The Large Scale Structure of the Dynamic Steady State Universe

1

Conrad Ranzan

While the question of a reason for the repulsion issuing from the positive energy of empty space doesn't lead us anywhere, it makes sense to ask how this repulsion will manifest itself. —Henning Genz[1]

1 WHAT IS ACTUALLY EXPANDING?

The basic question that must be asked: does the space-expansion redshift necessarily imply an expanding universe? Does the unlimited expansion of space, as evident in the cosmic spectral redshift of light from distant galaxies, necessarily mean that the entire universe is expanding?

The main supporting evidence for the standard model, the Big Bang Inflationary (BBI) model of the universe, is the Doppler-expansion interpretation of the redshift of light from distant galaxies. The greater the redshift, the faster the object is receding from the observer, and thus the greater the distance. The cosmic redshift is interpreted to mean, first and foremost, that the objects of the universe are flying apart with respect to each other in a large scale unconfined universal expansion. Although the model had predicted that the expansion rate would decrease and eventually be halted by the collective gravity of all the matter in the universe, observations in 1998 proved otherwise. A study of Type 1A supernovae showed that the expansion of the universe, instead of slowing down, is actually accelerating. "It's definitely the strangest experimental finding since I've been in physics," was the reaction of Dr. Edward Witten of the Institute for Advanced Study in Princeton.[2] It appears that gravity is insufficient to limit the expansion. Not only is there a problem with deficient gravity (or insufficient mass) but there is a problem in determining what new energy or "dark force" is driving the observed acceleration. A rethinking was required.

A more realistic model of the universe had to be found. Fortunately, there has never been a shortage of models to choose from. The only constraint was that a model must, in one way or another, conform to Einstein's famous theory of gravitation, the theory of general relativity (GR). This universally accepted theory describes the most powerful forces that rule and shape the universe. In the 1920s Alexander Friedmann extrapolated the theory onto the cosmos and showed that the universe could be either expanding or contracting —but it could not remain as a static universe. Theorists, ever since, have concentrated on either expansion or contraction. For instance, in the *big-bang big-crunch* model the universe first expands and later contracts. The current standard BBI model is pure expansion —highly problematic expansion.

Yet it seems, no one has seriously questioned the underlying premise. Maybe universal expansion is not universal. Has anyone pondered these questions? Couldn't GR be applied to a universe that is expanding in one region while contracting in another? Instead of a universe with *expansion* OR *contraction*, what about a universe with *expansion* AND *contraction*? And the most obvious question of all, *How could a theory of local spacetime be extrapolated to the universe as a whole*? There should have been a rejection of the unrealistic over-extension of general relativity theory. Any sort of realistic application must deal with sub-regions of the universe (especially if the whole universe extends to infinity). Anyway, this necessary rethinking did not take place —at least not in standard cosmology.

In keeping with the theme of universal expansion, new inflation models were developed and old ones re-examined. Andrei Linde's old *Chaotic Inflation* model comes to mind. Then an interesting variation was proposed; called the *self-reproducing inflationary universe* it eternally keeps expanding as a chain reaction, producing a fractal-like pattern of universes. "In essence, one inflationary universe sprouts other inflationary bubbles, which in turn produce other inflationary bubbles."[3] Predictably, though, most of the considerable effort went into salvaging the original BBI model. In the end the consensus among cosmologists was that, yes, it was still the entire universe that expands. Only now it was expanding faster than ever because of a new force, the Lambda force, Einstein's cosmological constant (or something that acted just like it).

In searching the scientific literature I found that there was no shortage of diverse models to choose from and additional models are being created, it seems, with every edition of one or another science publication; yet, no model could be found that uses a synchronic expansion and contraction of space. I found no evidence that anyone or any group is currently researching a model containing this dual property of space. The *Dynamic Steady State Universe* (DSSU) is the first to incorporate these complementary properties. The DSSU uses, as its very foundation, the concept of the simultaneous spatially separated expansion and contraction of *space*. *Space* expands slowly in large regions and contracts rapidly in comparatively small regions. Hence, the DSSU is described as a ***non-expanding universe consisting of expanding space***.[4]

Generally speaking, in standard cosmology, all the models being seriously considered assume the entire universe is expanding. These models are based soundly on the concept of space expansion; however, this concept is then unscientifically extrapolated into *the expansion of the entire universe*!

> *The presumed expansion of the locally observed universe, which is admitted to being a mere fraction of the total [universe], does not mean for one moment that the entire universe is so affected. It seems reasonable that some parts of the universe could expand while others contract.*[5]

2 EXPANSION REDSHIFT IN A NON-EXPANDING UNIVERSE

In postulating an alternative model, a non-expanding universe model, is it possible to accommodate the uncompromising fact that the cosmic redshift of all distant galaxies is caused by the expansion of intervening space itself? If a non-expanding universe can be found, in which the space-expansion redshift is proportional to distance, then clearly the presence of such a redshift does not necessitate a big bang type of universe.

Consider a universe which is expanding in vast regions and simultaneously collapsing in much smaller regions. Also consider the condition whereby the volumetric expansion of the expanding regions closely balances the contraction in the collapsing regions. Then whatever objects are floating around in the universe would simply be carried along with the local expansion and eventually accumulate at the boundaries of adjacent expanding regions. Expanding *space*, bumps into neighboring expanding *space* and where they meet contraction occurs. Nothing could be simpler.

Interestingly, one would still observe a spectral redshift in cosmic distance measurements. Astronomers may correctly assume that the larger the redshift the greater the distance to the object being measured. In the new model the redshift continues to serve as the fundamental means for determining cosmic distance. However, the interpretation that the redshift is a measure of the object's receding motion and, what amounts to the same thing, the expansion of the universe, are both not necessarily true. There is simply *no way to determine from the redshift alone whether space is expanding in an expanding universe, or expanding within a non-expanding universe.* Yet the distinction is of utmost importance.

Of particular significance to the new model is that "expansion redshift is independent of the way the universe expands… whether slowly, quickly, or in a series of jerks… [even] the time taken to expand… the way in which the expansion occurs have nothing to do with the expansion redshift." As detailed by Edward R. Harrison in *Cosmology the Science of the Universe* only the net amount of expansion is important.[6] Furthermore, it does not matter *where* the expansion occurs, as long as it takes place somewhere —anywhere— along the line of sight.

It has already been stated that the volumetric space expansion is balanced by an equal amount of space contraction. Now, if the postulated contraction regions are considered to be intensely contracting 'points' which are randomly distributed in relatively compact regions: then the line-of-sight will be only slightly affected. Most lines-of-sight will miss these 'points'. As a result there would be very little *space contraction* detected; while the much larger region of *space expansion* would be unmistakably apparent. Understand that the space-contracting region induces a small blueshift (the light wave shrinks slightly); while the space-expansion region induces a relatively large redshift (the light wave stretches). The evidence accumulated in the light-wave passing through these regions appears to astronomers solely as a ***net redshift***.

From this, the conclusion can be drawn —and the question posed above can be answered— that ***an expansion redshift does not necessarily mean that the Universe as a whole is expanding***.

3 BUBBLE FORMATION PROCESS

The following description of bubble formation and evolution is meant to be purely as an imaginary chain of events to produce the end result. It is a model re-creation of the universe; but it is not a sequence that actually occurred in the Universe. The description is not to be interpreted as the creation of our Universe. Since the universe is infinite both in time and in dimensional space, it cannot have a single event beginning. Furthermore, a dynamic steady state universe does not need a beginning —a steady state implies a perpetual existence. Infinity does not have endpoints. The following process of the "creation" of a cellular dynamic steady state universe is simply an imaginary exploration. However, the dynamics described are considered real and, in fact, are essential in maintaining a perpetual equilibrium in the Universe.

To describe the shape of the expanding regions it would seem only logical to start with circles. Consider random circles that lie in a plane; circular mini-universes lying in an infinite planar universe. The circles have only three attributes: they expand, they are flexible, and they have a specific limiting size (the dynamics that lead to equilibrium is explained in a following subsection). As the random circles expand they will bump into each other (possibly absorbing the much smaller ones). The entire surface becomes filled with circles of more or less equal size. As they continue to expand they will deform. The contact boundaries become straight lines (Fig. 1) and the buffer spaces disappear. There can be no gaps between circles since our planar universe consists of deformed circles and nothing more. At maximum expansion, the web-like pattern of straight lines reveals a regular hexagonal pattern.

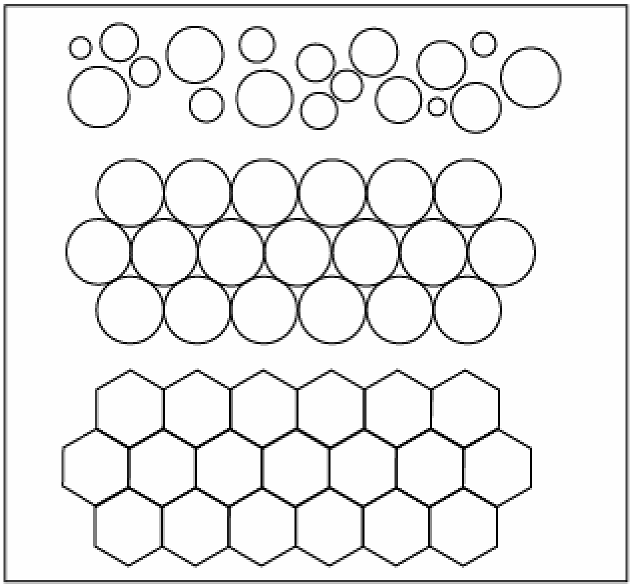

Fig. 1. Expanding circles (top), fill a hypothetical plane (middle), and form a hexagonal pattern on reaching equilibrium (bottom).

In describing the expanding regions in three dimensions, the conceptual circles become spheres, and the contact lines become contact planes. When two bubble universes expand into each other a flat boundary region or wall forms between them (Fig. 2) analogous to soap bubbles.

When three bubble universes expand into each other three 'walls' will form at angles of 120°; and all three meet at a line. A plane of expanding units will form a hexagonal pattern of 'walls' (Fig. 2).

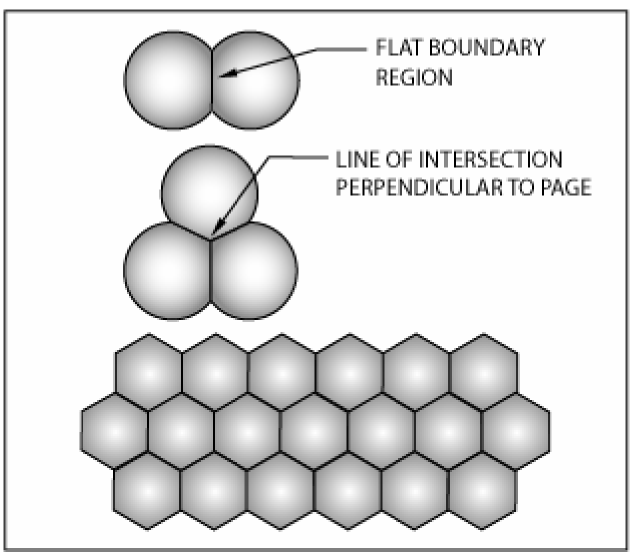

Fig. 2. Expanding bubble universes form flat interface region (top) and flat regions meeting at angles of 120° to an axis perpendicular to the page (middle and bottom). A layer of bubble universes (bottom).

But for bubbles in multiple layers, things become somewhat indeterminate. When rigid spheres are considered there exist only two methods of closest packing.[7] One is known as the *hexagonal closest-packed* structure and the other is the *cubic closest-packing*.[8] In both structures each sphere is in direct contact with 12 nearest neighbors: 6 lie in one layer, 3 in the layer above, and 3 in the layer below. If these rigid spheres (with 12 contact points) can be visualized as turning into flexible and expanding bubbles it is easy to see that the 12 contact points will become the 12 flat surfaces surrounding and shaping each bubble. Surprisingly, there are two possible shapes that will result; each is geometrically distinct. Both are classified as being dodecahedral polygons. Computer simulations have shown that *hexagonal closest-packing* will produce an 'irregular' dodecahedron consisting of rhombuses and trapezoids; while the *cubic closest-packing* results in a shape with 12 identical rhombic faces.

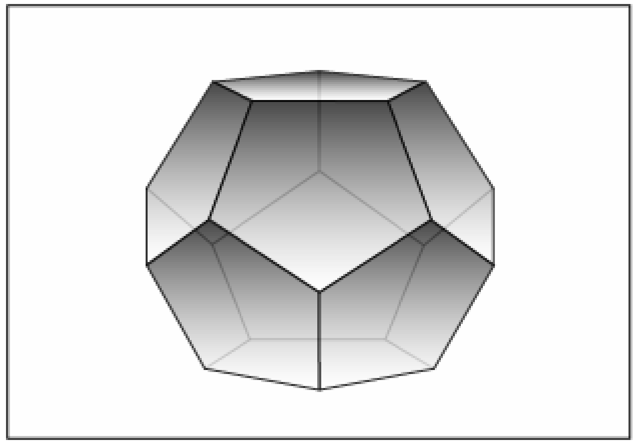

Fig. 3. Regular dodecahedron has 12 regular and identical pentagons. Although this structure is regular and has numerous symmetries it is ***not*** possible to assemble units into a regular 3-dimensional array in which no gaps occur between units.

There also exists a non closest-packed variation and can be formed as follows: If the spheres are placed (around the central sphere) with 5 each in two adjacent layers, and one above and one below, for the same total of 12, then a regular dodecahedron, with regular pentagonal faces, will result (Fig. 3).[9] Again, each bubble interfaces with its closest neighbors at these 12 faces.

4 VORONOI CELLS

Let us consider a variation of the cosmic bubble making procedure. Only this time we will apply the precision of a branch of geometry called the theory of Voronoi cells. The cosmic bubbles are to be separated by what are called Voronoi boundaries.

As before, a plane is covered with random circles (Fig. 4, top). The centers of the circles are marked and will be referred to as GCs (for geometric centers). In step (2) the circles themselves are no longer of interest and are removed. The GCs themselves now represent the center of some 'mysterious' repulsive force; consider the GCs not as the source points of the force but rather as the

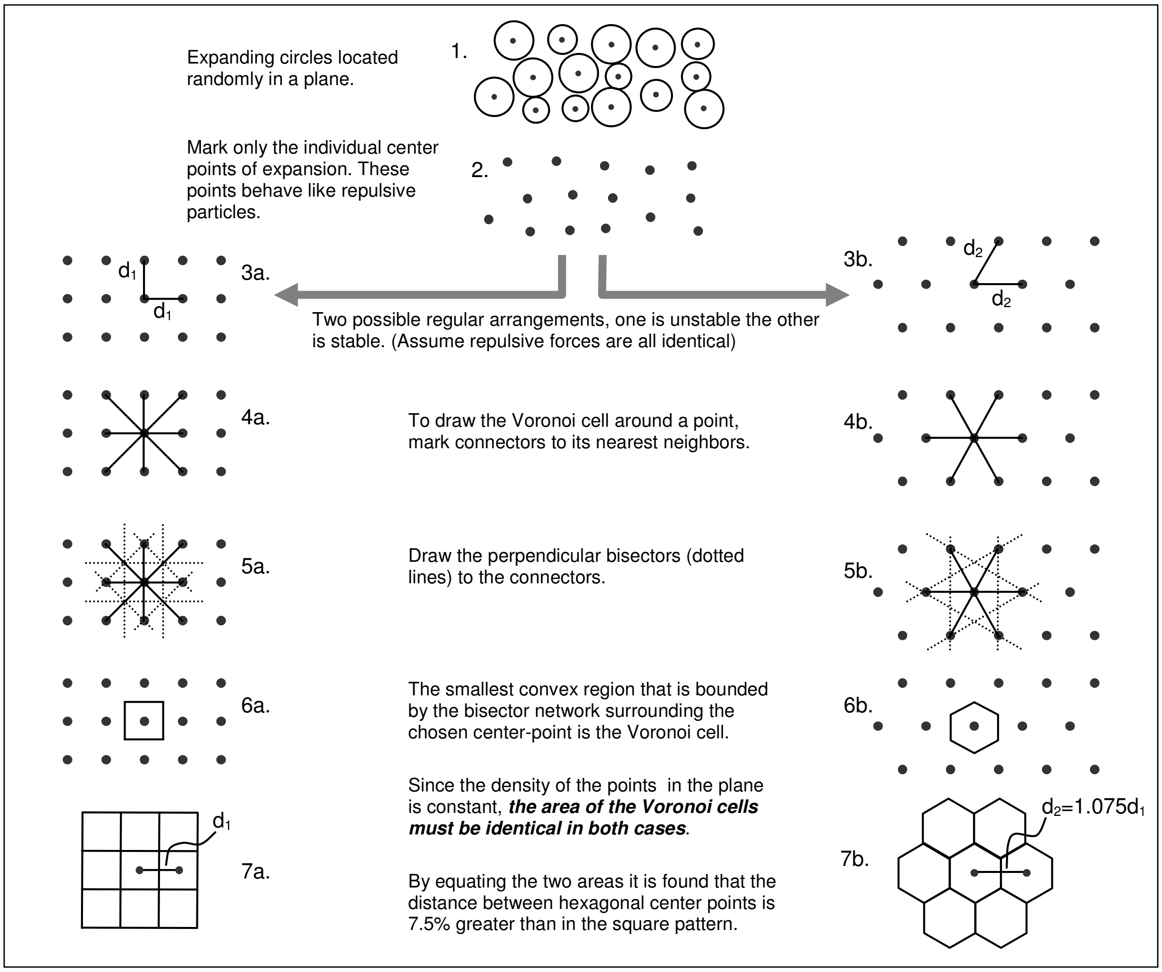

Fig. 4. ***Expanding circles act as if under the control of a repulsion force*** increasing the distance between centers of expansion. *Voronoi cells* aid in the analysis of the geometry. The force of repulsion will push to maximize the distance between the center points and thus form the hexagonal Voronoi cell pattern.

center of their region of repulsion. The assumption is that all the GCs have the same capacity for repulsion; and being free to move about, these points will behave like particles averse to each other.

The GCs, in an effort to distance themselves from their neighbors, can arrange into two possible patterns: a Cartesian grid (3a), and a symmetrical diagonal grid (3b). In the Cartesian grid each GC is equidistant from its 4 closest neighbors, a distance designated as d_1. In the diagonal grid each GC is equidistant this time from 6 nearest neighbors, and this distance is labeled d_2 in the diagram (3b).

The procedure for drawing a typical Voronoi cell is to choose a GC and connect it to each of the surrounding ones (4a & b). On these radiating connectors draw perpendicular bisectors shown as dotted lines at (5a & b). Find the smallest convex region that is bounded by the bisector network surrounding the chosen GC. This region is known as the Voronoi cell. One of the distributions of GCs reveals a square Voronoi cell and the other, a hexagonal Voronoi cell. (6a & b)

By repeating the procedure we end up with two symmetrically tiled planes: one with squares the other with hexagons. Intuitively we know that the hexagonal pattern will be the natural outcome of the repulsive force; but can it be proven? Realize that the density of the GCs is identical in both patterns (i.e., they occupy the same area in both patterns). In other words the area of the square cell is equal to that of the hexagonal cell:

$$\text{Area}_{\text{HEXAGON}} = \text{Area}_{\text{SQUARE}}$$
$$6 \times \tfrac{1}{2} d_2 \times \tfrac{1}{2} d_2 \times \tan 30^\circ = d_1^2 ,$$

and from this we can show that

$$d_2 = (\tfrac{2}{3} \times \sqrt{3})^{1/2}\, d_1 = 1.075\, d_1 .$$

Thus, the GCs, by 'choosing' the hexagonal pattern, can distance themselves almost 7.5 percent farther from their neighbors than by 'choosing' the square pattern. In making this 'choice' the GCs fulfill their goal of maximizing distance which increases by a 1.075 factor *without any change in the total area of its domain*; only the shape of its domain is important. (7a & b)

A similar analysis applies to 3-dimensional space. Instead of expanding circles, we use expanding bubbles. Now instead of drawing perpendicular bisector lines on the lines joining GCs we simply imagine perpendicular planes separating GCs. Each GC is then completely surrounded by perpendicular planes. Again we will quantitatively compare patterns, this time between a cube, which can be thought of as a 3-dimensional version of a square, and a rhombic dodecahedron, as a 3-dimensional version of a hexagon. The density of the GCs in space is identical for both arrangements, and so the volume of the cube must be equal to the volume of the dodecahedron. (For geometric details of the dodecahedron see the chapter *Dodecahedra*, Table 1, and treat ½d_D as the inscribed sphere radius.)

$$\text{Volume}_{\text{DODECAHEDRON}} = \text{Volume}_{\text{CUBE}}$$

$$4\times\sqrt{2} \times (\tfrac{1}{2}\, d_D)^3 = (d_C)^3 ,$$

$$d_D = \sqrt[6]{2} \times d_C = 1.1225\, d_C ,$$

Therefore by using Voronoi cells with the dodecahedral shape instead of the cubic shape the distance between geometric centers has *increased* by a substantial 12.25 percent.

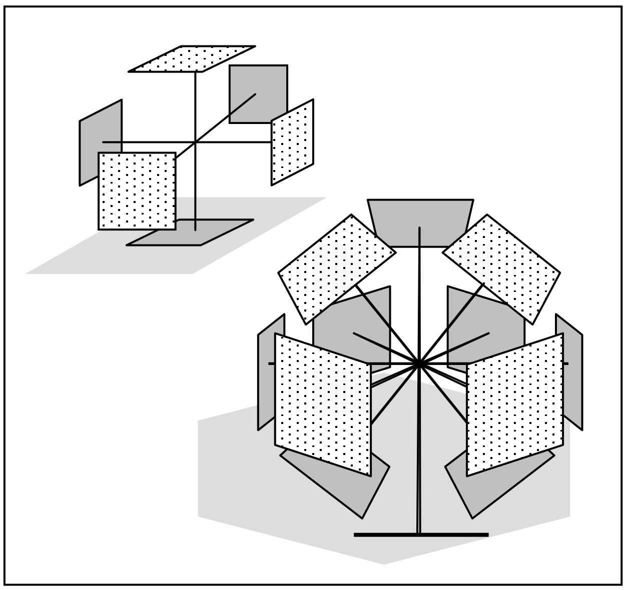

Fig. 5. Voronoi boundary planes, in exploded view, for the hexahedron (cube) and the dodecahedron.

Now what is so important about Voronoi polyhedral cells? ...Well it appears that our Universe is structured as Voronoi cells in the shape of dodecahedra.

> *Now the Voronoi cell is a polyhedron. Astronomers have recently discovered that the large-scale distribution of matter in the universe resembles a network of such polyhedra. Most galactic clusters seem to be located on the boundaries of neighboring Voronoi cells. This pattern has been called the Voronoi cell model of the universe...* —Ian Stewart[10]

And in the words of one of these astronomers: "In the Voronoi model, centers of voids are located randomly, and clusters are placed as far from void centers as possible. ... During dynamical evolution matter flows away from the low-density regions and forms filaments and clusters of galaxies."[11]

Space expansion acts as a repulsion force that tries to maximize the distance between centers of expansion. These geometric centers represent the centers of the voids from which space expands. And they act like centers of anti-gravity, from which matter is conveyed outwards. The Voronoi boundaries become the highly interactive *interface* between bubble universes. As the space inside the cells expands, star clusters and galaxies and other matter becomes concentrated along the common Voronoi boundaries.

As a historical note, the cells are named after Georgii F. Voronoi (1868-1908) a Russian mathematician who worked on number theory and multidimensional tilings. The concept of boundary formation has many diverse applications and not surprisingly has been 'rediscovered' many times. The cells could just as well be called Dirichlet domains and Wigner-Seitz cells.[12]

5 THE COMPONENT UNIT-UNIVERSE

> *The bubble interior would be a void, but the bubble wall would be the site of vigorous activity.* —Jeremiah P. Ostriker[13]

Once the bubble universes have fully expanded, reached equilibrium, and formed the dodecahedral shape, **no major boundary expansion occurs**; bubbles should all be about the same size. Because bubbles are formed by identical forces (the universal dynamic laws of nature) their diameters will not vary significantly. Minor boundary changes may take place, but any increase in size of one bubble will be at the expense of its neighbors. Note that the *space* inside the units continues to expand, and at the boundaries, contract.

The equilibrium that is being referred to is the balance between the slow expansion of space within the bubble on the one hand, and the rapid contraction of space in the thin walled boundaries on the other. The two complementary rates are related in a self adjusting system (detailed in the chapter *Self-Regulation of the Size of the Component Universe*). In conventional terminology we could say that the inflationary force —the Lambda force— is balanced by the gravitational force. In any case, equilibrium occurs and limits the size of the bubbles. This is so whether a bubble is hypothetically isolated or whether it is part of a closely packed array.

The size of the component bubble universe is determined by the equilibrium between the rates of expansion and contraction. The bubble shape, as shown earlier, is determined by the interaction among the bubbles.

Our constructed model, up to this point, is a universe dense with cosmic sized bubbles. There is no free space between bubbles. They are not pieces of the universe floating randomly within some larger universe. The model consists of nothing but compacted bubbles. And compacted 'flexible spheres' have a dodecahedral shape (Fig. 6).

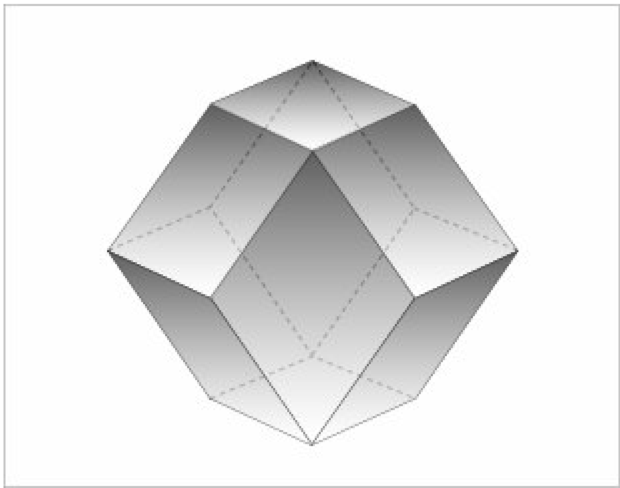

Fig. 6. Idealized rhombus-faced dodecahedral unit-universe. This polygon shape results from the *cubic-closest packing* of an assembly of *bubble universes*.

The building block of the DSSU is the dodecahedron: The *cubic closest-packed* polyhedron has 12 identical rhombus faces, 24 edges, and 14 nodes. Although the faces are all identical, it cannot be called a regular polyhedron because some vertices have three edges while others have four; also these two sets of vertices lie on separate circumscribing spheres.

The *hexagonal closest-packed* polyhedron (not shown) consists of 6 rhombus and 6 trapezoid faces; consequently, it cannot be called a regular polyhedron.

However, both have numerous mirror and rotational symmetries and share all the basic geometric properties of having the same number of faces, edges, and nodes; even their volume, surface area, and inscribed sphere and circumscribing spheres can be equated.

The particular dodecahedron which an observer can expect to find in a cellular universe depends on the stacking arrangement. A random stacking pattern will result in both dodecahedral shapes. A change in the pattern represents a *cubic-hexagonal packing asymmetry*.

Within a dense array each unit-universe is surrounded by 18 others. The exploded view (Fig. 7) gives some idea of how the units are actually 'packed' together. Interestingly, although a typical dodecahedral unit-universe has only 12 faces it actually interacts with 18 others (at least under idealized conditions). In a typical arrangement there are the obvious 12 units corresponding to the 12 faces, and then there are the less obvious 6 additional units that respectively connect to the 6 major nodes (of the central cell). An observer inside the central unit would be surrounded by an abundance of 14 nodes and 18 voids. It is little wonder that our cosmic neighborhood appears rather chaotic.

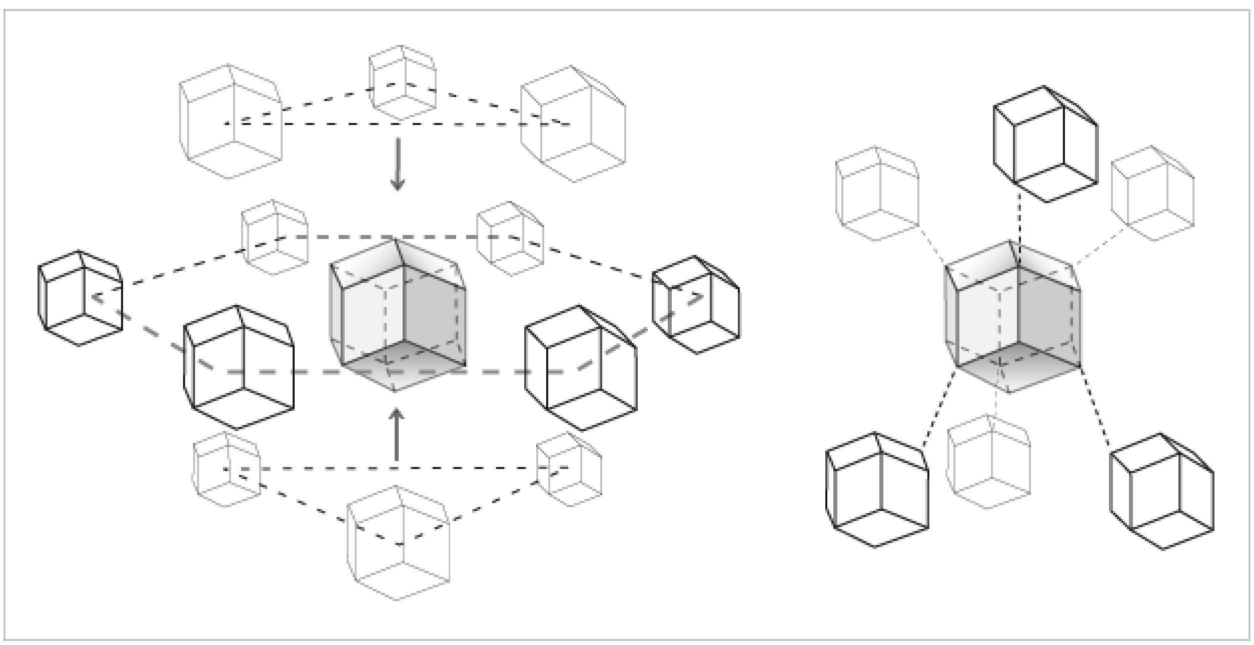

Fig. 7. *Each cosmic cell is typically surrounded by eighteen similar cells.* The exploded views show the twelve units that meet at the faces of the central cell (left) and the six units that only 'touch' at respective major nodes (right).

6 The LARGE SCALE GALAXY STRUCTURES

Clusters tend to lie close to one another. ...[And] the voids are evidently an integral part of the process of clustering and superclustering. —Gregory and Thompson[14]

Into our bubble universes we now add matter (mass and energy). Anything placed into expanding *space* will, of course, move in the direction of expansion; and since expansion is radial, matter will comove with *space* in an explosion-like pattern. In effect, matter will undergo freefall towards the outer boundaries. These boundaries between adjacent bubbles we will call interfaces.

The interface region is where the matter of the bubble universes accumulates. Each universe shell is accreting the material not only from its own universe but also that from the twelve (plus six) surrounding neighboring units.

At typical flat interface regions the material from two units aggregates (Fig. 8). Vast sheets of star clusters and minor galaxies would be expected to form.

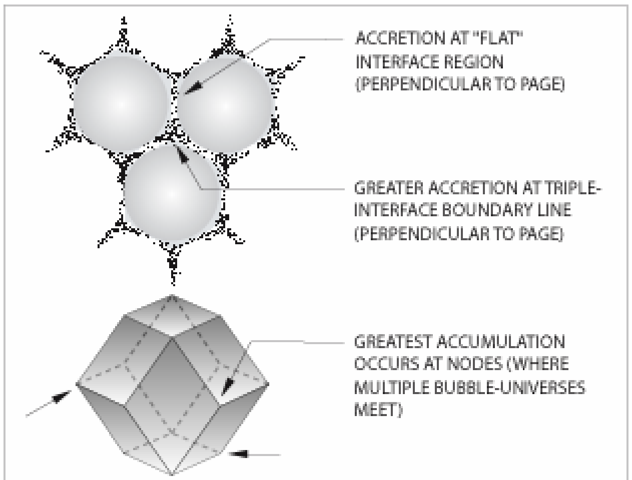

Fig. 8. Material, comoving with *expanding space*, accumulates at flat interface regions, at triple-interface boundaries, and at nodes.

Accumulation is even greater at a *triple-interface boundary line*. This is to be expected since *space* is expanding towards this boundary from three separate bubbles bringing with it comoving elliptical galaxies and the usual gas clouds. It is here that one would expect to find a *linear or filamentous cluster,* a galaxy cluster with a highly elongated longitudinal axis. A good example is a portion of the Hercules supercluster. Another example is the boundary in which our home galaxy is located. Gérard de Vaucouleurs in 1953, after years of observing and classifying galaxies, pointed out that most of the bright galaxies —extending from the local group neighbors to beyond the Virgo cluster— were confined to **a narrow belt** perpendicular to the Milky Way.[15]

And finally, accretion of galaxies and debris is predicted to be greatest of all where four (or in some cases six) bubble universes meet at a 'point' —at any node of the dodecahedron. Here the material arrives from up to six sources. A clear and 'nearby' example is the Virgo cluster; another is the core of the Coma cluster.

Margaret J. Geller, working at the Harvard-Smithsonian Center for Astrophysics to map the Universe has stated "the pattern of galaxies in our three-dimensional slice of the universe suggested that sheets, or walls, containing thousands of galaxies mark the boundaries of vast dark regions nearly devoid of galaxies."[16] The DSSU model readily explains her and her colleagues' remarkable observations. The rhombic and trapezoidal interfaces represent the locations of the "sheets of galaxies". The "vast dark regions nearly devoid of galaxies" are the *space* expanding, *space* creating, interior regions of the dodecahedral unit. A glance at their 1986 "wedge of galaxies" map (CfA Redshift Survey and Catalog website[17]) shows an abundance of possible "linear superclusters" and (edge view) "sheet superclusters". The stick figure is an unmistakable feature of the map and can be readily reproduced by taking the section of appropriate thickness through a group of joined dodecahedra. Also noteworthy is that the largest supercluster plotted occurs precisely where expected —at the vertex of a dodecahedron, at the conjunction of eight boundary edges.

The Geller-Huchra map and other measurements of galaxy clusters, in particular the distance between any obvious galaxy concentrations, have been used in a preliminary estimate of the size of a typical unit-universe. It was found that the distance between nearest nodes is roughly 125 million lightyears (MLY) and the distance across opposite nodes is about 300MLY. It is predicted that the component universes are all about the same size, in that they enclose similar volumes. This prediction follows from the dynamic properties of the DSSU —from the two *space postulates* and the two *particle postulates*. To verify the consistency of structure size, existing data, observations, and studies need to be re-evaluated, possibly reinterpreted, in the light of the distinct unit-universe structure. Our own studies have shown that there are no major obstacles in plotting large galaxy structures (clusters and superclusters) onto corresponding unit-universe structures; and relating observed voids with corresponding unit-universe interiors.

NODAL STRUCTURES. At each node of the unit-universe there exists a symmetrical sub-structure. One of these structures is called a *tripod* (Fig. 9 top). Each and every one of the 6 angles of the structure is 109.5° (idealized). The tripod shape is derived from the boundary edges where four dodecahedra meet and share a common node. This region is where the galaxies from each of the adjacent four dodecahedra aggregate or cluster and form into a majorcluster. The other nodal structure is the *quadrapod* (Fig. 9 bottom) and is found at the nodes where six unit-universes meet. In the astronomical world these multi-armed structures represent various groupings of galaxy clusters (Fig. 10). And on the largest scale, the multiple linking of ***tripods and quadrapods*** represent vast and extended superclusters.

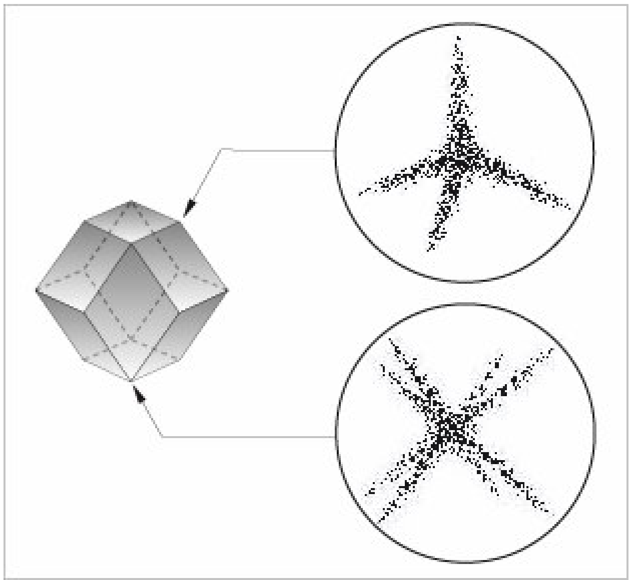

Fig. 9. Nodal structures. The 4-arm structure (top) occurs at nodes where four bubble universes meet. The 8-arm structure (bottom) occurs at nodes where six universes meet. The dots represent galaxies and globular clusters.

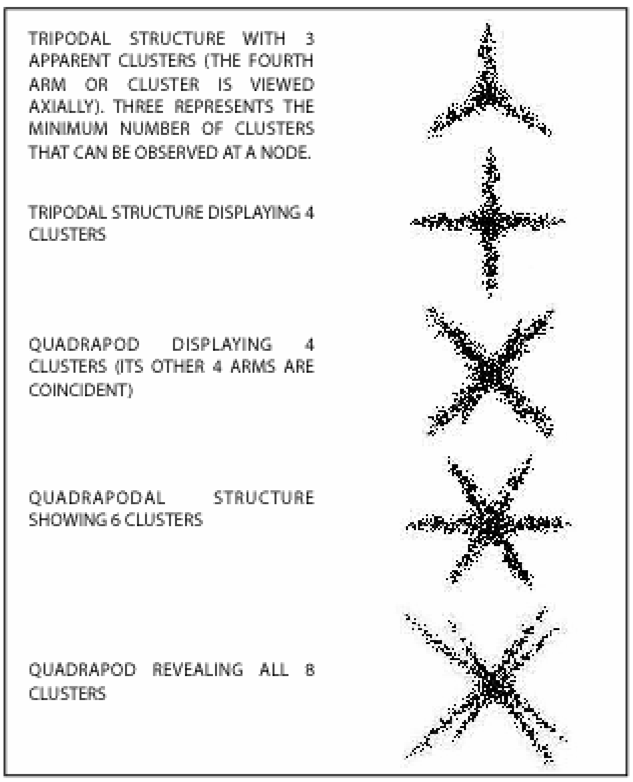

Fig. 10. Nodal structures viewed at various angles and rotations. The dots represent galaxies and globular clusters. The linking of these nodal clusters forms the net or web-like pattern often described by astronomers.

The linking of multiple tripods and quadrapods reveals a distinctive net-like pattern (Fig. 11). By increasing the number of nodes and increasing the depth of view, the structures will link to become skeletal dodecahedra and form a web-pattern of quadrilaterals —a pattern difficult to delineate on a 2-dimensional surface but often described by astronomers. The Estonian astronomer, Jaan Einasto of Tartu Observatory, at the 1977 International Astronomical Union meeting presented his analysis of the distribution of the several hundred galaxies for which data was then available. Einasto had found that the Universe has a cellular structure; the large scale organization of galaxies has a net-like cellular structure with interconnected strings of galaxies surrounding empty regions. Laird Thompson and Stephen Gregory found that galaxies were never isolated but appeared to be joined to larger structures in chains or filaments with empty regions in between.[18]

And more recently Einasto stated, "observational evidence suggests that rich superclusters and voids form a quasi-regular network of scale ~100-130h^{-1} Mpc [about 350MLY];" and "voids between superclusters have mean diameters about 100h^{-1} Mpc [326MLY]." It appears the "Cellular large-scale structure may be the end of the fractal structure of the Universe."[19] In other words, the observations suggest that there are no bigger structures than the dodecahedral cells.

ASYMMETRY. How does the cubic/hexagonal packing asymmetry affect the structure of the DSSU? When bubble universes are arranged exclusively in the "cubic" pattern (as in Figures 7 and 11) then the result is the consistent alternate linking of tripods and quadrapods. Tracing a path along any boundary edges, in a 3-dimensional array, produces an alternating sequence of the two nodal shapes. This is also true for the nodes of a single dodecahedron.

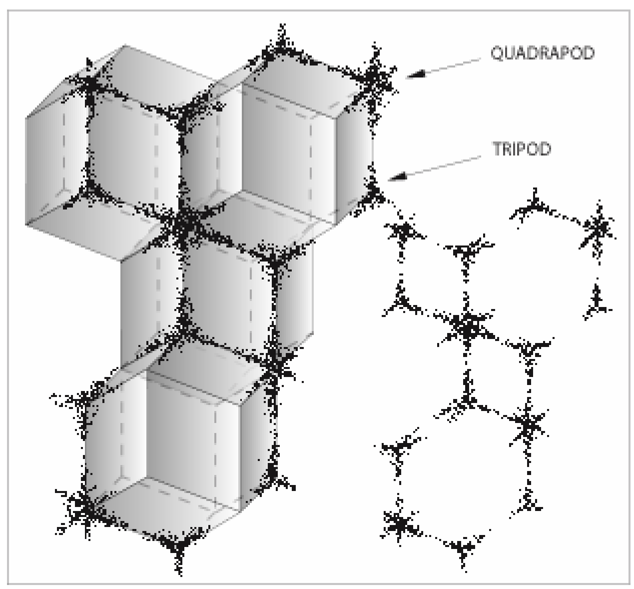

Fig. 11. *The linking of multiple tripods and quadrapods presents a distinctive net-like pattern.* Nodal structures, in schematic, as they are related to a grouping of bubble universes (left). On the right are the same structures without the dodecahedral framework. The nodes selected lie more or less in the same plane.

However, with the hexagonal-packing asymmetry tripods and quadrapods can be linked into like pairs. Of the 24 links that form a single rhombic-trapezoid dodecahedron 6 will join similar structures, while 18 will join dissimilar structures.

7 THE TWO 'SPACE' POSTULATES OF THE DSSU

At the heart of the process of maintaining the cellular structure of the DSSU are the twin *space postulates*. At first glance it would appear that neither of the concepts embodied by these postulates is new. Expansion and contraction of space are ideas that have been around for a long time. What is new is the *simultaneous expansion and contraction of space* in spatially separated regions thereby giving shape, structure, and stability to the Universe.

Space and the two dynamic properties of this *space* need to be defined.

SPACE DEFINED. In the new cosmology, *space* is defined as: (1) the very essence of the universe; (2) a foam of quantum pulsating ***precursors*** (pulsating between the virtual and real states); (3) not contained within a true vacuum (but this is an unresolved issue); and (4) having the property that it will expand when in its natural state of tension (in regions absent of mass) or when subjected to cosmic tension; and (5) contract when in contact with matter or in the vicinity of matter.

Space, as the essence of the universe, is a *virtual-real quantum foam*. *Space* is a sea of units of the most fundamental energy fluctuations. For reasons that will become clearer later, the units themselves (the sub-microscopic space-units) are called ***precursors***.

THE NATURE OF *SPACE*. *Space* is the axiomatic essence of the Universe.

Space includes not only what is normally thought of as the 'vacuum' or the void but also includes the spatial interstices of matter. The *virtual-real foam* fills the 'emptiness' of atoms. This amounts to a considerable presence, since atomic structure is 99.99% non-particle volume.

The density of *space* is a constant. This is the reason the speed of light is constant. If the density of space were not constant, neither would the speed of light.

Furthermore, the density of *space* is always maximum. There are no gaps —no vacuous spaces— between the precursors. The ultra high density (the absence of gaps) is the reason that light waves are conducted at a truly enormous rate and represents the ultimate high speed.

By means of the *space contraction postulate*, space has the ability to interact with and to 'grab' onto matter.

SPACE POSTULATE #1: *'Space', when subjected to a tension force, expands.*

The rate of expansion is extremely small. For the interior of a unit-universe it has been calculated to be just over 6 cm per kilometer of length every one million years.

The expansion has a peculiar anti-gravitational effect. To astronomers it is the Hubble expansion; to astrophysicists it represents cosmic *inflation*; to mathematicians it is the hyperbolic curvature of three-dimensional space; and to theorists, the consequence of the vacuum energy. The force is a negative pressure and results in an increase in the quantity of *space*.

The expansion of *space* can be directly compared to Einstein's *cosmological constant* a force which he included in his calculations in an attempt to produce a balanced static universe based on general relativity theory. A positive *cosmological constant* is comparable to the expansionary effect of DSSU *space*.

The expansion of DSSU *space* is similar to the expansion in the familiar BBI model. However, while the BBI expansion is unconfined, the DSSU expansion is confined within the bubble-like unit-universe. The mechanism limiting the expansion is provided, in part, by postulate #2.

SPACE POSTULATE #2 *is the contraction of 'space'. Space (and in effect spacetime) contracts within mass bodies, mass objects, and mass particles. Furthermore, it contracts within a space-contraction field surrounding gravitating mass bodies.*

The result of this postulate is that the expansion of the unit-universe is halted, in the sense that equilibrium is established and maintained. The equilibrium state determines the size of the unit-universe.

The *space* flowing from the voids is consumed; that is, it is contracted out of existence by the gravitating bodies of the interface regions.

Einstein stated in his *theory of gravitation* that gravity distorts space; gravity is the dynamic —the geometrodynamic— activity of space and time. This is interpreted by the DSSU model to mean that the *virtual-real foam* is absorbed or simply that *spacetime contracts*. The DSSU model gives "gravitational distortion of space" a physical meaning and defines it as the *absorption and inhomogeneous contraction of the virtual-real foam by matter*.

The absolute contraction of *space* is the physical meaning behind the mathematical distortion of spacetime of general relativity theory.

8 THE NEW DYNAMIC UNIVERSE

MISGUIDED BUBBLE MODELS. So as not to confuse the reader, it is worth repeating that despite all the talk of bubble formation, the DSSU is *not* a bubble forming universe. The DSSU bubble structures are perpetually extant; they are not created. Bubble creation is an idea that is far too radical —unnecessary and unrealistic. In fact, I can't think of anything more radical than proposing different laws of physics for each bubble universe as does the *Self-Reproducing Inflationary Universe*![20] However bubble formation seems attractive to many. As mentioned near the beginning, one of the latest versions of the

Inflationary Models [there are many] actually uses an exponential bubble-formation process (including arbitrary physical laws). Quoting from an article by Andrei Linde, a leading astro-physicist: "Recent versions of inflation theory assert that instead of being an expanding ball of fire the universe is a huge, growing fractal. It consists of many inflating balls that produce new balls, which in turn produce more balls, ad infinitum."[21]

In another version, known as *open inflation*, being promoted by professors Martin A. Bucher and David N. Spergel, "Bubble universes are self-contained universes that grow within a larger and otherwise empty 'multiverse'." Their model is by no means easy to explain. I fail to understand how they manage to fit "an entire hyperbolic universe (whose volume is infinite) ... inside an expanding bubble (whose volume, though increasing without limit, is always finite)." No doubt they have an airtight mathematical explanation. Now, we may wonder, what about the packing of these bubbles. "What if two bubbles collide? [Precisely!] Their meeting would unleash an explosion of cosmic proportions, destroying everything inside the bubbles near the point of impact."[22] This self-destruction can't be good news. And yet this *open inflation* universe is supposed to be an *expanding* model...

Clearly, all bubble universes are not alike. Andrei Linde's universe has "self-generating" bubbles "sprouting" like weeds; Bucher and Spergel's inflationary universe has suicidal bubbles. And we haven't even mentioned Alan Guth's bubble universe; in his original version the bubbles were way too small, then in a later version they were way too BIG. Maybe we'll take a closer look in a later chapter. As for the DSSU, it seems distinctly tame by comparison: no big bang, no bubble replication, no runaway inflation. Inflation, called space expansion in the DSSU, is quietly —in a steady-state-like manner— contained within an array of stable cosmic bubbles.

Here's the all-important difference: Andrei Linde's bubbles are used to expand the universe as required by the BB orthodox view. The DSSU, in contrast, uses the bubbles as an organic[23] framework that holds the Universe in a steady state as required by the observational evidence.

The DSSU is a new model, a comprehensive model. It is a *dynamic model* on the unit-universe scale; a *steady state model* in all its dynamic processes; and a *static model* on the largest scale. The defining feature is the expansion of space within a non-expanding universe. It is a universe in which the large structures such as galaxy clusters are *not* moving apart from each other.

The formation and shape of the large scale structures (the galaxy clusters) and of the *largest* scale structures (the dodecahedral unit-universes) are readily explained by DSSU theory. The DSSU qualitative model uses the dynamic distortion of space —a distortion which manifests itself as expanding *space* (as defined). Expanding-space bubbles of cosmic proportions are confined by adjacent expanding-space bubbles. Matter, comoving with *space*, aggregates at the bubble interfaces forming characteristic planar, filamentous, and nodal clusters of galaxies. Gravitating mass at the interface produces a contracting effect on *space*; a constant flow of *expanding space* is thereby sustained. The twin properties of *space expansion* and *space contraction* maintain equilibrium within a lattice of bubble universes, which, individually, conform to the dodecahedral shape of close-packed cells. The expansion and contraction properties represent the **space dynamic** aspects of the DSSU. While the equilibrium they maintain in an extended array represents the **steady-state** aspect of the DSSU. Hence the DSSU is characterized by the **expansion of *space* within a non-expanding universe.** The shapes of the large scale structures are the result of and maintained by the dual effects of expansion and contraction; by the push of expansion and the pull of gravity.

HOMOGENEITY and ISOTROPY. On the scale of the unit dodecahedral universe the DSSU is neither homogeneous nor isotropic. Only on the very largest scale, in which an extended array of bubble universes is considered, can it be said that the DSSU is both homogeneous and isotropic. On such a scale, we find the almost perfect state of homogeneity and isotropy generally found only in a crystal. We may justifiably say that on the truly grand scale the DSSU is a wonderful and marvelous *fluid crystal*.

Many leading scientists over the centuries, including Isaac Newton and Albert Einstein believed that the universe is unchanging, neither contracting nor expanding. It now turns out that on this fundamentally important point they were right after all! With the recent discovery of the cell-sustaining processes of the *Dynamic Steady State Universe* it is possible to validate the view that the Universe does ***not*** expand —*only space itself expands*. While the concept may sound paradoxical, it is simply that space expands within the Voronoi cells and simultaneously contracts at the Voronoi boundaries. The size of the cells does not change and neither does the greater universe. Whether we like it or not the Universe is a steady state universe. □

NOTES AND REFERENCES

[1] Genz, H. *Nothingness: The Science of Empty Space* p292
[2] Witten, E. Quoted by Dennis Overbye *The Universe Might Last Forever…* NY Times 2002 Jan 1
[3] Linde, Andrei *The Self-Reproducing Inflationary Universe* Scientific American, Spring 1998, Sp. Ed. Cosmos, p98
[4] The Dynamic Steady State Universe (DSSU) theory was first presented at the 2002 ESO Astrophysics Symposium in Munich, Germany
[5] Martin Jr., Roy C. *Astronomy on Trial* p193
[6] Harrison, Edward R. 1981, *Cosmology the Science of the Universe* p236
[7] Mahan, B. H. 1969, *University Chemistry,* Closest-Packed Structures p108-111

[8] ***Hexagonal packing*** refers to the closest packing of spheres into symmetric units of the *hexagonal Bravais lattice* (crystal structure). And ***cubic packing*** refers to the closest packing of spheres into symmetric units of the *face-centered cubic Bravais lattice*.

[9] The ***regular dodecahedron*** is one of only 5 regular solids. Historically, it was well known to the Pythagoreans and was used by Kepler in a mystical-mathematical application to describe the order and symmetry of the planets.

[10] Stewart, Ian *Scientific American May 1998* p103
[11] Einasto, J. *Large Scale Structure, Elsevier Preprint*, Sept.30, 2002 p14 & 17
[12] Stewart, Ian *Scientific American May 1998* p102-3
[13] Ostriker, Jeremiah P. & Steinhardt, Paul J. *Scientific American*, Special Ed. Cosmos, Dec 2002 p48
[14] Gregory, S. A. & Thompson, L. A. *Universe of Galaxies* p91 & 94
[15] Overbye, Dennis 1991 & 1999, *Lonely Hearts of the Cosmos* p266
[16] Geller, M. J. *The Big Picture, Natural History*, 2000 February
[17] CfA Redshift Survey and Catalog website: http://cfa-www.harvard.edu/-huchra/zcat/
[18] Gregory, S. A. & Thompson, L.A. *The Astrophysical Journal* June 15, 1978 p784-799
[19] Einasto, J. *The Structure of the Universe on 100MPC Scales,* World Scientific Feb 2003
[20] Linde, Andrei *The Self-Reproducing Inflationary Universe, Scientific American Spring98 Special Edition Cosmos*
[21] Linde, A.; Ibid.
[22] Bucher, Martin A. & Spergel, David N. *Inflation In a Low-Density Universe, Scientific American Jan 1999*

[23] "**organic** framework" because the dodecahedral boundaries are in a continuous state of dynamic renewal.