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Natural Cause of Galaxy Rotation

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Abstract: Presented is a clear description of the mechanism by which galaxies acquire significant rotation. Beneath the apparent random motions and concentrations of galaxies lies the simplicity and regularity of a cosmic-scale cellular structure. It is explained how the dynamics that sustain this cellular structure is responsible for (1) the initial linear motion of galaxies, particularly of 'field' ellipticals; (2) the oscillation of the trajectories of galaxies; and (3) the preponderance of gravitational mating of galaxies at favorable locations of the cosmic cellular structure. The importance of the boundaries between cosmic cells is recognized, for this is where the bombardment of galaxies from adjacent cells takes place, leading to random collisions. These collisions, in conjunction with induced trajectory oscillations, result in orbital interactions with varying degrees of angular momentum —from stellar-scale to galactic-scale. As a bonus, the explanation of the so-called *random motions* of galaxies becomes self-evident and the galaxy *morphology-density mystery* is resolved. A clear answer is given to the decades old question of why ellipticals dominate the population of the densest regions of a cluster, while spirals are observed to comprise a majority in the elongated (filamentous) region of a cluster.

Keywords: Galaxy Rotation, Galaxy Evolution, Spiral Galaxy Formation, Cosmic Gravity Domains, Galaxy Clusters, Dynamic Aether, Cellular Cosmology, DSSU Theory

1. Introduction

1.1. Definitions

The eminent objectivist philosopher Ayn Rand was noted for the clarity of her ideas. She learned and taught: "Definitions are the guardians of rationality, the first line of defense against chaos of mental disintegration."

Words herein mean exactly what they are supposed to mean, exactly what the English language intended them to mean. There are, however, for the sake of clarity, a few words whose meaning need to be narrowed and a couple of specific terms that need to be carefully defined.

The word *space*, when used in the astronomical or cosmological context, refers to the background region within which everything exists; it refers to the 3-dimensional void of nothingness; it means space as an empty container. The term *space medium*, or universal space medium, refers to the nonmaterial aether (as define by DSSU theory*) that permeates ALL space. And to make it clear that this medium is significantly unlike the traditional concepts of aether, an abridged definition is given here:

DSSU aether: The subquantum medium that permeates all space. It is the *nonmaterial essence* of the Universe; it consists of essence units (or *precursors*) —fundamental essence fluctuators, or essence oscillators. As a basic space medium, it serves as the propagator of electromagnetic waves. As a dynamic space medium, it manifests gravitation in its four observable forms [1].

The capitalized word "Void" refers to the large underdense regions of the universe's cosmic cellular structure.

Everything being presented herein is in the context of the real Universe. Its name is the Dynamic Steady State Universe (DSSU); its firmly-established validity is discussed in the closing commentary. DSSU cosmology holds that the universal space medium is the ultimate bedrock of Nature, and further, that the space medium expands and contracts *regionally and equally* resulting in a cosmic-scale cellularly-structured universe. It is a model based on the premise that all things are processes. In the context of the history of astrophysics, it is the first *true* Steady State (SS) universe —SS nonexpanding, SS cellular, SS infinite, SS perpetual [2]. Furthermore, and most importantly, the DSSU's functionality rests on a unified theory of gravity based on aether [1].

The concept most important and most relevant to the discussion is that of cosmic-scale gravity cells; and the associated term is *gravity domain*.

Gravity domain: is a cosmic region within which all comoving bodies fall inward; and from which no gross body can escape. It is permeated by an aether (defined above) that determines the domain's dynamic and kinematic characteristics. In the context of the DSSU cellular cosmology, individual domains neither expand nor contract; and are nominally shaped as tetrahedra and octahedra. A dense galaxy cluster always nests at the center.

* DSSU theory is based on the fact that the Universe is cellular, a discovery that became the focus of research with Jaan Einasto (of Estonia) beginning in the 1970's and was given the necessary theoretical foundation at the international Munich Symposium in 2002. In DSSU theory, the universal space medium is dynamic. This means that *aether* expands and *aether* contracts. The medium does one or the other according to its location in the cellular structure of the Universe. Galaxy motion follows from this basic fact.

1.2. Suppositional Problem of Galaxy-Galaxy Encounters

Galaxies tend to cluster, stars tend to cluster. It's what contractile gravity does, it pulls things together. But there is a big difference here. Galaxies do not cluster in the way that stars cluster.

If galaxies were distributed within a cluster like the unperturbed way in which stars are distributed within globular clusters, there would be no way to initiate significant galactic interaction —there would be no way to bring about large-scale galaxy rotation. Tidal effects, even on a galactic scale, are wholly inadequate.

Significant galactic rotation requires significant initial motion —preferably the motion of galaxies in opposing directions. There needs to be a close encounter of galaxies originating from different directions. But even this, in itself, is not enough. It may produce a tidal distortion and little more. The reason why this is not enough: The trajectories of such galactic encounters are either hyperbolic or parabolic and, in the absence of any other factors, such encounters are a one-time visit, a "short" and incomplete swing around each other, never to re-cross paths, never to meet again. See Figure 1. Such is the nature of the basic gravity effect as formulated by Kepler and Newton.

No, the basic gravity effect is not sufficient for the task. Something else is required, some other effect that causes galaxies to repeat their encounters over and over. The additional influence must persist long enough for the self-gravitation of the galaxies to become "locked" together.

In our Dynamic Steady State Universe, such an effect exists. The explanation of how it works requires an understanding of, first, the shape of the cosmic gravity cells, and second, the nature of aether-based gravity. The first is important because it is within the Voids of the cosmic cells that galaxies form and evolve while "falling" towards its gravitational center. The second is important because it, and it alone, provides the reality-based cause of gravity —the essential causality missing from 20th-century physics.

We start with the gravity domains.

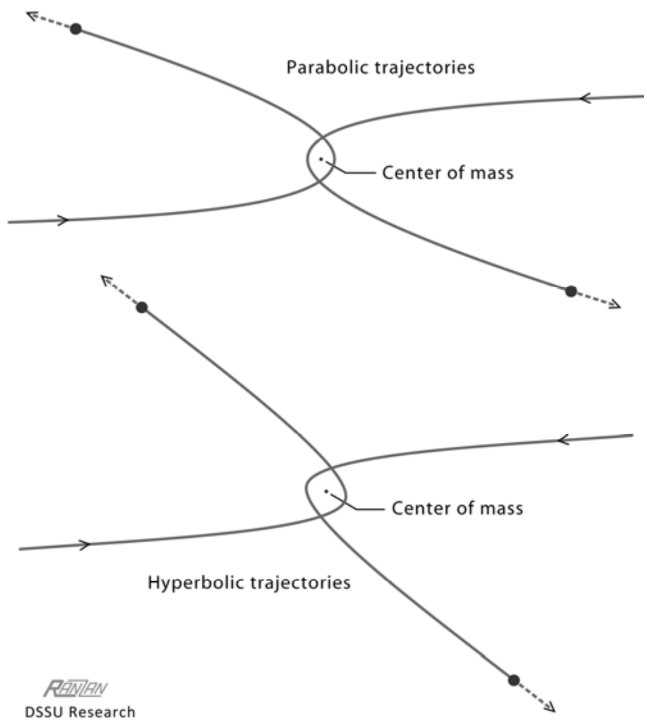

Figure 1. *Hyperbolic and parabolic trajectories are the norm for (non-collisional) flyby gravitational encounters. Two objects, whether stars or galaxies, approaching each other from a great distance in space can never "capture" each other into elliptical orbits.*

2. Cosmic Gravity Domains

Every dynamic system found in nature —steady state or cyclical— manifests cellular structure. Our Universe is a gravitational dynamic system; it runs perpetually in a steady state; it manifests cellular gravity domains.

2.1. Shape

Before discussing the shape of gravity cells, it helps to be familiar with the universe's structural cells —its visible network or tessellation.

In accordance with the aether theory of gravity and the Voronoi principle, the Universe is structured as rhombic dodecahedra (and rhombic-trapezoidal dodecahedra). See Figure 2. The proof and mathematical details are covered in the research article *Large-Scale Cell Structure of the Dynamic Steady State Universe*, which explains how the rhombic dodecahedron is the optimum space-filling shape. Foremost in the explanation is the harmony of opposing processes —primarily, *aether expansion* in the Voids and *aether contraction* in the regions of matter aggregation [3]. Additional details are presented in the book *Guide to the Construction of the Natural Universe* [4, p114].

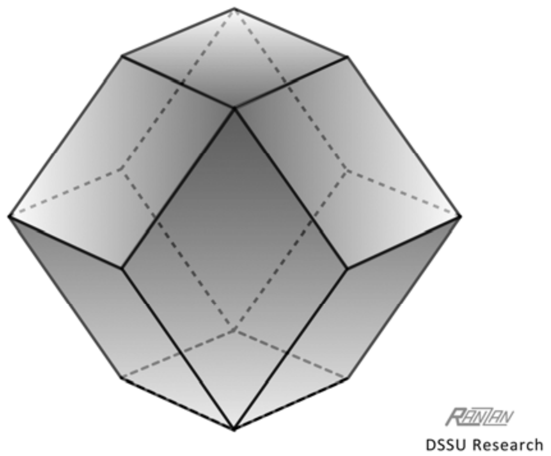

Figure 2. *Cosmic cell (idealized). Cosmic structural cells, approximately 300 million lightyears across, are shaped as rhombic dodecahedra (and rhombic-trapezoidal dodecahedra, not shown). The shape is sustained by the aether theory of gravity and the Voronoi principle. The central Void is surrounded by 14 nodes which represent centers of galaxy clusters.*

An important feature of the dodecahedral cells: They tend not to change in size. A self-regulating mechanism is involved in maintaining size stability. Aether continuously expands within a large portion of the interior; but at the same time aether continuously contracts at the cell boundaries (the boundaries of dodecahedral-shaped *structural* cells). Aether emerges from the Voids; while it drains away at the boundaries, and near the boundaries, and particularly around the nodes. Picture in your mind the dodecahedral cells as being vast aether-flowing systems —not as a cyclical flow, but as a perpetual one-way streaming. The only thing missing from this picture is matter (mass and energy stuff). It too is a self-regulating steady state system. There is, however, no need (nor writing space) to go into the details of the processes —except to note that the nodes of the cells are the main centers of gravity.

The systematic activity may be summarized this way: Aether expansion is contained within cosmic sized "bubbles" —*aether* expands within, yet the structures themselves DO NOT expand (Figure 2). While *aether* within the cosmic cells expands, the boundaries between cells limit the expansion. In fact the boundaries reverse the expansion by absorbing the aether flow —by contracting the *aether-space* that constitutes the flow.

The nodes of the dodecahedral cells represent the location of rich galaxy clusters. Hence they are regional centers of gravity. But notice there are two kinds of nodes. The significance of this is that within an extended tessellation of cells one node-type will be surrounded by four Voids, while the other type will be surrounded by six Voids. The discussion will focus on the simpler structure —called, for obvious reason, a "Minor node." It is much easier to illustrate. A schematic cross-section is shown in Figure 3 (a); a perspective view, more or less isometric, is shown in Figure 3 (b). (If time and space permit, the "Major node" may be discussed later.) The (a)-part of the figure shows three 2-dimensional cosmic structural cells *sharing* a Minor node. The (b)-part of the figure shows four 3-dimensional cosmic structural cells *sharing* a Minor node.

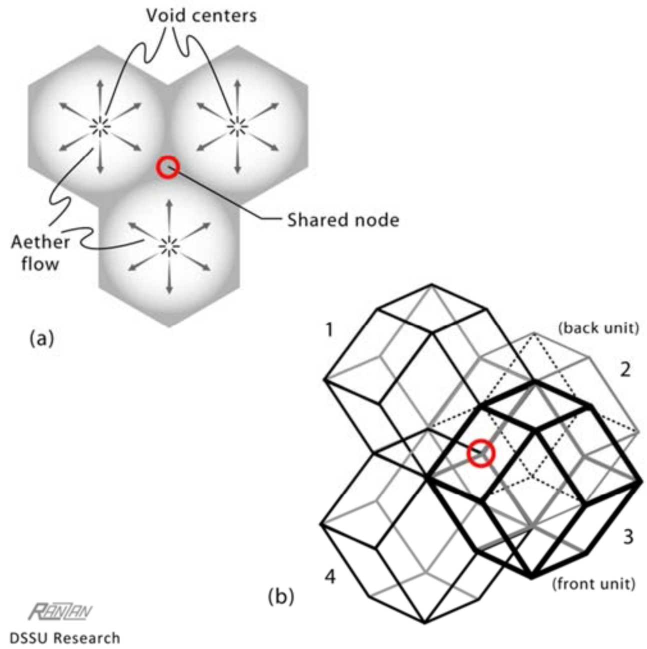

Figure 3. *Cosmic structural cells. Part (a) shows a 2-dimensional schematic of cells about a common node. Part (b) shows a 3-dimensional representation of four cells "packed" around a common node (indicated by the red circle). The universe's distribution of Voids and galaxy clusters can be modeled with rhombic dodecahedra, with galaxy clusters centered on the nodes. The perspective view shows how the close packing of such cosmic cells entails the meeting of four dodecahedra at one node. Essentially four cosmic cells contribute the material that sustains the particular cluster associated with this node.*

Now for the shape of the autonomous domains. The domain of any cosmic gravitating region is found simply by joining-up the nearest Void centers. To be more specific, the domain of gravitational influence of any nodal galaxy cluster (in this case the cluster at a Minor node) is bounded by the surfaces defined by "joining together" the surrounding Void centers. For the 2-dimensional hexagonal schematic, the domain is just a triangle, Figure 4 (a). For the dodecahedral arrangement, the shape of the gravity domain turns out to be a tetrahedron, Figure 4 (b) and 4 (c). The purpose of the figure is to delineate the boundaries of what is best described as an *autonomous gravity cell / domain* surrounding a Minor node.

But what is really important to the main discussion of what causes galaxies to rotate is that the gravity domains are partitioned into sub-regions.

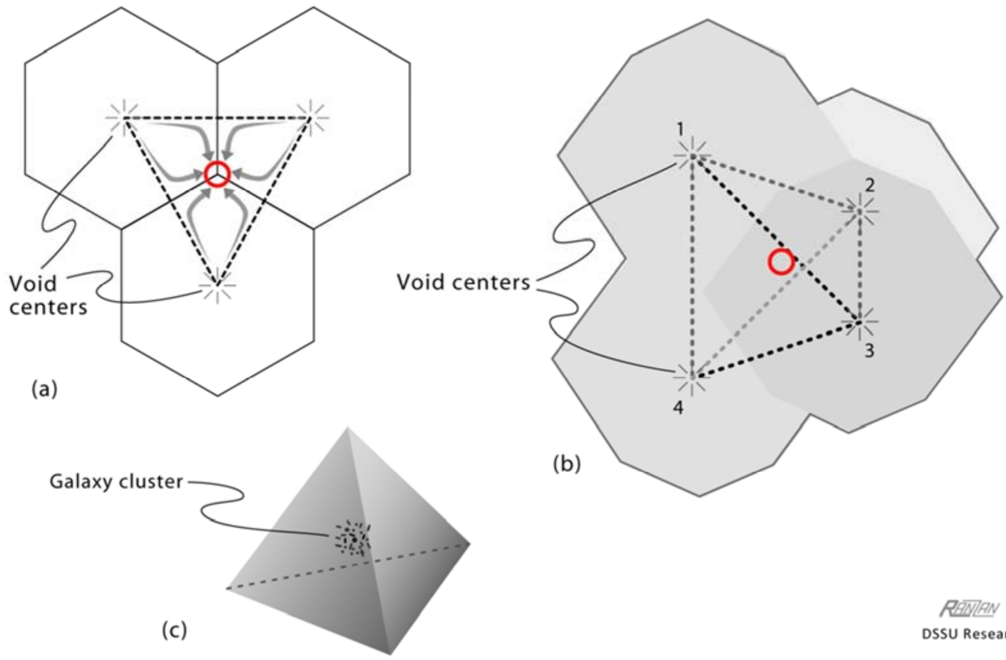

Figure 4. *Gravity domain of the nodal galaxy cluster. For the two-dimensional analogy, part (a), the shape of the domain is simply a triangle. For the three-dimensional representation, part (b), the gravity cell is shaped as a tetrahedron. The autonomous gravity domain of a "Minor node" galaxy cluster (a 4-branched nodal structure) is a four-sided polyhedron. In part (c) the tetrahedron is reoriented and shown with the galaxy cluster at its center. (The red circle indicates the gravitational center of each domain).*

2.2. Gravity Lobes

Cosmic gravity domains are divided into sub-regions, or *lobes*. Their shape is defined by the kinematic and dynamic properties of the space medium (aether), as manifest in the grand-scale flow patterns. It is a flow pattern consisting of emergence and divergence within the Void regions and convergent streaming in (and near) the matter-dense regions. The 2-dimensional analogy has a triple lobe pattern, Figure 5 (a); the tetrahedron has a quadruple lobe pattern, Figure 5 (b).

Each lobe has the shape of a six-sided polyhedron, as can be clearly seen in the exploded view, Figure 5 (c). Three of the sides extend into a Void; the other three sides interface with the other lobes. It means, every lobe interfaces with every other lobe. Take a close look. Altogether, the interior of the tetrahedral cell has six interfaces. Count them. By the numbers, the four lobes have a total of 12 sides *facing the central galaxy cluster*; 2 sides are always joined together to form a "hidden" interface; therefore, there must be six interfaces in the actual gravity cell.

But there is more to this than the six interface surfaces where pairs of lobes interact. There are boundary edges (four altogether) where a trio of lobes interact —where the interaction is most intense.

It is at the interfaces between the lobes belonging to the same gravity cell where the sought-for conditions exist; here is where Nature generates large-scale orbital motion, and which, in turn, leads to galactic rotation.

At the interface between lobes belonging to the same gravity cell (autonomous gravity domain), there we have the environment for generating large- and small- scale orbital motion. There lies the cause for galactic angular momentum.

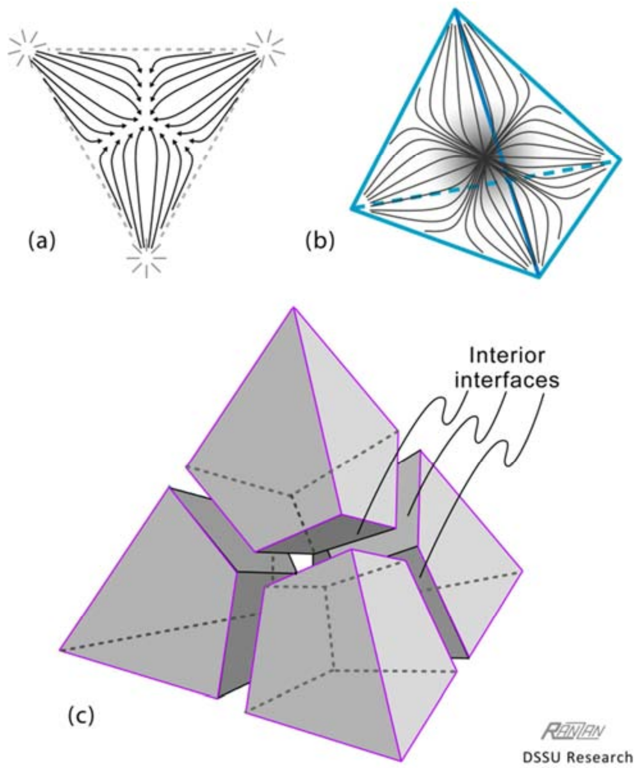

Figure 5. *Gravity lobes of the typical cosmic gravity cell. Part (a) shows the lobes for the hexagonal cells of the two-dimensional analogy. Part (b) is a sketch of the four lobes of a tetrahedral cell. Part (c) presents an exploded view of the gravity cell revealing the idealized shape of the lobes and the six hidden interfaces between lobes. In each case (a),(b) & (c), the nodal galaxy cluster —the region of greatest matter density— is located at the center.*

3. Interface Activity

3.1. Oscillatory Motions

The workings of the interfaces surrounding the tetrahedron's gravity center is the crucial factor that totally changes the motion of galaxies and their gravitational interaction.

In a long and unending process, galaxies emerge and grow in the Void, all the while "flowing" toward the interface. The linear motions of galaxies originate as a comovement whereby matter and aether flow together from the depths of the cosmic voids (Figure 6). While a galaxy is in the region of its originating Void, its motion relative to the comoving medium is zero; but relative to the target interface, its motion rises as it gets closer to the interface and may exceed 2000 kilometers per second [5].

Nature follows this simple script: The aether flows from the Void; now and then, a galaxy is carried along with the flow; the interface region absorbs a significant portion of the aether flow, the rest continues on its journey towards the tetrahedron's center of gravity; while the galaxy's significant momentum propels it clear across the interface. That last part, the overshoot into the adjacent lobe, is the important part.

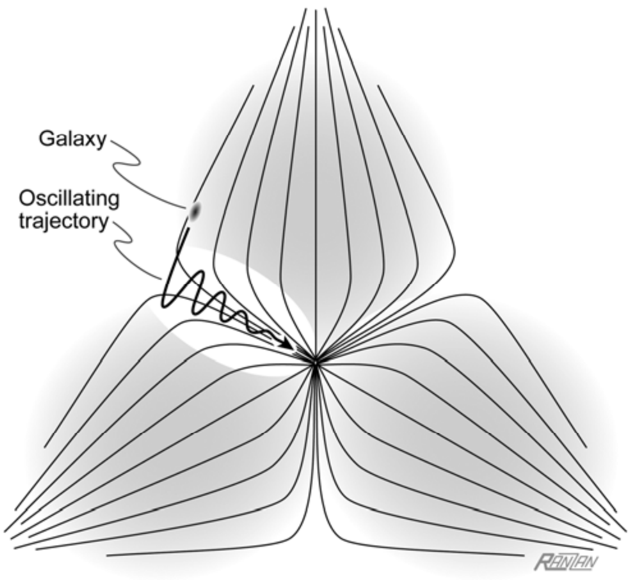

Figure 6. *Mechanism of trajectory deviation from pure comovement leading to path oscillation. A galaxy reaches its maximum speed (and momentum) upon its initial approach to the interface boundary. Assuming the subject galaxy manages to avoid major perturbations and collisions, then its path will look like the dampened oscillation shown. Factors, described in the text, cause the galaxy to follow an oscillatory path. (Not to scale).*

As shown in Figure 6, the galaxy comoves with expansion towards the interface gaining linear momentum and inertia great enough to carry it clear across and into the neighboring lobe. (The gravitational attraction of the matter that is already present at the interface also contributes to the gain in momentum.) Once within the interface and even more so beyond it, forces act on the galaxy to diminish its speed and reduce its momentum. The effects of (1) the "push" of expansion away from the Void, in accordance with aether-gravity Rule #1, given below; (2) the pull of gravity towards the matter-dense interface, per Rule #2 given below; and (3) the change of kinetic energy due to the impacting mass-flow (the mass streaming towards the interface); these eventually bring the galaxy's "up-stream" motion to a halt. The galaxy finds itself adrift well within the neighboring lobe. The same forces continue to act on the galaxy; speed and momentum, now in the opposite direction, relentlessly increase. The galaxy is on its return journey, accelerating back across the interface towards the originating lobe. Upon its return the galaxy may repeat the crossing cycle.

Provided there are no gravitational close encounters, the repeat cycles become an oscillation —a multi-billion-year side-to-side motion subject to the dampening influence of the viscosity of the gas and dust that accompanies the aether flow and, of course, the viscosity of material that is always present at the interface.

The aether theory of gravity has rules for cosmic cells:

Rule 1. As a general statement, galaxies tend to move away from the center of expansion. This means galaxies move away from the nearest vertex of the gravity cell. (In the present discussion, this refers to the vertices of the tetrahedral cell).

Rule 2. Galaxies tend to move toward the region of convergence —toward the region of greater density of "flow lines." The density of convergent flow lines is an informal measure of the intensity of contractile gravity. (This is analogous to the density of magnetic lines of force representing the strength of the magnetic field).

3.2. Gravitational Engagement

Given the occurrence of the natural oscillations as described, it should be easy to see how two (or more) galaxies can become entangled in a gyrating embrace. All it takes is for the galaxies to be oscillating out of phase. A pair of structures may originate from the same gravity lobe, as shown in Figure 7 (left-hand interface), or from opposite lobes as in Figure 7 (right-hand interface). Once the encounter is initiated, there really is no escape. The oscillation mechanism and the mutual gravitation, together, ensure the engagement is binding.

More generally, galaxies at or near the interface are always at risk of succumbing to an engagement, sometimes being trapped repeatedly. The traps, the conflicting paths, are endlessly turning up. Throughout the interface regions there are endless possibilities —a veritable maze of criss-crossing trajectories. And so it is that astronomers "witness" the weaving and dancing, the seemingly erratic swings and call it *peculiar* galactic motion; and they witness the steady spinning of galaxies streaming along cosmic filaments connected to great clusters. A clear example of this is the filament extending from the Fornax Cluster to the Virgo Cluster [6]. Astronomers see what DSSU theory predicts they should see.

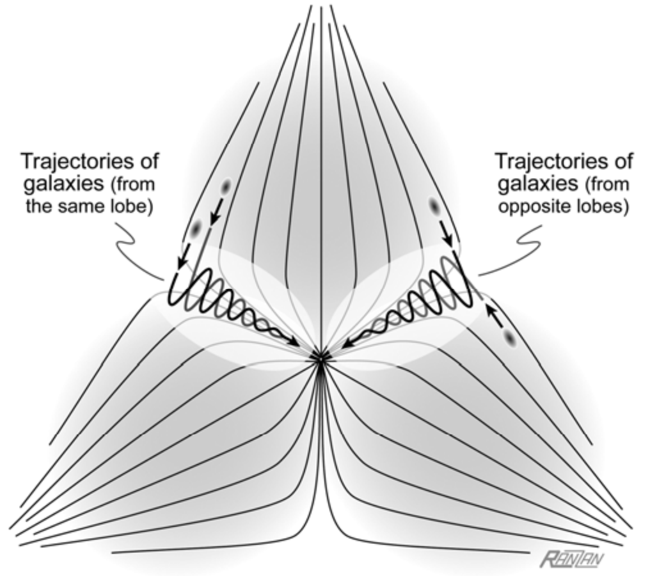

Figure 7. *Paths of out-of-phase galaxies —oscillating in opposition as they navigate the converging zone. Two galaxies originating from the same gravity lobe (Left portion) and two galaxies originating from opposite gravity lobes (Right portion) happen to arrive with out-of-phase oscillation. If the galaxies also arrive reasonably near to each other, then the routine oscillation will transition to mutual orbital motion, followed by the two spiraling into each other, and end with a merging into a single rotating galaxy. (Not to scale).*

If a pair of galaxies are out of phase by 360 degrees and in the same plane (in other words they are following the same path but one wavelength apart), then the galaxies will gradually merge, but, it would be an engagement without the formation of spiral structure. In such a case, with the maximum phase difference, the pair —even though they may have originated from opposite lobes— would mostly, if not always, be on the same side of the interface and the necessary conflicting motion would be absent. And so, no orbit, no rotation, no spiral. In the event that rotation does ensue, it will not be significant. Conclusion: the ideal phase difference for the formation of spirals is 180 degrees, i.e., one-half of an oscillation wavelength.

Exemplar scenario number 1 (Figure 8): Say two galaxies, with no prior perturbation, meet at the densest part of the interface. In other words, the encounter is on an axis that aligns with the central galaxy cluster (which may be about 100 million lightyears away). The galaxies crisscross the axis in opposite directions; and come closest to each other when crossing the axis. The passing encounter is such that the galaxy that happens to be closer to the distant cluster will be retarded in its motion (the motion parallel to the interface axis). While at the same time, the gravitational encounter will cause the other galaxy to gain speed (the speed component parallel to the interface axis). These changes in speed are simply the consequence of the change-in-direction effect illustrated earlier in Figure 1. Obviously if one galaxy is being pulled forward and the other is slowed, then by the time they re-engage they will have switched places along the axis. The former follower will now be the leader. This switching occurs with each crossing of the interface axis (with each half oscillation cycle). It could be thought of as a leapfrogging effect. However, when viewed by an observer moving along with the frame of reference of the barycenter, the picture is of an elongated orbiting system. The dampening discussed earlier causes the galaxies to orbit ever closer, ever more circular, and ever faster.

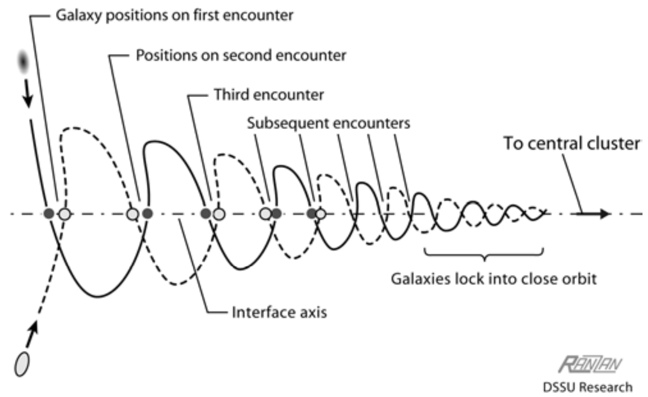

Figure 8. *Gravitational engagement example 1: Idealized symmetrical encounter of two galaxies originating from opposite lobes. The two galaxies are one-half cycle out of phase; and their separate trajectories are approximately in the same plane. Notice the leapfrogging effect as leader and follower repeatedly switch places (on each encounter along the interface axis). With each crossing the eccentricity of the mutual orbit becomes less and less. With each crossing the galaxies come closer together; and ultimately they join to become a single rotating galaxy. (No attempt is made to show the inevitable tidal distortions such as tails and bridges. Not to scale).*

Exemplar study number 2 (Figure 9): In this example there is no initial close encounter. The two galaxies start out following roughly the *same trajectory* and are one-half cycle out of phase. Gravity gradually brings them closer together as the leader's motion is retarded and the follower gains. But there is more to it. The wavelength of the leader gets shorter, while that of the follower gets longer. Eventually the oscillations become out of synch to the extent that the two galaxies will encounter each other moving in opposite directions. The leapfrogging action comes into play. And again, orbital motion is induced and ultimately a spiral structure is produced.

The discussion has focused on the engagement of field elliptical galaxies (negligible or no rotation and not belonging to a central cluster). But it also happens that galaxies having previously undergone the rotation-acquisition process may become involve in a new engagement. In other words, a field spiral may enter into another partnership —even with another spiral.

Consider the Milky Way and the Andromeda galaxies; they may very well be involved in such an advanced type of engagement as they accelerate towards the great Virgo Nodal concentration. Our Galaxy is currently leading in the journey toward the Virgo node; Andromeda, also known as M31, is following not far behind (about 2.5 million lightyears). In the gravitational interaction between the Milky Way and the neighboring M31 galaxy, the Milky Way is being retarded along its journey toward the Virgo Supergalaxy M87; and at the same time M31 is receiving a boost toward the same destination. The gap between them is closing at the rate of about 300 kilometers per second (based on a blueshift index of 0.001001). In time they will form a close orbit about each other (about their common center of gravity) and settle into a new spiral-like configuration.

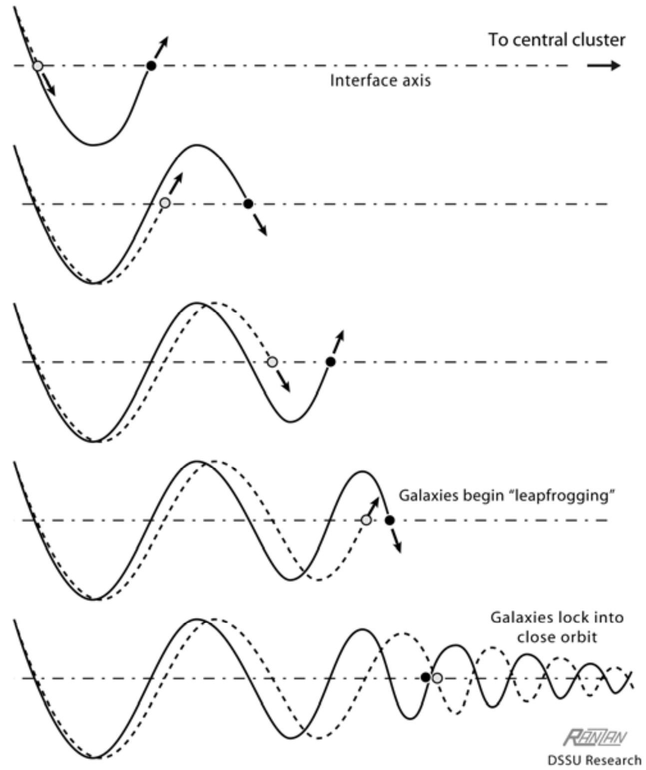

Figure 9. *Gravitational engagement example 2: Idealized stop-action sequence of two galaxies initially following the same trajectory and initially one-half cycle out of phase (one-half wavelength apart). Each time they cross the interface axis the galaxies will be closer together. In the 4th stop-action image, the galaxies are close enough to initiate gravitational leapfrogging, the effect discussed in the text. The galaxies then lock into an ever tightening close orbit. They become a single structure with a staggering amount of rotational energy. (As viewed in the frame of reference of the cosmic gravity domain. Not to scale).*

And keep in mind, the M87 death-trap galaxy at the center of the Virgo cluster remains a long journey away (50 to 60 million lightyears); our Galaxy and Andromeda still have many billions of years' time in which to join into a new and bigger spiral. The details of the engagement could be made more substantive. It would be very interesting to study how their rotation planes are related; and compare their rotation sense. These are rather complex issues, mainly because a galaxy may acquire multiple axes of rotation.

There is one certainty. Ultimately, the engaged pair (or remnant) will end up being absorbed into M87 and will end its existence within the central supermassive Black Region. (Yes, "Black Region" is a special term and has not been previously defined, but its meaning is self-evident.)

The scenario that leads to the spiral morphology is unambiguous. When galaxies have trajectories that are out of phase (as shown in the figures) and are reasonably close to each other (close enough to exert a gravitational influence) then the stage is set. The galaxies, no longer free to follow the simple unencumbered oscillating path, follow, instead, a distorted oscillating course; then they begin orbiting; the orbit tightens; they spiral into each other; and in the end they merge into a single rotating galaxy.

For readers unfamiliar with the aether theory of gravity, the described mechanism raises an obvious question. Once a pair of galaxies (or even a group of galaxies) has established a mutually orbiting configuration, why should the orbit gradually tighten up? Why should the galaxies spiral into each other? … The answer lies in aether's inability to sustain stress. There are four stresses aether succumbs to: (i) the stress of excitation relating to the primary cause of gravity; (ii) the stress of compression of convergent flow; (iii) the stress of compression associated with intense gravitational waves; and (iv) the stress of shear of vorticular flow. Since the aether that exists in our Universe is noncompressible, it reacts to these stresses by self-dissipating —it vanishes. It vanishes quite literally. It does this in relationship to the degree of the stress. Rotation causes shear stress. In the context of rotating systems, the resulting self-dissipation of aether causes a significant amplification of the normal Newtonian gravity. The details of the reaction-to-stress processes are presented in the published article *The Nature of Gravity –How one factor unifies gravity's convergent, divergent, vortex, and wave effects* [1].

Before ending this section, a related question should be addressed. What about stellar-scale rotations, can the model account for the acquisition of stellar and gas-cloud rotations? It is the nature of the dynamics of the cosmic gravity cell, that galaxies often colliding, partially or head-on. Large galaxies are constantly encountering dwarf galaxies and globular clusters. The colliding structures just pass through each other, sometimes repeatedly. Actual star-on-star collisions are extremely rare; but near encounters are common. Smaller scale angular momentum is acquired and manifests in the numerous binary stars, multiple star systems, and planetary systems found within galaxies of the interface environment. Again, the interface turbulence is the direct cause.

The key ingredient in the gravitational engagement of proximate out-of-phase galaxies is the combination of cross-interface oscillation *and* along-interface vacillation.

4. Summary of the Causal Mechanism

... this grand book of the universe which stands continually open to our gaze... is written in the language of mathematics, and its characters are triangles, circles and other geometric figures, without which it is impossible to understand a single word of it; without these, one wanders in a dark labyrinth.

–Galileo Galilei, 1623, The Assayer

The basic problem in generating galaxy rotation. In the absence of conflicting motion, two galaxies (previously unperturbed) when involved in gravitational encounter will simply merge into one. No galactic-scale rotation will ensue.

Granted, conflicting motion is necessary. In that case, as discussed earlier, proximate gravitational encounters would (in the absence of mitigating effects) entail hyperbolic and/or parabolic trajectories resulting in a growing separation of the two galaxies, never to meet again. Again, no significant rotation can be expected.

Core idea behind the cause of galaxy rotation. As discussed earlier, both conflicting motion and certain mitigating effects must be present if a gravitational encounter is going to result in a spiral-type galaxy. Within what sort of cosmology are both conditions to be found? Not in an expanding universe; there, galaxies for the most part are drifting apart with very little opportunity for interactions; any clustering that does occur is highly symmetrical; galaxies simply converge towards a regional gravitational center. Such regional centers would have large-scale spherical symmetry and preclude any large-scale rotation. In a static-space universe —a nonexpanding universe— the situation is not much different. The answer lies in geometry —in the geometry of the way the Universe is intrinsically cellular.

Once again it is the 3-dimensional geometry (not 4-dimensional geometry) of the universe and the dynamic motion of the space medium (not curved space) that provide answers consistent with observations. DSSU theory provides the essential mechanism that sustains the observed distribution of galaxies and explains their various motions. The theory holds the simple and elegant solution to the riddle of galaxy rotation.

Beneath the apparent random motions and haphazard concentrations of galaxies lies the simplicity and regularity of a cosmic-scale cellular structure. The Universe, it turns out, consists of autonomous gravity cells, cosmic-scale and nonexpanding, shaped as tetrahedra and octahedra [7, 4, 3]. And within those cells, sustained as they are by the presence of a dynamic space medium, all the necessary conditions do exist: Gravity subdomains that generate the kinetic energy, and the interfaces (between subdomains) that induce oscillatory galaxy motion. The interfaces trap galaxies and compel them to interact; this is the heart of the mechanism. (See Figures 5, 6, and 7)

The answer lies in a cellular universe. Needless to say, there is much more to be explored. More than facilitating the generation of grand-scale rotation, the cosmic gravity cells dominate the ongoing process of galaxy evolution.

5. Relevant Comments

5.1. The Missing Cause in Academic Cosmology

In the preparation of this article, several textbooks and related sources were checked for details on the conventional mechanism causing galaxies to rotate.

Checked was the popular textbook *Constructing the Universe*, in which the author David Layzer discusses angular momentum in terms of its conservation, its dissipation and its transfer, but nothing as to its cause! Nothing relevant is listed in the index. And worse, Layzer points out that the most obvious fact about the Universe is that its matter distribution is clumpy but gives no convincing explanation for the cosmic nonuniformity in the distribution of galaxies.

Checked the Cambridge Encyclopedia of Astronomy. No description of the cause of galaxy rotation was found.

Checked the authoritative Encyclopedia Britannica, without success.

Even Carl Sagan's classic book *Cosmos* was checked.

There were many others. They all refer to rotation but make no mention of what caused it; same situation exists for a search on angular momentum. Seems that what is not understood is simply deemed unimportant; what is impenetrable is just neglected. One physicist/author, commenting on the work of astronomer Vera Rubin, stated that her research centered on the "study of the most mundane and unglamorous areas of astronomy, the rotation of galaxies."[8, p148] Incidentally, the now legendary Vera C. Rubin (1928-2016) had no causal model either.

Conventional cosmology has no explanation for the cause of galaxy rotation and no plausible model for the observed major galaxy clusters; and most embarrassingly, and not unrelated to the previous two, no solution to the decades-old dark matter mystery. In the words of Michio Kaku, a professor of theoretical physics,

> "In addition to the still-unsolved dark matter problem, there is an equally perplexing cosmological puzzle involving the unexpected clumping of galaxies into gigantic clusters." [8, p153]

Although written back in 1995, the lament still holds. And the fundamental cause of rotation is still ignored.

5.2. Instances in Need of a Cause

Let's be clear on this. This is not some trivial matter —not some rare incidental feature. Over 70 percent of all large galaxies are classed as spirals. That is, almost three-quarters of the brightest star systems in the visible universe are spinning [9]. They each possess a staggering degree of angular momentum! Their spin is great enough to turn them into flattened disks.

Spirals, however, are not the most common in terms of the total number of galaxies. Dwarf ellipticals are by far the most common type. A characteristic feature of ellipticals, from dwarfs to giants, is the complete absence of rotation or a negligible degree of rotation. Why this pronounced difference in morphology, and in spin *versus* no-spin? Astronomers need to know.

The problem is usually framed as the morphology-density mystery. Astronomers have long wondered why the vast majority of the galaxies along a spread-out cluster are rotating; while most of the galaxies in a dense cluster are characteristically not rotating. The question, in other words, is: Why do spirals dominate the filamentous clusters, while ellipticals dominate the rich clusters?

It's a long-standing issue. As expressed in *Scientific American*, some years ago: The "so-called morphology-density relation has long puzzled astronomers."

Where galaxies are sparsely distributed through space, spirals overwhelmingly dominate the population, only 10 to 20 percent are ellipticals. For the galaxies that are packed into clusters the situation is reversed. There, one finds “Ellipticals are the majority, and the spirals that do exist are anemic systems depleted of gas and young stars.” [10, p16] Then there is the question, posed in the same *Scientific American* article, of “Where does this angular momentum come from?” [10, p19] … The authors of the article, Guinevere Kauffmann (Max Planck Institute) and Frank van den Bosch (Yale University), are considered to be world experts on the theoretical modeling of galaxy formation. With the new insight their expertise and understanding can surely grow.

In the field of plasma physics there is a fascinating theory called the Alfvén hypothesis, proposed by Swedish Nobel laureate Hannes O. Alfvén (1908-1995), in which a galaxy spinning in the magnetic fields of space acts as an immense dynamo, inducing electric currents in the interstellar plasma. The currents flow in great filamentary spirals toward the center of the galaxy, then turn and flow upward along the spin axis. By modeling the effects of electromagnetic vortices on plasma clouds, Alfvén’s former student Anthony Peratt, found that it was possible to simulate the formation of all known types of galaxy. And in some simulations, concentrated jets of plasma burst out of the galactic core. As Alfvén had predicted, the simulations suggested that the arms of spiral galaxies are formed by giant vortex filaments carrying electric currents towards the galactic center. This unusual and elegant theory is backed by lab research (Los Alamos National Laboratory) and astro-observations [11]. The only thing missing was the cause of the angular momentum!

Can the Alfvén model be extrapolated to the largest scale?... Maintaining that “the Big Bang never happened” Alfvén suggested that his plasma vortex filaments, given enough time, will grow and organize the entire universe into a complex web of magnetic fields, electric currents, and plasma —a cosmic power grid that gathers matter around and along its network [11]. *If only there was a source for the necessary rotation!*

The tool from statistical mechanics known as the *virial theorem*, and the *cosmic virial theorem*, uses the velocities of the individual members of a cluster of bodies and relates them to the overall gravitational potential energy. With mathematical precision, it integrates their individual movements. But, of course, it cannot give a *cause* for the motion; and without *that cause*, the theorem may be (and is being) misapplied. The use of the virial theorem in investigations of galaxies overwhelmingly point to the existence of much more matter in galaxies than can be seen in the form of stars. Similarly by using the peculiar motions (assumed to be random) of galaxies within a dense cluster, the misapplied virial theorem predicts a mass content that greatly exceeds the expectation from the sum of the visible galaxies. A grave misinterpretation has been generated. The virial theorem leads to a vast over-estimate of the actual mass within spirals and within galaxy clusters. It leads, in fact, to the unsolvable dark matter problem. This affects all astrophysicists. (Is there a one who has not worked on DM?)

The Toomre brothers famously conducted dramatic computer simulations showing two galaxies drifting past each other, rotating in opposite directions, and producing realistic spiral arms and filaments. But again, they too lack the mechanism that causes the original rotation in their simulated galaxies.

The astronomers Stephen Gregory and Laird Thompson conducted a detailed study of the filament-like Perseus-Pisces system and noted “that many of the individual galaxies in the … system have planes of rotation that are either parallel to the axis of the supercluster filament or perpendicular to it.” [12, p93] The findings “suggested the possibility that the rotation axes of some galaxies were correlated not only with the rotation axes of other galaxies but also with the gross structure of the supercluster filament. The idea has received support from studies by Mark T. Adams, Stephen E. Strom and Karen M. Strom of Kitt Peak, who found similar rotational correlations in the combined data from several flattened clusters.” [12, p96]

The findings are in remarkable agreement with what is predicted from an understanding of the interface activity within the DSSU framework. The term “filament” has a recognizable meaning in connection with the geometry of the gravity cells; the filament-like structure refers to the densest portion of the interface. The filament is the longitudinal boundary zone where three gravity lobes meet (see Figure 5).

In their report, Gregory and Thompson added prophetically, “This observation … may tell something about the way galaxies and superclusters are formed.” [12, p93] Also, “If such correlations are confirmed, supporters of the conventional model of galaxy formation would probably face insurmountable obstacles in producing an explanation.” And rightly so, for the simple reason: “The random statistical processes in the conventional model are not conducive to generating organized rotational motion over any large scale.” [12, p96]

Here again, astronomers need to recognize the underlying geometry involved in the causal mechanism of rotation; only then can the formation processes and the plane-of-rotation correlations be understood.

5.3. Recent Development

Last December 10th, one-half of the Nobel Prize in Physics for 2019 was awarded to Canadian-born James Peebles. The citation stated it was “for contributions to our understanding of the evolution of the universe …" and "for theoretical discoveries in physical cosmology." According to the Press Release[1] of the Royal Swedish Academy of Sciences:

> James Peebles’ insights into physical cosmology have enriched the entire field of research and laid a foundation for the transformation of cosmology over the last fifty years, from speculation to science. His theoretical framework, developed since the

1 Press Release: https://www.nobelprize.org/prizes/physics/2019/press-release/.

> mid-1960s, is the basis of our contemporary ideas about the universe.
>
> The Big Bang model describes the universe from its very first moments, almost 14 billion years ago, when it was extremely hot and dense. Since then, the universe has been expanding, becoming larger and colder. Barely 400,000 years after the Big Bang, the universe became transparent and light rays were able to travel through space. Even today, this ancient radiation is all around us and, coded into it, many of the universe's secrets are hiding. Using his theoretical tools and calculations, James Peebles was able to interpret these traces from the infancy of the universe and discover new physical processes.
>
> The results showed us a universe in which just five per cent of its content is known, the matter which constitutes stars, planets, trees – and us. The rest, 95 per cent, is unknown dark matter and dark energy. This is a mystery and a challenge to modern physics.

In a separate report issued by the Royal Swedish Academy of Science, Peebles is credited with having worked out the details of "*how matter could ... clump up to form the galaxies and galaxy clusters that we now see in space*." [13]

From a report [14] issued by the The Nobel Committee for Physics praising "The ground-breaking work by Peebles":

> "The way theory and observations now fit is astounding and the number of parameters are few. Still, *there are observations that cannot be fully explained at the present time*. Measurements of the Hubble parameter in the late-time Universe do not quite match what is predicted from CMB physics. The explanation is currently unknown. Systematic errors in the measurements could potentially be responsible, or, *perhaps new physics is still hiding somewhere out there*.
>
> Physical cosmology, with its interplay between observations and theory, is a tremendous success story that over the past half century has changed the way we view our Universe. Once, cosmology was a subject full of unfounded speculations and little data. It is now an exact mathematical science, where evermore accurate observations play a key role. The era of discovery is not over. As the measurements become more precise, new and unexpected phenomena are likely to be discovered. *Physical cosmology will have more surprises in store*, and Peebles is the one who has shown us the way to discover them." [Emphasis added]

Another announcement[2], this one from his Manitoba alma mater, where Peebles is considered to be the master of the universe, stated:

> "Peebles advanced the concept of a dark matter component to the universe and its implications for the evolution of structure. Through this, and other work, he helped establish the theoretical framework for our picture of *how galaxies have formed and evolved*." [Emphasis added]

James Pebbles is the undisputed master of 20^{th}-century cosmology and astrophysics. He has received numerous prizes and honors, surely more than any other person within this field of study. The conferrals include some of the most eminent in astronomy. He holds the prestigious position of Albert Einstein Professor of Science at Princeton University. Little wonder that many believe him to be the greatest cosmologist of the last six decades.

Summarizing Peebles' main contributions to 20^{th}-century cosmology: (1) He constructed an account of the evolution of an expanding universe and the formation of cosmological structure culminating in galaxy clusters. (2) He developed theories for the evolution of galaxies. (3) In order to give some degree of credibility to the first two, he invented and developed dark matter physics.

Be that as it may, the Nobel selection committee, in what amounts to a breathtaking understatement, reminds everyone: "Still, there are observations that cannot be fully explained".

As pointed out earlier, one of the most iconic characteristic of a large percentage of galaxies is large-scale rotation. In the case of spirals, this rotation is revealed most spectacularly. Yet Peebles' theory of galaxy formation fails to identify the basic cause. It is an omission comparable to having a theory of blood transmission through the arteries and veins of the body and failing to include the beating heart!

And then there is the devastating evidence. His theory of galaxy formation within an evolving universe is flat-out contrary to reality. Within the framework of Peebles' BB cosmology (in which supposedly "the age of the Universe is now known with better than 1% accuracy to be 13.8 billion years"), extremely distant galaxies are now routinely discovered that are theoretically not much older than one-half billion years —yet appear fully mature. But Peebles knows full well that galaxies cannot possibly form in such a short time span. On the cosmic time-scale, 500 million years is just a coffee break —barely time enough for two rotations of our Milky Way Galaxy.

It is time to recognize and absorb the significant developments that have occurred during the last decade in the field of cosmology. The real Universe does not evolve. It does not expand. Our Universe — sustained as it is by steady state dynamic processes— is cellular.

Professor Pebbles now has the opportunity to complete his theory —to fill in the missing portion of his model of the formation and evolution of galaxies. By exploiting the cosmic-gravity-cell concept he can more realistically model the structure of the universe, *incorporate the missing cause of galaxy rotation*, solve the morphology-density mystery, and, as a bonus, make his "dark matter" completely irrelevant.

5.4. Concluding Words on a Conclusive Theory

How can one be so sure that this is the correct theory of galaxy rotation?

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2 Source link: https://news.umanitoba.ca/nobel-prize-in-physics-james-peebles-master-of-the-universe-shares-award/.

Reasonable certainty comes from the fact that the described mechanism is an integral part of the DSSU, the cosmology that (1) has passed every test, every challenge it has confronted; that (2), unlike other cosmologies, has no paradoxes; and that (3) is the only cosmology that passes the ultimate test of validity [15] —including the checkmate observation. The DSSU passes the Abell-85 test: It alone can explain what is by far the most unusual, and heretofore most inexplicable, pattern of galaxy clusters in the observable universe [16]. The model actually predicts the structural pattern.

Furthermore, there are no gaps in the theory; no major observations that cannot be explained; and the evolution of galaxies is but a logical element. By reasoning from first principles, then following the logical consequences of those principles as embodied in DSSU theory, an unambiguous (remarkably self-evident) cause of galaxy rotation has been uncovered.

In conclusion, the domain of astrophysics now, at long last, has a valid theory of the cause of galaxy rotation.

The kind of beauty that we find in physical theories is ... the beauty of simplicity and inevitability —the beauty of perfect structure, the beauty of everything fitting together, of nothing being changeable, of logical rigidity.

—Steven Weinberg, *Dreams of a Final Theory*

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