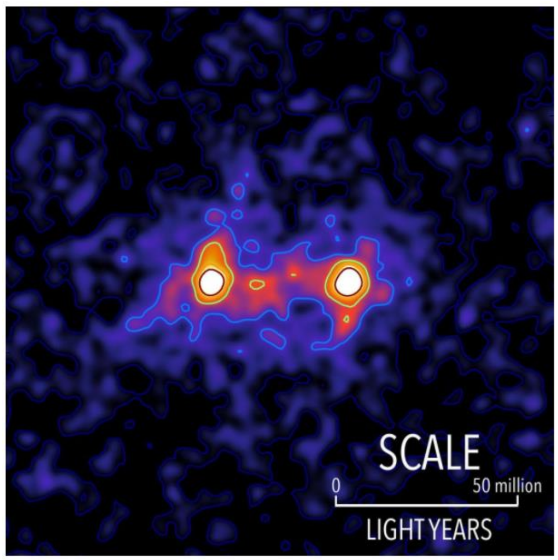
Everything in the Orvonton model is in gravitational revolution about Uversa, which is near the Milky Way. The calculated center of mass for the galaxies in the Local Group is about halfway between the Milky Way and Andromeda. Gravitational revolution can only occur about a center of mass, and Uversa is more than a million light-years from this calculated center. However, this calculation assumes that the distribution of mass in the Local Group is accurately indicated by the distribution of its galactic mass. This is very probably incorrect, since galaxies make up a very small percentage of the total gravitational mass in the Local Group.

In the 1970s it was discovered that stars revolve too quickly around galactic centers; the quantity and distribution of observable matter in galaxies is inconsistent with the orbital velocities measured. This led to a major revision in the standard model of cosmology. The hypothesis of an unobservable substance called "dark matter" had to be included in the model, in order to explain these galactic motions. Dark matter responds to gravity, but it does not emit or absorb electromagnetic energy; it is invisible. Unlike ordinary matter, gravity does not appear to cause dark matter to densely concentrate at a single point.

In the solar system gravity causes 99.8 percent of ordinary matter is densely concentrated in the sun. Dark matter remains diffusely distributed in the region of galaxies. Orbital velocities about a galactic center are explained by a particular distribution of dark matter. The gravitational mass contained within an orbital radius determines the orbital velocity, according to $v^2 = GM/r$. On the galactic scale, 85 percent of gravitational mass is dark matter. The mass M_{dm} of dark matter inside an orbital radius is thought to increase in direct proportion with the radius. This causes the ratio M_{dm}/r to remain constant, resulting in a constant orbital velocity. The quantity of dark matter varies with the radius instead of inversely with the volume. It is unknown what is responsible for the tendency of dark matter to be distributed in this way.

In standard cosmology dark matter accounts for 85 percent of all gravitationally responsive mass. The remaining 15 percent is ordinary baryonic (atomic) matter, of which galaxies are made. About 90 percent of all baryonic matter is believed to be in unobservable forms, such as clouds of gas and dust. As a result, the luminous matter of galaxies only accounts for about 1.5 percent of total gravitational mass. It cannot be assumed that two percent of the total mass prescribes how the remaining 98 percent must be distributed. Recent investigations indicate that unobservable mass is, in fact, distributed differently.

Ex. 11 Dark Matter Bridges between Galaxy Clusters



Credit **University of Waterloo**

Various models of the dark matter halos encompassing galaxies do not align well with the forms traced by baryonic matter. There is a serious mismatch between the distributions of dark and baryonic matter that is well-recognized and referred to as the "missing satellites problem." In a 2017 paper researchers tentatively identified "dark matter bridges" between thousands of galaxy clusters 4.5 Bly distant. [18] These bridges are densest when clusters are less than 40 Mly apart. A representation of these bridges is shown in Exhibit 11. They do not look like either galaxy cluster, having complex irregular forms. This strongly suggests there is an invisible dark matter bridge between the Milky Way and Andromeda which extends past both for some significant distance.

Dark matter tends to remain diffusely distributed, since it does not respond to gravity in the same way that baryonic matter does. The distribution of dark matter in the Local Group is unknown. It is quite possible that 98 percent of gravitationally responsive mass within 4 Mly of the Milky Way has a barycenter coincident with Uversa's location. But the only way to determine how unobservable mass is actually distributed in the Local Group is to detect the gravitational effects it has upon the observable motions of its galaxies.

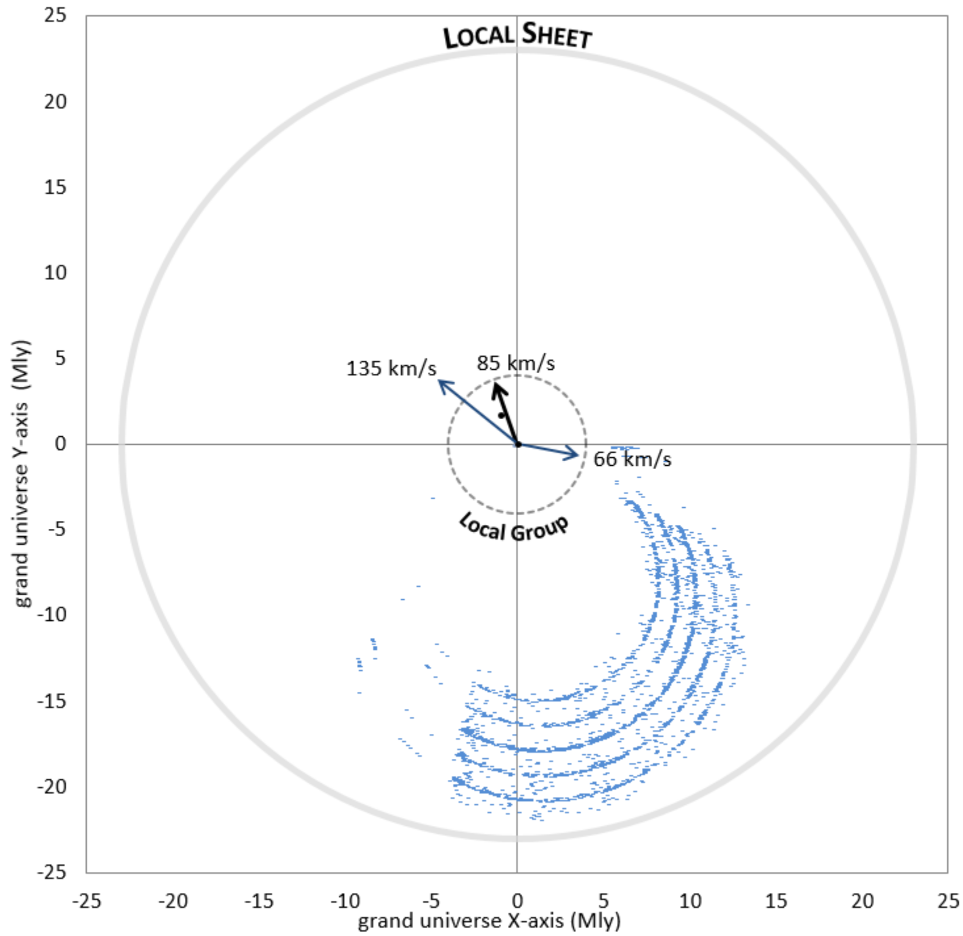
6. The Revolution of the Milky Way about Uversa

The Milky Way has a velocity of $\mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}} = 135$ km/s in the reference frame defined by the other galaxies in the Local Group. The Local Group has a velocity of $\mathrm{V}_{\mathrm{LS}}^{\mathrm{LG}} = 66$ km/s in the reference frame defined by the 158 galaxies in the Local Sheet which are outside the borders of the Local Group.

Tully identifies the Local Sheet in part by the symmetry of its space expansion around a location that is approximately coincident with the Milky Way. He considers it a preferable frame of reference from which to measure peculiar velocities in the larger field. "We advocate the use of the Local Sheet as a frame of reference in preference to the Local Group because the reference sample is 5 times larger and more widely distributed." The Local Sheet is a means of identifying a stationary point in the Local Group against which its small peculiar motion of 66 km/s can be measured.

The Milky Way moves in the Local Group and the Local Group moves in the Local Sheet. These two motions can be combined to find the Milky Way's motion in the Local Sheet. This is analogous to a passenger walking toward the back of a moving bus. The passenger's speed over the road is the sum of how fast he walks and how fast the bus is going. The Milky Way's velocity in the Local Sheet frame of reference $\mathrm{V}_{\mathrm{LS}}^{\mathrm{MW}}$ is the vector sum of two motions: $\mathrm{V}_{\mathrm{LS}}^{\mathrm{MW}} = \mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}} + \mathrm{V}_{\mathrm{LS}}^{\mathrm{LG}} = 85 \pm 25$ km/s toward $\alpha = 109.6 \pm 23$, $\beta = 48.9 \pm 15$ ($l = 114.1,\ b = -11.0$). This is 12° from the direction to Andromeda, which is 5° closer to a direct hit on Andromeda than $\mathrm{V}_{\mathrm{LG}}^{\mathrm{MW}}$.

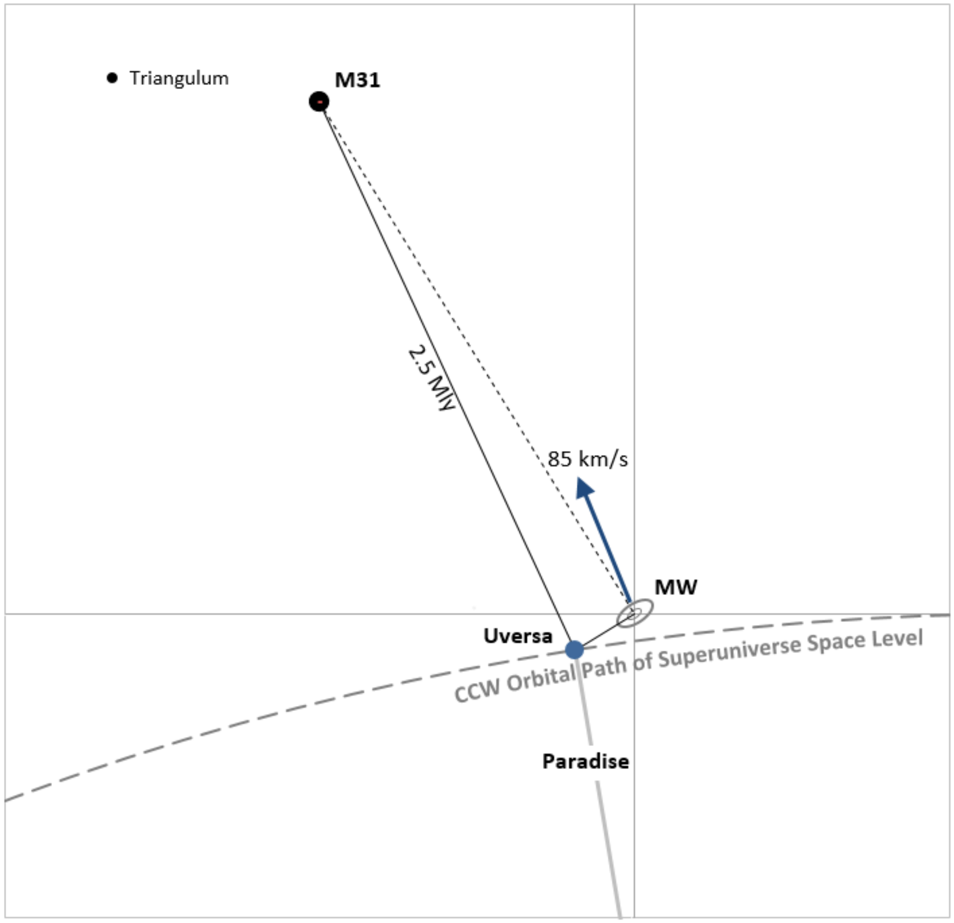
Ex. 12 Motions in the Local Sheet



In Tully's model V_{LS}^{MW} is a peculiar motion measured relative to a stationary point in the Local Sheet frame. Space is expanding in the Local Sheet frame, and the only stationary point in this frame is at its center of space expansion; all other points are moving away from this center. The Milky Way has a velocity of 85 km/s relative to this center. This location is somewhere in the vicinity of the Milky Way in Tully's model. The boundary of the Local Sheet is not defined well enough to more precisely locate its center of expansion.

In the Orvonton model the Milky Way orbits Uversa, and the direction of its velocity must be approximately perpendicular to the direction to Uversa, which was identified in § 4. The direction to Uversa is along the intersection of the galactic and grand universe planes at $\alpha = 212.9°, \beta = 0°$. The angle between Uversa and V_{LS}^{MW} is 98.6°. Within the margin of error ($\pm\sim 20°$) for V_{LS}^{MW}, the direction of the Milky Way's motion is perpendicular to the direction to Uversa. The velocity of the Milky Way in the Local Sheet is consistent with an orbital velocity about Uversa, as required by the Orvonton model.

Ex. 13 Orbital Velocity of the Milky Way about Uversa in Orvonton's Frame



The perpendicular angle between the direction to Uversa and the Milky Way's velocity of 85 km/s is consistent with Uversa being located at the stationary center of the expanding Local Sheet frame. The Local Sheet's center is near the Milky Way, and Uversa is in this vicinity at the center of revolution (mass) in the Local Group frame. The centers of the Local Sheet and Local Group frames can be coincident. Effectively, the Local Sheet is a uniformly expanding region of space which permits a more precise determination of the center of the Local Group frame, which is Orvonton's frame.

In the Orvonton model the Local Sheet frame is replaced by Orvonton's frame, which is the Local Group frame. This changes Tully's Local Group frame into a proxy for the Andromeda system frame, since Andromeda and its satellites are the predominate determinants of Tully's measurement of the Milky Way's velocity in the Local Group. Tully interprets V_{LG}^{MW} as the Milky Way moving toward Andromeda, not as Andromeda moving toward the Milky Way.

Correlation of Reference Frame Hierarchies

Tully's Model		*Orvonton Model*	
$\mathrm{V_{sun}}$	Solar System	$\mathrm{V_{sun}}$	Solar System
$\mathrm{V^{sun}_{MW}}$	Milky Way	$\mathrm{V^{sun}_{MW}}$	Milky Way
$\mathrm{V^{MW}_{LG}}$	Local Group	$\left.\begin{matrix}\mathrm{V^{MW}_{M31}}\\ \mathrm{V^{M31}_{LG}}\end{matrix}\right\\} \mathrm{V^{MW}_{ORV}}$	Orvonton (Local Group)
$\mathrm{V^{LG}_{LS}}$	Local Sheet		

In Tully's model the Milky Way, Local Group and Local Sheet frames are related by two linear velocities with two different causes. Gravity pulls the Milky Way toward Andromeda. Tully does not cite a specific cause for $\mathrm{V^{LG}_{LS}}$, apparently attributing this vector to random gravitational interactions between the two frames. In the Orvonton model these two velocities are replaced by the orbital velocity of the Milky Way about Uversa, which is completely explained by gravitational revolution.

7. The Revolution of Andromeda about Uversa

In the Orvonton model both Andromeda and the Milky Way orbit Uversa. This dynamic feature is not present in Tully's model. This imposes several demands on the Orvonton model. A significant degree of coordination between the location of Uversa and the motions of the Milky Way and Andromeda is required. The Milky Way's velocity of 85 km/s is compatible with its revolution about Uversa. In addition, Andromeda should also have an orbital velocity. There is substantial reason to expect that this velocity is comparable to that of the Milky Way.

The planets in our solar system have different orbital velocities which are determined by their distances from the sun. Under linear gravity, a planet's orbital velocity squared is inversely proportional to its orbital radius $v^2 \propto 1/r$ ($v^2 = GM/r$). For example, Saturn is 9.5 times farther from the sun than the earth, and its orbital velocity of 9.7 km/s is 32 percent of the earth's orbital velocity of 30 km/s ($0.32 = \sqrt{1/9.5}$). However, this relationship does not hold for the revolution of stars about a galactic center or for satellite galaxies.

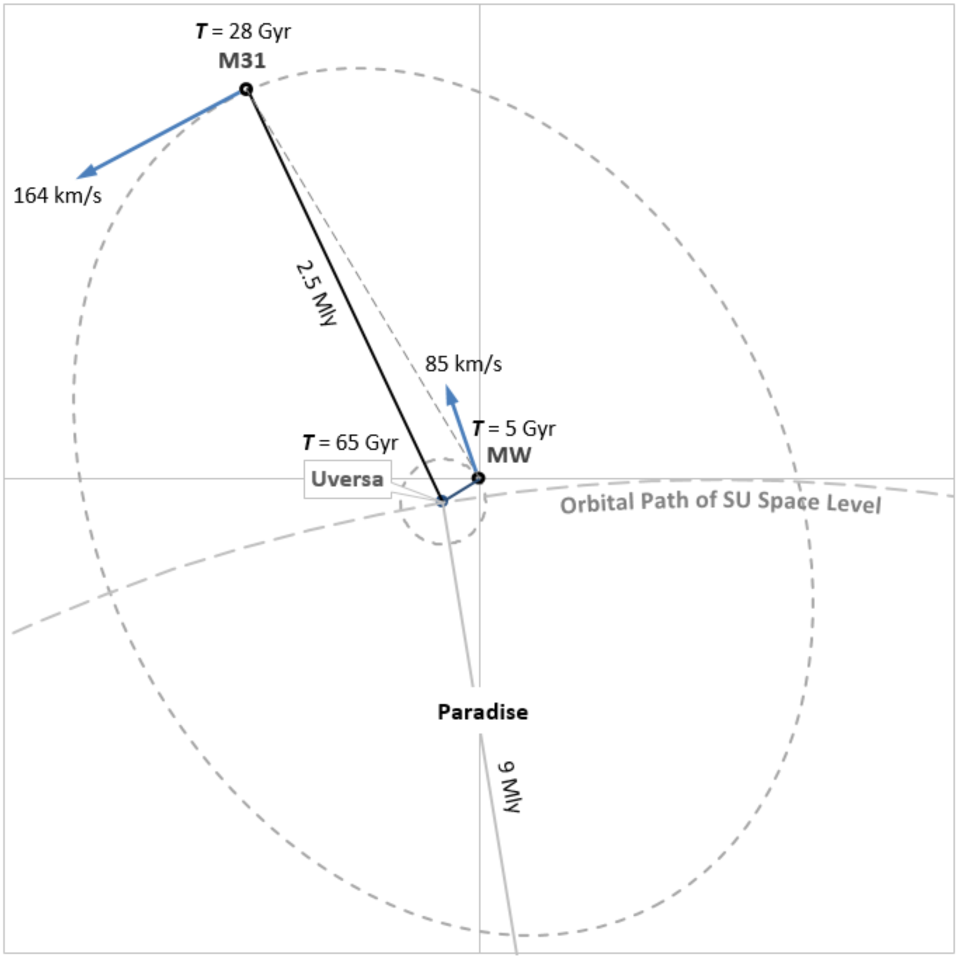
The sun is 26,000 light-years from Sgr A* and has an orbital velocity of 219 km/s. A star at half this distance (13,000 light-years) has a velocity of 210 km/s, which is much lower than the 311 km/s expected from $v^2 \propto 1/r$. A star twice at twice the distance (52,000 light-years) has a velocity of 260 km/s, much higher than the 156 km/s expected. Galaxies are said to have "flat rotation curves," because orbital velocity does not change much as the orbital radius increases. This phenomenon is currently explained by the hypothesis of dark matter. The same holds for satellite galaxies. For example, the Large Magellanic Cloud is 9 times farther away from Sgr A* than the sun is, but its orbital velocity is 262 km/s. [13]

On the galactic scale orbital velocities remain roughly constant as the orbital radius increases. Kinematically, the square of orbital velocity equals the acceleration times the radius $v^2 = ar$. If orbital velocity is roughly constant over a wide range of radii, then the acceleration is roughly proportional with the inverse of the radius $a \mathrel{\widetilde{\propto}} 1/r$, instead of with the inverse of the radius squared $a \propto 1/r^2$ ($a = GM/r^2$). This relation becomes less approximate as the acceleration goes below $a_0 \cong 1.2\ x\ 10^{-10}$ m/s^2. (See Wikipedia entry for Modified Newtonian Dynamics.) This acceleration occurs at a certain radial distance; for the Milky Way this is about 60,000 light-years from Sgr A*. The orbital velocity at this distance equals $v^4 = GMa_0$, or about 260 km/s. Beyond this radius the orbital velocity is relatively constant, and the relation between acceleration and radius is $a \propto 1/r$.

The details of this empirical relation are significant for the Orvonton model. The Milky Way is 225,000 light-years from Uversa and has an orbital velocity of 85 km/s. The acceleration acting on the Milky Way is $3.4\ x\ 10^{-12}$ m/s^2 ($a = v^2/r$). This is far less than a_0, so this orbital velocity of 85 km/s around Uversa should not change much as the distance from Uversa increases. This leads to the expectation that Andromeda should have an orbital velocity of approximately 85 km/s, even though Andromeda is 11 times farther from Uversa than the Milky Way.

Until recently, technical limitations have made direct measurements of Andromeda's orbital (transverse) velocity virtually impossible. If Andromeda has an orbital velocity of 85 km/s, it only moves about 10 billionths of one degree in one year. The first direct measurement was achieved in 2012 by R. P. van der Marel using the Hubble Space Telescope. [5] This study examines three small star fields in Andromeda over a 5-7 year period and tracks the transverse motions of their stars against distant background stars. It finds Andromeda has a small transverse velocity of 17 ± 17 km/s in a counter-clockwise direction. This generally supports traditional assumptions about the lack of Andromeda's transverse motion. The study measures a radial velocity of -109.3 ± 4.4 km/s, consistent with previous studies. This accurate measurement of radial velocity prompted numerous press reports about the collision which will (supposedly) occur between Andromeda and the Milky Way in a few billion years. (NASA animation [7])

Ex. 14 Orbital Velocities and Possible Orbital Paths about Uversa



The second measurement of transverse velocity was in 2016 by J. B. Salomon. [6] This study takes a more comprehensive approach by examining the motion of the whole Andromeda system, which includes 40 satellite galaxies. The study uses precise distance measurements of Andromeda and its satellites published by the Pan-Andromeda Archaeological Survey over a multi-year period. It finds the Andromeda system has a transverse velocity of 164.4 ± 61.8 km/s in a counter-clockwise direction. It finds a radial velocity of -87.5 ± 13.8 km/s. This is the first measurement, so far, of a significant transverse velocity for Andromeda. Within the large margin of error of ± 62 km/s, this transverse velocity is consistent in amplitude and general direction with the model's expectation that Andromeda has an orbital velocity of roughly 85 ± 25 km/s.

Both studies agree that Andromeda's transverse motion is in a counter-clockwise direction relative to the Milky Way. The direction of the Milky Way's velocity relative to Uversa is also in a counter-clockwise direction. This common direction is another requirement of the model, since natural satellites in gravitational revolution about the same center should have the same orbital direction.

The authors briefly consider whether the prediction of a galactic collision made by the 2012 study is compatible with a transverse velocity of 164 km/s. They project that Andromeda will only come within 1.8 Mly (550 kpc) of the Milky Way at its closest point of approach; Andromeda and the Milky Way will not collide. This point of nearest approach is consistent with the length of the semi-minor axis for an elliptical orbit. Since the direction to Andromeda is roughly perpendicular to the direction of this point of closest approach, the 2.5 Mly to Andromeda is consistent with the length of a semi-major axis. This supports the projection of a possible elliptical orbit about Uversa for Andromeda, which is shown in Exhibit 14.

8. The Velocity between the Milky Way and Andromeda

The 2012 and 2016 radial velocity measurements of -87.5 km/s and -109.3 km/s are mutually consistent. The orbital velocity of the Milky Way about Uversa equals $\mathrm{V}_{\mathrm{LS}}^{\mathrm{MW}} =$ 85 km/s and is consistent with these two approaching velocities. In the Orvonton model this approaching velocity between Andromeda and the Milky Way can only be explained, if the Milky Way and Andromeda are in specific positions in their orbits about Uversa. This is yet another dynamic requirement imposed by the model.

In the solar system the earth has approaching and receding velocities relative to the outer planets. These velocities are induced by the longer periods of revolution for the outer planets. For half a year the earth moves closer to Saturn, whose orbital period is 29.5 years, and this causes an approaching velocity between the two. As seen from the earth, for six months Saturn moves from astronomic conjunction with the sun (Saturn is in the same direction as the sun) to opposition with the sun (Saturn is in the opposite direction as the sun). This approaching velocity is zero at conjunction, increases to a maximum halfway through of 30 km/s (earth's orbital velocity). At this halfway point, the earth is moving directly toward Saturn, while Saturn is moving transversely to our line of sight. From this halfway point to opposition, the induced velocity decreases from

30 km/s back to zero. From opposition to conjunction a receding velocity that increases and then decreases is induced between the earth and Saturn.

This same reasoning applies to orbits about Uversa. Viewed from the Milky Way, as Andromeda moves from conjunction with Uversa to opposition, the approaching velocity between the Milky Way and Andromeda should increase from zero to a maximum equal to the Milky Way's orbital velocity of $V_{LS}^{MW} = 85$ km/s, when it is halfway between conjunction and opposition. The angle from Andromeda to the Milky Way to Uversa is 91.6°. This is almost exactly halfway between conjunction and opposition, which is the one location where all of the Milky Way's orbital velocity is directed toward Andromeda. This induces an approaching velocity of −85 km/s between the Milky Way and Andromeda, which is consistent with multiple measurements of this velocity. The dynamics of the model can explain this approaching velocity.

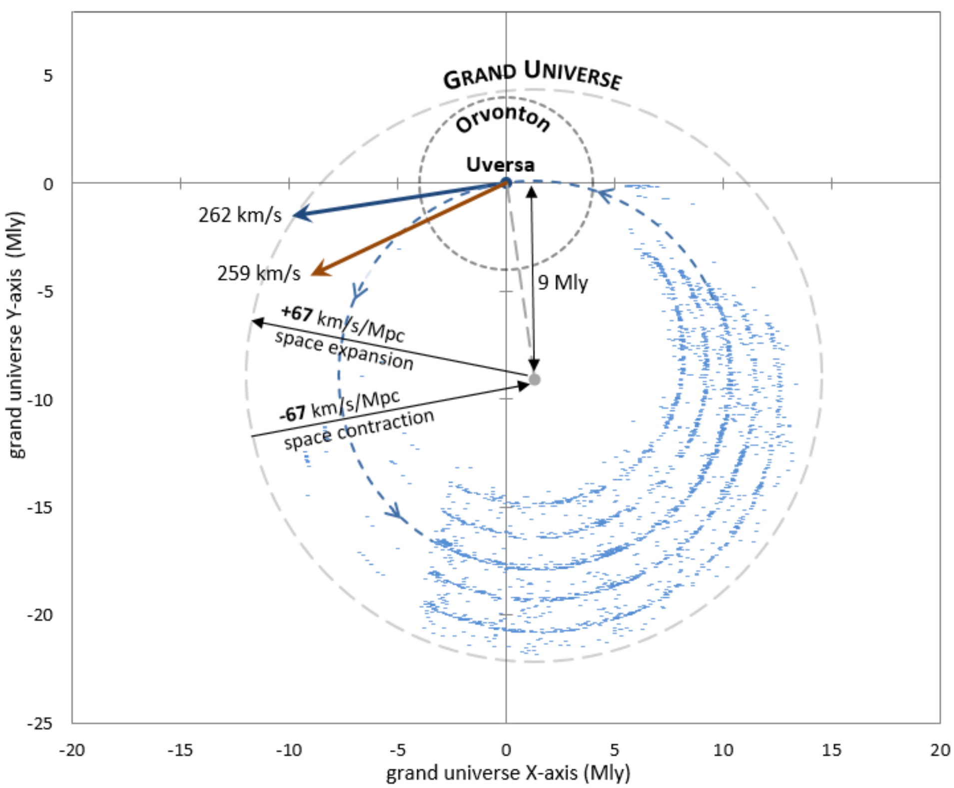
This is a fairly demanding test of the Orvonton model. The Milky Way, Andromeda, and Uversa must be in specific positions, and Andromeda and the Milky Way must orbit Uversa in the same direction. The orbital velocity of the Milky Way has to be the sole cause of the approaching velocity between it and Andromeda. This specific arrangement only happens once during each revolution of the Milky Way about Uversa. At a velocity of 85 km/s it takes the Milky Way 5 billion years to complete a revolution about Uversa. The orbital positions of both galaxies are in the correct relationship just once every 5 billion years. The model passes this test. Failing this test would have very significantly diminished the model's validity.

The standard model explains this approaching velocity as a simple gravitational attraction. It cannot explain a significant transverse motion for Andromeda, except by appeal to some randomly occurring external cause. The Orvonton model easily explains both the vector of the Milky Way's motion and the amplitudes and directions of Andromeda's transverse and radial motions. This ability to explain the dynamics of all three motions in terms of gravitational revolution about Uversa is significant confirmation that the center of total mass in the Local Group is coincident with the location of Uversa.

9. The Orbital Velocity of Orvonton (Local Void Vector)

To explain the Local Sheet apex Tully infers the Local Sheet must have a vector $V_{VSC}^{LS \leftarrow LV}$ = 259 km/s away from the region of the Local Void. Tully attributes this motion to a sort of gravitational "repulsion" originating from the Local Void. In the GU model this motion is attributed to the counter-clockwise gravitational revolution of Orvonton about Paradise. The revolution of galaxies within Orvonton occurs within the non-expanding space of the Local Group. By contrast, galaxies revolve about Paradise in the expanding space of the grand universe. Space expansion pushes galaxies away from Paradise, while at the same time these galaxies revolve about Paradise. These are referred to as primary and secondary absolute motions, because they occur relative to the absolutely stationary Isle of Paradise.

Ex. 15 The Orbital Velocity of Orvonton (Local Group)



Space expands from "just below" nether Paradise for a little over one billion years and then contracts toward this point for an equal period of time. In the GU model this point of respiration is in the direction of the CMB dipole, which points 5.7° beneath Paradise. During this 2 billion year cycle of space respiration, space alternately pushes galaxies away from and pulls them towards Paradise.

The entire seven superuniverses participate in the two-billion-year cycles of space respiration along with the outer regions of the master universe. When the universes expand and contract, the material masses in pervaded space alternately move against and with the pull of Paradise gravity. The work that is done in moving the material energy mass of creation is *space* work but not *power-energy* work. **12:4.12-13**

The motion of expanding (contracting) space actually moves galaxies. This *space work* is different from the *power-energy work* that occurs when material masses interact and exchange energy. The absolute motion of space expansion does not involve the exchange of physical energy, even though it exerts a "force" which causes galaxies to move. In the modern concept, the universal dispersion of matter following a big bang causes space to expand. In the revealed concept, space expansion *causes* matter to disperse. While the dynamic is inverted, the relation between space and matter is similar, in that galaxies are co-moving with expanding space in both concepts.

In the GU model space is expanding from beneath Paradise. This is fully consistent with current theory, in which any point in space can be chosen as the reference point from which to measure expansion. The distance to Paradise is 9 Mly, which equals 2.76 Mpc or $8.48\ x\ 10^{22}$ meters. Space expands within the grand universe (Local Sheet) at $H_0 = 67\ \mathrm{km\ s^{-1}/Mpc}$. The proper velocity of space expansion at our location is calculated with Hubble's formula $v = H_0 D$.

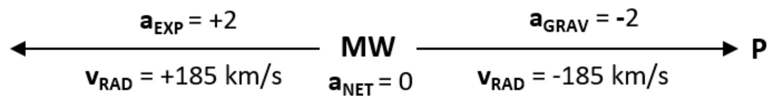
$$v = H_0 D = \frac{67\ \mathrm{km/s}}{\mathrm{Mpc}} * 2.76\ \mathrm{Mpc} = 185\ \mathrm{km/s}$$

The rate of space expansion can be transformed into a rate of uniform acceleration. The acceleration of space expansion a_{EXP} which produces a velocity of 185 km/s over a distance of 9 Mly can be calculated with the equation for linear velocity $v^2 = 2ad$.

$$a_{\mathrm{EXP}} = \frac{v^2}{2d} = \frac{(184{,}969\ \mathrm{m/s})^2}{2 * 8.48\ x\ 10^{22}\ \mathrm{m}} = +2.01\ x\ 10^{-13}\ \mathrm{m/s^2}$$

Space expansion causes an acceleration of $a_{\mathrm{EXP}} = +2.01\ x\ 10^{-13}\ \mathrm{m/s^2}$ away from Paradise. This will carry a galaxy away from Paradise, unless Paradise exerts an equal and opposite gravitational acceleration on it of $a_{\mathrm{GRAV}} = -2.01\ x\ 10^{-13}\ \mathrm{m/s^2}$. This centripetal acceleration causes a velocity of -185 km/s toward Paradise (by convention, a negative sign indicates acceleration toward a gravitational center).

EXPANSION: Outward Acceleration caused by Space Expansion Counterbalanced by Gravitational Acceleration

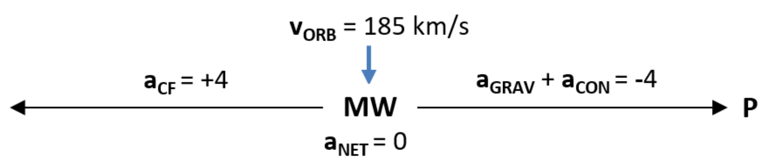


A non-orbiting galaxy is held stationary at 9 Mly from Paradise when gravity is strong enough to cause it to "fall" *through* expanding space toward Paradise at a peculiar velocity of -185 km/s. After a billion years, expansion changes over to contraction, and the inward motion of space contraction starts to accelerate the Milky Way toward Paradise at $a_{\mathrm{CON}} = -2.01\ x\ 10^{-13}\ \mathrm{m/s^2}$. This acceleration from contraction is added to the gravitational acceleration, and together the two cause an inward acceleration of $-4.02\ x\ 10^{-13}\ \mathrm{m/s^2}$. A centrifugal acceleration of $a_{\mathrm{CF}} = +4.02\ x\ 10^{-13}\ \mathrm{m/s^2}$ is now required to keep the Milky Way from falling into Paradise. The orbital velocity required to cause this outward acceleration is given by ${v_{\mathrm{orb}}}^2 = ar$; the orbital velocity squared equals the acceleration times the orbital radius.

$$v_{\mathrm{orb}} = \sqrt{ar} = \sqrt{(4.02\ x\ 10^{-13}\ \mathrm{m/s^2})(8.48\ x\ 10^{22}\ \mathrm{m})} = 185\ \mathrm{m/s}$$

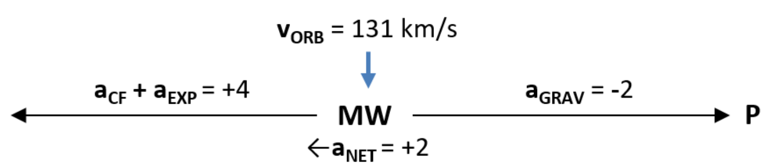
The inward acceleration during space contraction is counterbalanced by the centrifugal acceleration caused by an orbital velocity of 185 km/s.

CONTRACTION: Inward Acceleration Counterbalanced by Centrifugal Acceleration from an Orbital Velocity of 185 km/s



Things remain in balance until space contraction ends after a billion years and space expansion starts again.

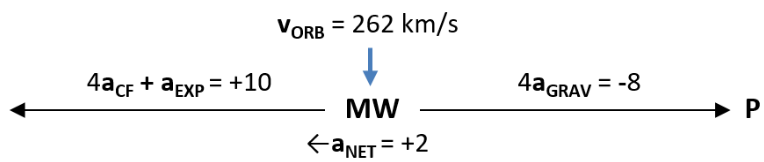
EXPANSION: Outward Acceleration from Space Expansion causes an Imbalance between Centripetal and Centrifugal Accelerations



The inward acceleration caused by space contraction disappears. This reduction in centripetal acceleration decreases the orbital velocity from 185 km/s to 131 km/s. The acceleration of space expansion is now added to the centrifugal acceleration caused by rotation for a total outward acceleration of $+4.02\ x\ 10^{-13}\ \mathrm{m/s^2}$, resulting in another imbalance. This imbalance can be reduced by increasing the orbital velocity, but what increase is reasonable and justifiable?

The observed velocity of 259 km/s known as the local velocity anomaly empirically justifies a fourfold increase in gravitational acceleration to $a_{\mathrm{GRAV}} = -8.04\ x\ 10^{-13}\ \mathrm{m/s^2}$. This acceleration causes an orbital velocity of 262 km/s, which is close to the amplitude of the Local Void vector.

Expansion: Imbalance Caused by Space Expansion is Reduced by Doubling the Orbital Velocity to 262 km/s



In the GU model the direction of this orbital velocity is perpendicular to Paradise ($\alpha = 188°$, $\beta = 0$ or $l = 200.4°$, $b = -21.6°$). The direction of this orbital velocity is 22° from Tully's Local Void vector, as shown in Exhibit 15. The component of 262 km/s acting in the direction of the Local Void vector is given by the cosine of 22° and equals 243 km/s ($262 \cdot \cos 22°$), which is consistent with Tully's amplitude of 259 ± 25 km/s. The difference in direction of 22° from the Local Void vector is not consistent. However, the specific direction of the Local Void vector is determined from the directions of the Virgo infall and the Local Sheet apex vectors. The Local Void vector must have this direction if it is to help explain the apex vector. The direction of the local velocity anomaly is only generally defined, because it occurs between a sparsely populated region on one side and the relatively unpopulated region of the Local Void on the other. The general direction of the local velocity anomaly is consistent with the direction of Orvonton's orbital velocity.

Tully explains $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}\leftarrow\mathrm{LV}} = 259$ km/s in terms of a repulsive gravitational force acting from the general region of the Local Void. This motion can also be explained by Orvonton's orbital velocity of $\mathrm{V}_{\mathrm{GU}}^{\mathrm{ORV}} = 262$ km/s caused by its gravitational revolution about Paradise.

10. The Tension between Primary and Secondary Absolute Motions

A puzzling dynamic in the GU model is its incorporation of the absolute motions of space expansion (contraction) and gravitational revolution. How can galaxies revolve about Paradise at the same time space expansion is pushing them away from Paradise? If Orvonton revolves about Paradise at 262 km/s and moves away from it at 185 km/s at the same time, it cannot be in a stable orbit. It would recede from Paradise along the path of an Archimedean spiral, which is inconsistent with a stable orbit. The concept of space respiration is crucial to resolving the tension between the dynamics of primary and secondary absolute motions.

When space contraction changes over to expansion, contraction stops pulling Orvonton toward Paradise and expansion starts pushing it away. At this time of changeover from contraction to expansion, Orvonton has no radial velocity relative to Paradise. Since linear velocity equals acceleration multiplied by time ($v = at$), Orvonton's outward velocity increases from zero at changeover to 6.3 km/s over one billion years. This is only 3.4 percent of the velocity of 185 km/s for space expansion at Orvonton's location. Over this same billion years the distance from Paradise to Orvonton only increases 0.1 percent ($d = \frac{1}{2}vt$). This minimal radial velocity and change in orbital radius allow Orvonton to follow a stable orbit about Paradise.

Over a respiration cycle, there is a minimal inward and outward radial motion of about 3.4 percent of proper velocity. This variation is consistent with the Hubble constant. There have been a dozen major determinations of this constant since the turn of the century. Their average is $H_0 = 70.7$ km/s/Mpc with a standard deviation of ± 2.6 km/s, which equates to ± 3.7 percent. The most recent determination of $H_0 = 71.9\ ^{+2.4}_{-3.0}$ km/s/Mpc has a standard deviation of 3.3-4.2 percent, consistent with previous findings. [16] This variation in the Hubble constant is in good agreement with the variation of 3.4 percent in the proper velocities of galaxies caused by space respiration.

> The entire seven superuniverses participate in the two-billion-year cycles of space respiration along with the outer regions of the master universe. 12:4.12

> …subsequent to the perfection of more powerful telescopes, it will appear that these far-distant systems (i.e. galaxies) are in flight from this part of the universe at the unbelievable rate of more than thirty thousand miles a second. But this apparent speed of recession is not real; it results from numerous factors of error embracing angles of observation and other time-space distortions. 12:4.14

Space respiration reconciles the apparent contradiction between these two nearby statements. It explains how galaxies can "participate" in space expansion and yet their "apparent speed of recession" calculated from the redshift of space expansion "is not real." The metric expansion of space causes a time-space distortion (cosmological redshift) in the light spectra of distant galaxies. This makes it appear they are receding at the velocity of space expansion, when they actually have proper velocities which are less than 4 percent of expanding space. The other time-space distortions probably include relativistic effects, as well as angles of observation.

The concept of space respiration is not viable in the standard model of cosmology. Space expansion is caused by the progressive dispersal of matter in the standard model, and space contraction would require a progressive concentration of matter. In the GU model expansion and contraction do not have a material cause. The authors "think the Conjoint Actor initiates motion *in* space." **12:4.3** They cannot prove it, but they suspect he also "produces the motions *of* space." **12:4.4** It is not possible to prove that Deity is responsible for space respiration. But it is possible to look for historical evidence of this phenomenon.

The more distant a galaxy is, the more ancient its light. It is possible to look back in time by observing the light from galaxies which are at progressively greater distances, as indicated by their redshifts. The proper velocities of galaxies emitting light during phases of space contraction should differ from the velocities of galaxies emitting light during phases of space expansion. There is evidence which appears consistent with a systematic variation in redshifts over a 2 billion year cycle.

A 2015 study used Type Ia supernovae to identify a 2.07 billion year cycle (1/7th of 13.8 billion years) of acceleration and deceleration in the rate of space expansion. **[17]** This is the precise length of the space respiration cycle: "It thus requires a little over two billion Urantia years to complete the entire expansion-contraction cycle." **11:6.5** The average variation in the amplitude of acceleration/deceleration in space expansion is approximately $\pm$4 percent, which is consistent with the average 3.7 percent variation in the Hubble constant. According to this study, an acceleration phase began roughly 400 million years ago. This is consistent with our current approach to the midway point in the phase of space expansion: "Pervaded space is now approaching the mid-point of the expanding phase." **11:6.4** It is either an unbelievable coincidence that the cycle lengths and phases of acceleration/deceleration and space respiration match this closely or the first is an artifact caused by the second.

11. The Peculiar Motion of Orvonton in Expanding Space (Virgo Infall)

The Virgo Cluster of galaxies is 53.8 Mly away (16.5 Mpc). At this distance and a Hubble constant of $H_0 = 72$ km s^{-1}/Mpc, its proper velocity is 1188 km/s ($v = H_0 D$). The heliocentric redshift velocity of the Virgo Cluster is 1079 km/s. Adjusting this redshift to the frame of the Local Sheet results in an observed velocity of 1003 km/s. Subtracting the proper velocity of 1188 km/s from this adjusted redshift velocity gives a peculiar velocity of -185 km/s ($v_{pec} = v_{obs} - v_{prop}$). Tully concludes from this the Local Sheet has a velocity of -185 ± 20 km/s toward the Virgo Cluster.

In the GU model both Orvonton and the Virgo Cluster, which is in the first outer space level, are in gravitational revolution about Paradise. Both are relatively stationary with respect to the center of the expanding frame of space located just below Paradise. Light emitted from Virgo transits through 54 million light-years of expanding space and is cosmologically redshifted by a proper velocity of 1188 km/s. Orvonton has a peculiar velocity through expanding space of -185 km/s, because gravity holds it at a constant radial distance from Paradise. Orvonton's velocity is toward the CMB dipole, which is in the general direction of Virgo, so the light from Virgo is blueshifted by a component of its velocity. Virgo is displaced 27.5° from the dipole, which is relatively inconsistent with the direction of Orvonton's peculiar motion. However, the component of -185 km/s directed toward Virgo is -164 km/s, which is consistent with Tully's finding.

Orvonton's speed toward the dipole is consistent with the amplitude of the Virgo Infall, accounting for 89 percent of it, but its direction is inconsistent with this infall.

In Tully's model the vector addition of the Virgo Infall and the Local Void vector results in the Local Sheet apex of $\mathrm{V}_{\mathrm{VSC}}^{\mathrm{LS}} = 323$ km/s. The vector addition of Orvonton's orbital velocity of 262 km/s and its peculiar velocity through expanding space of -185 km/s gives a resultant velocity of 321 km/s, which is nearly the same. However, the direction of this vector is 24.6° from the Local Sheet apex. The component of 321 km/s in the direction of the apex is 291 km/s, which is outside Tully's margin of error. The addition of Orvonton's two vectors does not explain the Local Sheet apex.

Orvonton's velocity can explain the amplitude of this apex motion but not its direction. The GU model explains the Local Sheet apex in terms of the dynamics of counter-rotation occurring between the superuniverse and first outer space levels. Before considering this dynamic, a model is needed for how gravity from Paradise acts upon these two space levels.

12. A Model of Absolute Gravity

On the scale of the solar system, gravitational acceleration varies inversely with the square of the radial distance $a \propto 1/r^2$ ($a = GM/r^2$). This inverse-square relation does not apply on the galactic scale. On this scale gravitational acceleration is proportional with the inverse of the radial distance $a \propto 1/r$, where $a < a_0$ (§ 7). Both of these relations are currently explained by linear gravity with the help of diffusely distributed halos of dark matter. Nevertheless, the relation between acceleration and distance under linear gravity changes from the solar to the galactic scale. Acceleration changes from a second order relation with the radius to a first order linear relation. This effect of scale upon gravitational attraction suggests there is a comparable change in this relation when moving above the galactic scale to something the size of the superuniverse space level.

In the late 19th century the French mathematician Joseph Bertrand developed an analytic proof known as Bertrand's Theorem. This theorem identifies two types of central force which can produce stable orbits: an inverse-square force $F \propto k/r^2$ and a proportional force $F \propto kr$. Linear gravity is an inverse-square central force. A proportional central force is modeled with Hooke's law of elasticity $F = kd$, where the force is directly proportional to the distance d of displacement and k is an elastic constant. Under an elastic force, acceleration varies in direct proportion with the distance $a \propto r$; that is, an object at twice the distance is acted upon by twice the acceleration. This is the inverse of $a \propto 1/r$, which seems to apply on galactic scales.

Bertrand's Theorem suggests the hypothesis that absolute gravity can be modeled as an elastic central force. (*cf.* [14]) There is a statement involving the concept of the Unqualified Absolute, which appears to support this idea.

> The universal presence of the Unqualified Absolute seems to be equivalent to the concept of a potential infinity of gravity extension, an elastic tension of Paradise presence. This concept aids us in grasping the fact that everything is drawn inward towards Paradise. The illustration is crude but nonetheless helpful. **11:8.9**

The comparison of Paradise gravity to a potentially infinite extension of the "elastic tension of Paradise presence" is considered a crude but helpful analogy; it illustrates the fact that "everything is drawn inward towards Paradise." An elastic force causes simple harmonic motion. This type of motion occurs when a mass that is attached by a spring to a fixed point is displaced some distance from this point. Simple harmonic describes the movements of a pendulum, a vibrating string, electromagnetic radiation, and many other phenomena. In this crude analogy the Isle of Paradise is the fixed point, a galaxy is the mass attached to the spring, and absolute gravity is the elastic force of the spring.

The motion of satellites governed by an elastic central force is characterized by radial harmonic motion. This is the angular version of simple harmonic motion. In radial harmonic motion all satellites have the same period of revolution $\boldsymbol{T}$, regardless of their distance from the central fixed point. Under an elastic force, the orbital velocity is directly proportional to the radius $v_{orb} \propto r$; the larger the radius the greater the velocity. This linear relation is similar to that between velocity and distance $v_{prop} \propto D$ in space expansion. If absolute gravity acts in this way, then both primary and secondary absolute motions are characterized by simple linear relations of direct proportionality.

The ratio of orbital velocity divided by the radius is constant under an elastic force. This simple ratio is the angular velocity $\omega = v_{orb}/r$, which is measured in radians per second. The angular velocity of Orvonton's revolution about Paradise is:

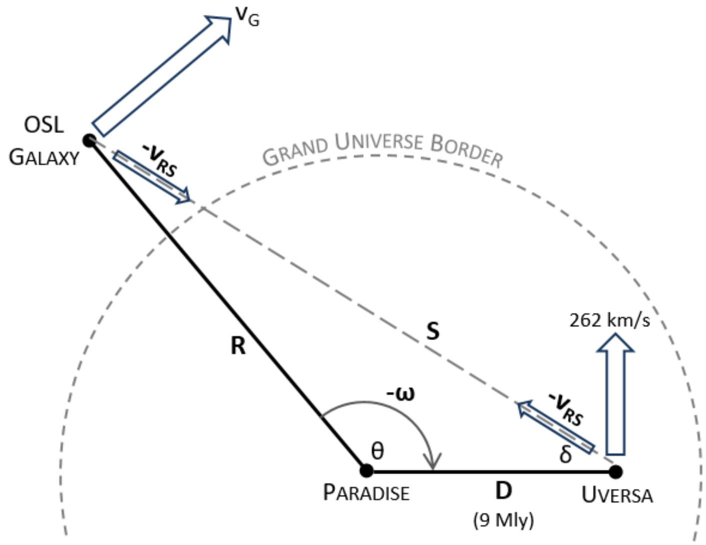
$$\omega = \frac{v_{orb}}{r} = \frac{262 \text{ km/s}}{8.48\ x\ 10^{22} \text{ m}} = 3.07x10^{-18} \text{ rad}/s$$

In radial harmonic motion the angular velocity ω is a constant for the whole system. This constant angular velocity at all distances causes all satellites to have the same period of revolution. Since absolute gravity governs revolution on truly cosmic scales, the angular velocity ω of Orvonton about Paradise is a universal constant. The orbital period $\boldsymbol{T}$ about Paradise for Orvonton and all space levels is 65 billion years, since $T = 2\pi/\omega$.

At this angular velocity galaxies change their positions in the sky by just a few billionths of a degree over the course of a year ($5.6\ x10^{-9}$ degree/year). This is about half of the limiting precision of 10 billionths of a degree (40 μas) with which the International Celestial Reference Frame was redefined in 2009. This precision is more than six times greater than the previous implementation of the ICRF in 1998. This limitation in the accuracy of angular measurement explains why the sidereal motions caused by universal revolution about Paradise have not yet been detected.

13. Peculiar Velocities Caused by Counter-Rotation (Local Sheet Apex)

Ex. 16 Peculiar Velocities Induced by the Counter-Rotation of The Superuniverse and First Outer Space Levels



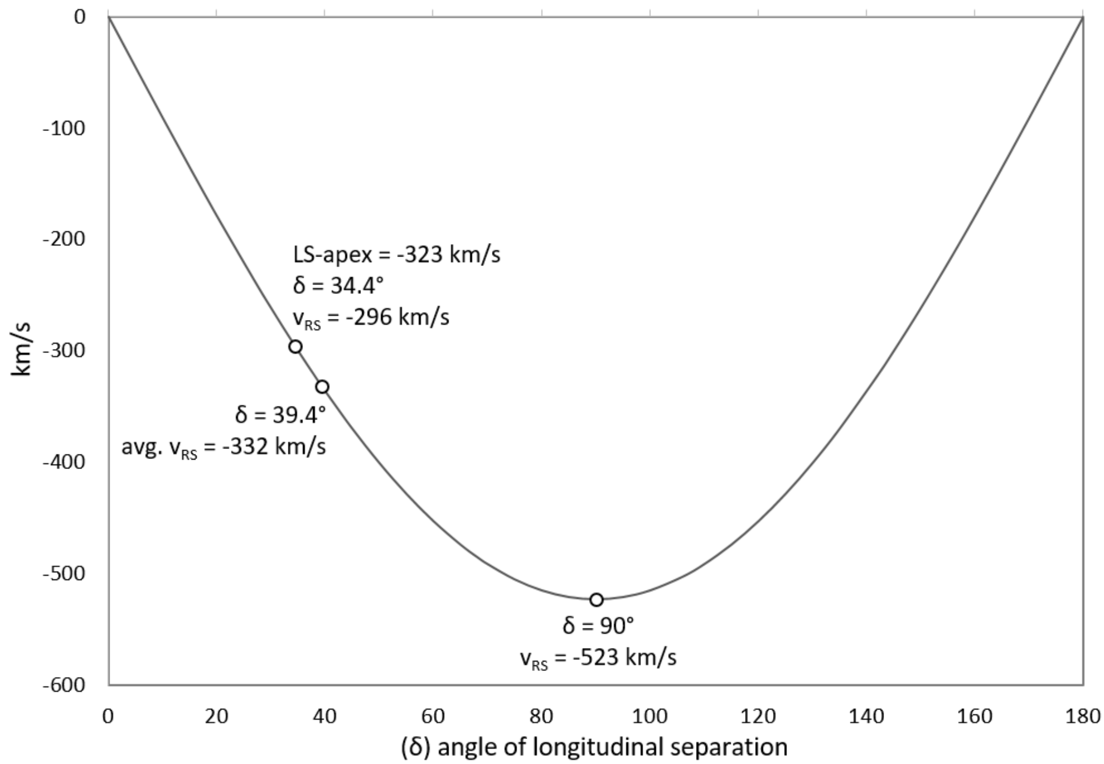
Calabrese Equation for Counter-Rotation Induced Velocity

$$v_{RS} = \frac{D\omega \sin\theta}{\sqrt{1 + \left(\frac{D}{R}\right)^2 - 2\left(\frac{D}{R}\right)\cos\theta}}$$

Galaxies in the first outer space level orbit Paradise in a clockwise direction, while those in the superuniverse space level orbit in a counter-clockwise direction. This causes the distance between Uversa and an outer space galaxy to increase for half a revolution (32.5 billion year) and decrease for the other half. This varying distance over time induces alternating approaching and receding velocities for the galaxy. Determining the approaching and receding velocity v_{RS} caused by the counter-rotation of adjacent space levels is a complex problem. This problem is solved by the mathematician Philip Calabrese in a 2005 paper. [15]

The final equation developed by Calabrese requires just four variables. The structure of the superuniverse space level establishes a distance to Paradise D of 9 Mly. Since the superuniverse and first outer space levels revolve in opposite directions and have the same angular velocity under absolute gravity, the total angular velocity is twice as large as that for Uversa alone or $\omega = -6.14\text{x}10^{-18}$ rad/s. The distances S and R and the angle θ can be either measured or calculated.

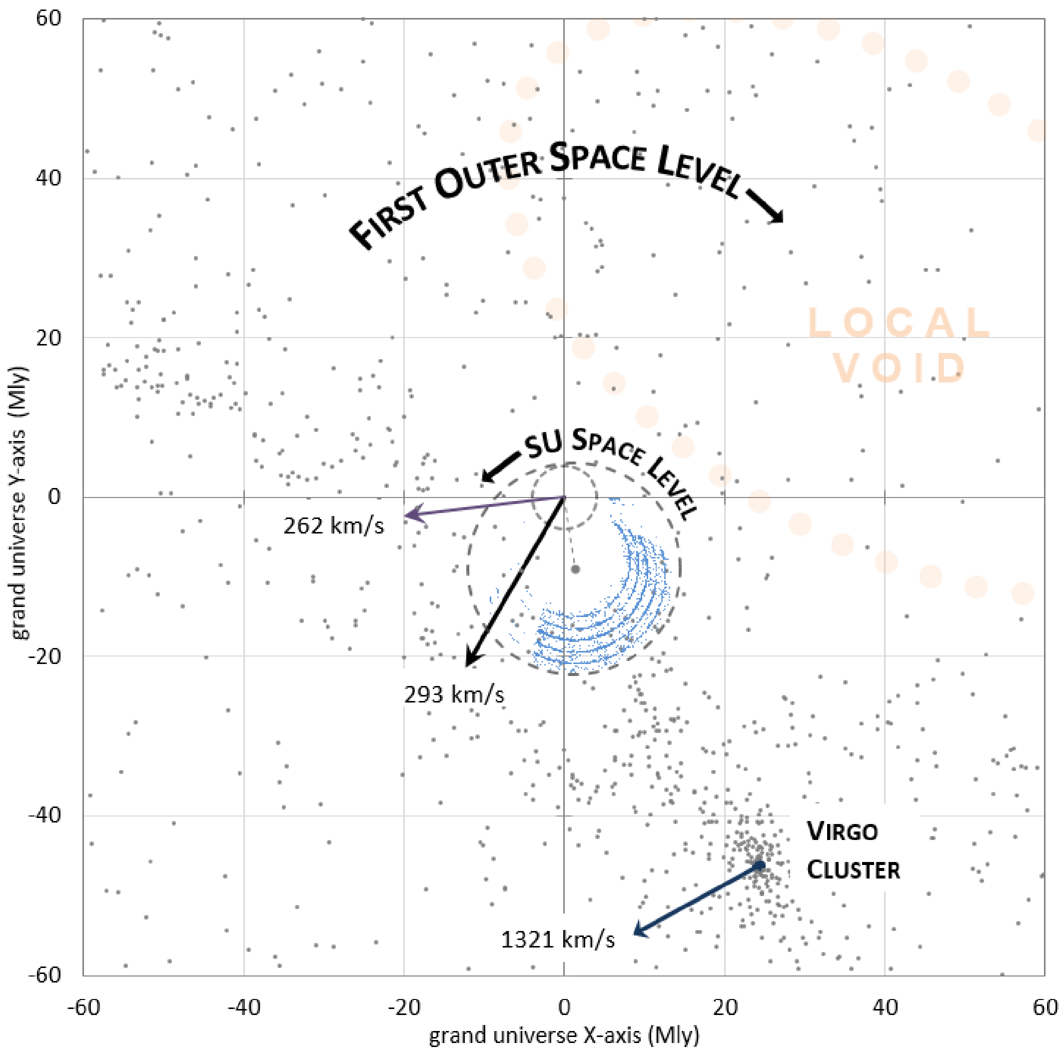
Ex. 17 Counter-Rotation induced Approaching Velocities by Angle of Separation (0°< δ <180°) from Paradise



Under the inverse-square law, the induced-velocities v_{RS} of galaxies in the same direction but at different distances would all be different, because the angular velocity ω for each galaxy would be different. Modeling absolute gravity as an elastic force has a very singular effect upon these v_{RS} velocities. Since the angular velocity ω is a universal constant, all outer space galaxies in the same direction wind up having the same induced velocity, regardless of their distances. The velocity v_{RS} is the same for all outer space galaxies with the same angle δ of longitudinal separation from Paradise. (The angle θ in Exhibit 16 varies with the distance to each galaxy.)

This greatly simplifies things as shown in Exhibit 17. All galaxies on the clockwise side of Paradise have negative approaching velocities which systematically vary from zero in the direction of Paradise $\delta = 0°$ to a maximum of -523 km/s in the direction of Orvonton's orbital velocity $\delta = 90°$. From $\delta = 90°$ to $\delta = 180°$ the velocity decreases from -523 km/s to zero. Measured counterclockwise from Paradise, these approaching velocities become equal but oppositely directed receding velocities.

Ex. 18 Counter-Rotation of the Superuniverse and First Outer Space Levels



In Tully's model the Local Sheet has a motion of $V_{VSC}^{LS} = 323 \pm 25$ km/s toward $\alpha = 244.4 \pm 7$, $\beta = 9.3$. This resultant vector summarizes the motion of more than 1500 galaxies. The direction of this vector is only 14° from the average grand universe longitudes and latitudes for these galaxies of $\alpha = 233.3$ and $\beta = 0.4$. It is worth noting that the average grand universe latitude is on the plane, while the average galactic latitude for these same 1500 galaxies is far off the galactic plane at $b = 18.8$. It makes sense that this resultant vector would have a longitude and latitude generally consistent with the average direction of the distribution of galaxies.

The longitude of $\alpha = 244.4$ has a clockwise longitudinal angle of separation of $\delta = 34.1°$. Counter-rotation causes all galaxies with this angle of separation to have a velocity of -293 km/s. This is consistent with Tully's finding, since a slight 1° decrease in Tully's longitude, which has a margin of error of $\pm 7°$, to $\alpha = 243.4$ results in $v_{RS} = -301$ km/s. The Calabrese equation is sensitive to small changes in longitude.

The equation gives an approaching velocity that is consistent with the specific vector of the Local Sheet apex. But this apex is the result of the vector addition of the peculiar motions of ~ 1500 galaxies outside the Local Sheet but within 135 Mly. Averaging the peculiar velocities v_{RS} of all outer space galaxies clockwise from Paradise up to $\delta = 90°$ ($0 > v_{RS} > -523$ km/s) gives a mean of $v_{RS} = -332$ km/s, which occurs at $\delta = 39.4°$. This angle of separation occurs at $\alpha = 238.7$, which is 5.3° of longitude from the Local Sheet apex. This is consistent in both amplitude and direction with Tully's determination. In the opposite quadrant there is a $v_{RS} = +332$ km/s. This is consistent with the Orvonton (Local Sheet) having a peculiar motion of 323 km/s in the larger frame of the Virgo Supercluster.

It is rather remarkable that the Calabrese equation gives results which are consistent with the Local Sheet apex, considering all of the assumptions upon which it rests. In the GU model this motion requires revolution about a point 9 Mly distant at the center of a ring-like arrangement thousands of galaxies. This revolution is caused by a new form of gravitational force that is directly proportional to the distance from this center. The apex velocity is caused by the counter-rotation of two concentrically arranged space levels. One of these is comparable to the region of the Local Sheet, which includes all of the grand universe. The other spans a region extending at least 112 Mly beyond the borders of the grand universe, which includes part of the first outer space level. Counter-rotation induced velocities do not appear to depend upon a galaxy's latitudinal displacement above or below the plane of this ring of galaxies, only upon its longitudinal displacement from the center of gravitational revolution.

If future data and analysis are consistent with the Calabrese equation, this would substantially validate the model's hypothesis that the space levels of the master universe revolve about Paradise under the control of absolute gravity.

14. Conclusion

Models of the structure of Orvonton and of the grand universe can be developed based upon the guidance in *The Urantia Book.* A ring-like arrangement of thousands of galaxies can be observed which matches the description of the superuniverse space level, if Orvonton is the Local Group. In the standard model each of the six identified velocities in the local velocity field has an isolated cause which is uncoordinated with the other five causes. These complex motions emerge by random happenstance out of the general field. In the GU model each of these motions is coordinated with all others to form a dynamic whole. The apparent complexity of these motions is simply explained by gravitational revolution about Uversa and Paradise.

The GU model appears consistent with both the structural and dynamic evidence. It provides an elegantly unified explanation for the organized motions of galaxies in the local velocity field.

APPENDIX

A. Grand Universe Spherical Coordinate System

The grand universe coordinate system is based upon the gravitational plane of the superuniverse space level and the location of Paradise. The galactic coordinates of the North Pole $l_{NP} = 122.89,\ b_{NP} = 28.60$ and the ascending node $l_{\Omega} = 212.89$ of the GU plane define the spherical coordinate system of the grand universe. Galactic coordinates (l, b) can be transformed into grand universe coordinates (α, β) with the following process.

GU NP & Ω in galactic coordinates: $l_{NP} = 122.89 \quad b_{NP} = 28.60 \quad l_{\Omega} = 212.89$

1. $rad. = deg.\ x\ \pi/180°$ Convert l_{NP}, b_{NP}, and l_{Ω} to radians {radians(*deg*) in Excel}
2. $\beta = \sin^{-1}\{\ [\cos b \cos b_{NP} \cos(l - l_{NP})] + [\sin b \sin b_{NP}]\ \}$
3. $\alpha = \tan^{-1}\left(\frac{y}{x}\right) + l_{\Omega}$ where $y = \sin b - \sin \beta \sin b_{NP}$
   $x = \cos b \sin(l - l_{NP}) \cos b_{NP}$
4. $deg. = rad.\ x\ 180°/\pi$ Convert α and β to degrees {degrees(*rad*) in Excel}

note: $\sin^{-1}$ is arcsine
$\tan^{-1}$ is arctangent {use atan2() function in Excel instead of atan()}

Grand universe coordinates (α, β) can be transformed back into galactic coordinates (l, b) using the GU coordinates of the North Pole $\alpha_{NP} = 302.89,\ \beta_{NP} = 28.60$ and the ascending node $\alpha_{\Omega} = 32.89$ for the galactic plane.

B. Vector Components with Directions given in Spherical Coordinates

A velocity is a vector quantity which has both a speed (amplitude) and a direction. The component $\vec{v}$ of a vector v at an angle θ to the vector is given by the cosine.

$$\vec{v} = v \cos \theta$$

The cosine of the angle θ between two directions specified in spherical coordinates as (l_0, b_0) and (l_1, b_1) equals:

$$\cos \theta = \sin b_1 \sin b_0 + \cos b_1 \cos b_0 \cos(l_1 - l_0)$$

The cosine of the angle θ can be converted to radians, which can then be converted to degrees to find the angle of separation between (l_0, b_0) and (l_1, b_1).

$$rad. = \cos^{-1}(\cos \theta) \quad \{\cos^{-1} \text{ is the arccosine}\}$$

$$degrees = rad.\ x\ \frac{180°}{\pi} \quad \{\text{or degrees}(rad) \text{ function in Excel}\}$$

C. Vector Addition involving Spherical Coordinates

1. Transform each vector v into its Cartesian x, y, and z components $v_x, v_y,$ and v_z. For $i = n$ vectors v_i with galactic longitudes and latitudes $(l_i,\ b_i)$:

$$v_{i,x} = v\cos\ b_i \cos l_i$$

$$v_{i,y} = v\cos\ b_i \sin l_i$$

$$v_{i,z} = v\sin\ b_i$$

2. Get the sums for the x, y, and z components.

$$\sum_{i=1}^{n} v_{i,x}, \quad \sum_{i=1}^{n} v_{i,y}, \quad \sum_{i=1}^{n} v_{i,z}$$

3. The amplitude of the resultant vector $\vec{v}$ is the square root of the sum of the squares.

$$\vec{v} = \sqrt{\left(\sum v_{i,x}\right)^2 + \left(\sum v_{i,y}\right)^2 + \left(\sum v_{i,z}\right)^2}$$

4. The longitude in radians of the resultant vector $\vec{v}$ is found using the arctangent.

$$l = \tan^{-1}\left(\frac{\sum v_{i,x}}{\sum v_{i,y}}\right) \quad \text{\{use atan2() in Excel\}}$$

5. The latitude in radians of the resultant vector $\vec{v}$ is found using the arcsine.

$$b = \sin^{-1}\left(\frac{\sum v_{i,z}}{\vec{v}}\right)$$

6. Convert radians to degrees of longitude and latitude.

$$deg. = rad.\ x\ \frac{180°}{\pi} \quad \text{\{or degrees}(rad)\text{ function in Excel\}}$$

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