

**15:3 & 15:4**  
**(“The Superuniverse of Orvonton” and**  
**“Nebulae—The Ancestors of Universes”)**

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**Sources for 15:3 & 15:4**

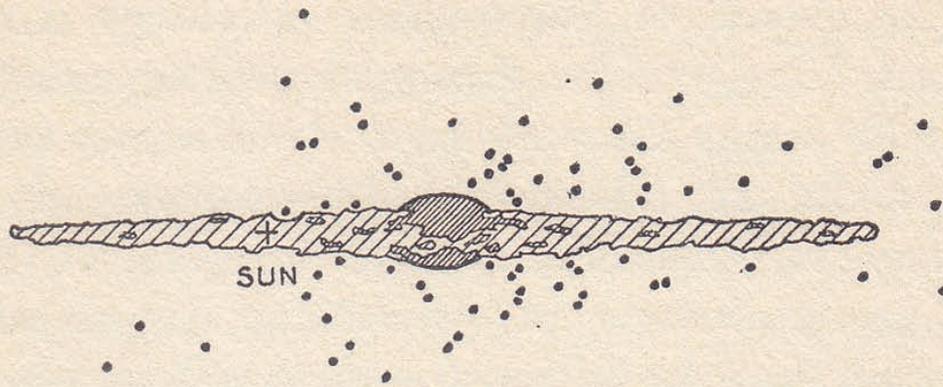
- (1) Ernest William **Barnes**, *Scientific Theory and Religion: The World described by Science and its Spiritual interpretation* (Cambridge: At the University Press, 1933)
- (2) Robert H. **Baker**, Ph.D., *The Universe Unfolding: The Story of Man’s Increasing Comprehension of the Universe Around Him* (Baltimore: The Williams & Wilkins Company, 1932)

*Note:* Chapter VI: “The System of the Milky Way” is attached to this chart.

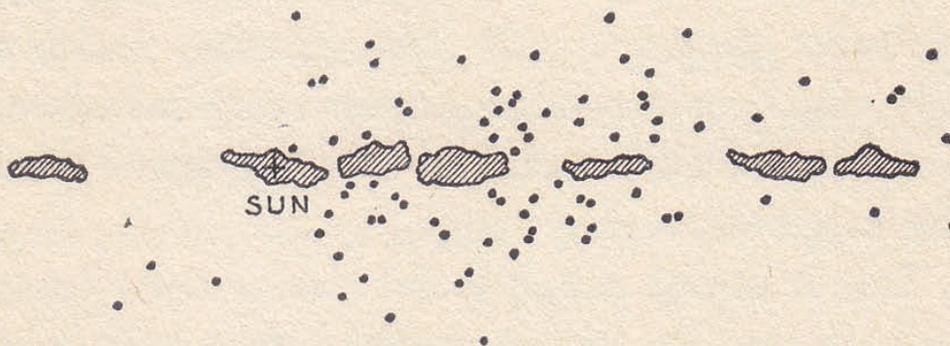
- (3) W. F. G. **Swann**, A.R.C.S., M.A., D.Sc., *The Architecture of the Universe* (New York: The Macmillan Company, 1934)

**Key**

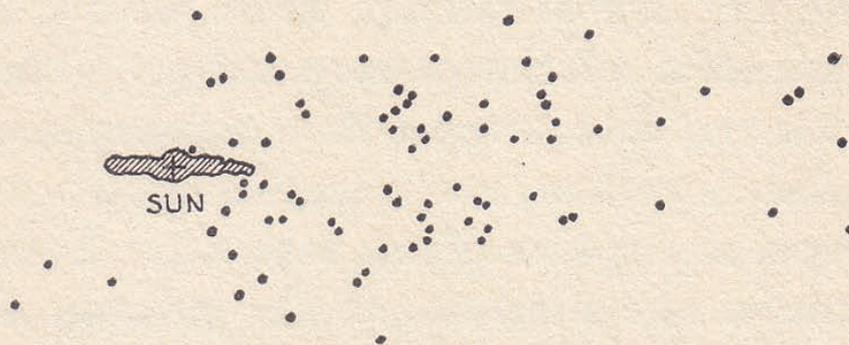
- (a) **Green** indicates where a source author first appears, or where he/she reappears.
- (b) **Yellow** highlights most parallelisms.
- (c) **Tan** highlights parallelisms not occurring on the same row, or parallelisms separated by yellowed parallelisms.
- (d) An underlined word or words indicates where the source and the UB writer pointedly differ from each other.
- (e) **Blue** indicates original (or “revealed”) information, or UB-specific terminology and concepts. (What to highlight in this regard is debatable; the highlights are tentative.)



(1) Single Great Galaxy



(2) Supergalaxy



(3) Single Smaller Galaxy

FIG. 6. Three Possible Distant Views of the Galactic System

Figure 6. (1) It will be the picture of a spiral nebula viewed edgewise. The glow that first attracted attention comes then from the nuclear

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## PAPER 15 — THE SEVEN SUPER- UNIVERSES

### 3. THE SUPERUNIVERSE OF ORVONTON

XI: THE GALACTIC UNIVERSE AND  
 THE GREAT NEBULAE (Barnes 336)

§253. *The shape and size of the galactic universe.*  
 (Barnes 336)

[contd] The outcome of recent research is to shew that the stars which we can see with the naked eye are but a small fraction of the number revealed by a telescope ... But practically all belong to a vast universe of stars which has the Milky Way for a sort of rim: for this reason it is called the *galactic universe* (B 340).

VI: THE SYSTEM OF THE MILKY  
 WAY (Baker 100)

[contd] The galactic system, or the system of the Milky Way, is the concourse of stars, bright nebulae, and dark dust clouds around us, whose dominating feature is the Milky Way (B 100).

15:3.1 Practically all of the starry realms visible to the naked eye on Urantia belong to the seventh section of the grand universe, the superuniverse of Orvonton.

The vast Milky Way starry system

represents the central nucleus of Orvonton, being largely beyond the borders of your local universe.

## II: THE BURSTING OF THE BARRIERS (Baker 14)

Our galactic system is a flattened **aggregation** of many tens of thousands of millions of stars.

Approximately **circular** in outline,

its diameter is 200,000 light years, and its **thickness is about one tenth as great** (B 32).

[I]t appears ... that the stars thin out with increasing distance from the earth least rapidly in the direction of the Milky Way;

and the rate of thinning increases symmetrically above and below this circle of star clouds (B 28).

This great **aggregation** of suns, dark islands of space, double stars, globular clusters, star clouds, spiral and other nebulae, together with myriads of individual planets,

forms a watchlike,<sup>1</sup> elongated-**circular** grouping

of **about one seventh of the inhabited evolutionary universes.**

15:3.2 From the astronomical position of Urantia, as you look through the cross section of near-by systems to the great Milky Way, you observe that the spheres of Orvonton are traveling in a vast elongated plane,

the **breadth being far greater than the thickness and the length far greater than the breadth.**

15:3.3 Observation of the so-called Milky Way discloses

the comparative increase in Orvonton stellar density when the heavens are viewed in one direction,

while on either side the density diminishes;

the number of stars and other spheres decreases away from the chief plane of our material superuniverse.

When the angle of observation is propitious, gazing through the main body of this realm of maximum density, you are looking toward the residential universe and the center of all things.

[Better methods of space measurement and improved telescopic technique will sometime more fully disclose the ten grand divisions of the superuniverse of Orvonton; you will at least recognize eight of these immense sectors as enormous and fairly symmetrical star clusters (41:3.10).]

15:3.4 Of the ten major divisions of Orvonton, eight have been roughly identified by Urantian astronomers.

The other two are difficult of separate recognition because you are obliged to view these phenomena from the inside.

## VI: THE SYSTEM OF THE MILKY WAY (Baker 100)

In summary, the three theories [of the Milky Way system] are:

(1) The system of the Milky Way is a single spiral structure some 200,000 light years in diameter, outlined by the globular clusters. The sun is near the center of one of its star clouds, the local system, about halfway between the massive center and the edge of the great system. [Note: This is what Baker calls the "classical theory".]

(2) It is a supergalaxy outlined as before by the globular clusters. The local system and other star clouds are separate galaxies comparable with the external galaxies. [Note: This is Shapley's theory.]

(3) It is a single spiral around 30,000 light years in diameter, comparable with the largest external spirals. The sun is not far from its center.... [Note: This is Trumpler's theory.] [contd next pg.]

Let us imagine ourselves suddenly transferred from the earth in the direction of the constellation Carina to a point a million light years away. We look around at a black starless sky, perfectly black except in one region where we see a ghostly glow. It is the galactic system (B 113-14).

If one of the three foregoing theories of the Milky Way system is correct, our picture will bear some resemblance to one of the three sketches in Figure 6. (1) It will be the picture of a spiral nebula viewed edgewise. The glow that first attracted attention comes then from the nuclear star clouds of Sagittarius.... (2) The extent of the system will be the same; but instead of an edgewise spiral we shall see a group of more or less isolated star clouds. In either case the flattened assemblage will be concentric with a much less flattened assemblage of star-like objects on the photograph, which are really the globular clusters. (3) The glowing patch will be delineated as a small edgewise spiral bisected by a narrow dark band, and located near the edge of the larger cluster system (B 114-16). [Note: See Appendix A.]

Recent surveys at the Harvard Observatory place the center of the great Sagittarius star clouds at the distance of 50,000 light years, thereby identifying them with the massive nucleus of the galactic system,

around which the other star clouds are arranged in a much flattened structure (B 102).

If you could look upon the superuniverse of Orvonton from a position far distant in space,

you would immediately recognize the ten major sectors of the seventh galaxy.

15:3.5 The rotational center of your minor sector is situated far away in the enormous and dense star cloud of Sagittarius,

around which your local universe and its associated creations all move,

The classical theory ... views the galactic system as a flat spiral organization some 200,000 light years in diameter. From opposite sides of its nucleus formed by the Sagittarius clouds

two streams of star clouds emerge and coil around in the same sense (B 102).

The local system, some ten thousand light years across, and having its center three hundred light years away in the direction of the constellation Carina, stands out clearly in the statistical results as the particular star cloud to which our sun belongs (B 101-02).

[Compare: It is no by means certain that the local system has a spiral form. A number of considerations suggest, in fact, that it is an irregular assemblage of lesser groups, resembling the Magellanic Clouds (B 109).]

[contd from 15:3.5] Our local star cloud, in which the sun has a fairly central position, is situated in one of the arms of the spiral,

about halfway from the center toward the edge (B 102).

and from opposite sides of the vast Sagittarius subgalactic system

you may observe two great streams of star clouds emerging in stupendous stellar coils.

15:3.6 The nucleus of the physical system to which your sun and its associated planets belong

is the center of the onetime Andronover nebula.

This former spiral nebula was slightly distorted by the gravity disruptions associated with the events which were attendant upon the birth of your solar system, and which were occasioned by the near approach of a large neighboring nebula. This near collision changed Andronover into a somewhat globular aggregation but did not wholly destroy the two-way procession of the suns and their associated physical groups.

Your solar system now occupies a fairly central position in one of the arms of this distorted spiral,

situated about halfway from the center out towards the edge of the star stream.

15:3.7 The Sagittarius sector and all other sectors and divisions of Orvonton are in rotation around Uversa, and some of the confusion of Urantian star observers arises out of the illusions and relative distortions produced by the following multiple revolutionary movements:

[J. H. Lambert, Alsatian contemporary of Wright and Kant, held somewhat similar views concerning the structure of the galactic system and the hierarchy of systems—systems upon systems, continuing to the limit of the imagination. “Thus everything revolves—the earth round the sun;

15:3.8 1. The revolution of Urantia around its sun.

the sun round the center of his system;

15:3.9 2. The circuit of your solar system about the nucleus of the former Andronover nebula.

this system round a center common to it with other systems;

15:3.10 3. The rotation of the Andronover stellar family and the associated clusters about the composite rotation-gravity center of the star cloud of Nebadon.

this group, this assemblage of systems, round a center which is common to it with other groups of the same kind;

15:3.11 4. The swing of the local star cloud of Nebadon and its associated creations around the Sagittarius center of their minor sector.

and where shall we have done?” (B 18)]

15:3.12 5. The rotation of the one hundred minor sectors, including Sagittarius, about their major sector.

15:3.13 6. The whirl of the ten major sectors, the so-called star drifts, about the Uversa headquarters of Orvonton.

15:3.14 7. The movement of Orvonton and six associated superuniverses around Paradise and Havona, the counter-clockwise processional of the super-universe space level.

15:3.15 These multiple motions are of several orders: The space paths of your planet and your solar system are genetic, inherent in origin. The absolute counterclockwise motion of Orvonton is also genetic, inherent in the architectural plans of the master universe. But the intervening motions are of composite origin, being derived in part from the constitutive segmentation of matter-energy into the superuniverses and in part produced by the intelligent and purposeful action of the Paradise force organizers.

15:3.16 The local universes are in closer proximity as they approach Havona; the circuits are greater in number, and there is increased superimposition, layer upon layer. But farther out from the eternal center there are fewer and fewer systems, layers, circuits, and universes.

#### **4 . N E B U L A E — T H E ANCESTORS OF UNIVERSES**

15:4.1 While creation and universe organization remain forever under the control of the infinite Creators and their associates, the whole phenomenon proceeds in accordance with an ordained technique and in conformity to the gravity laws of force, energy, and matter. But there is something of mystery associated with the universal force-charge of space; we quite understand the organization of the material creations from the ultimatonic stage forward, but we do not fully comprehend the cosmic ancestry of the ultimatons. We are confident that these ancestral forces have a Paradise origin because they forever swing through pervaded space in the exact gigantic outlines of Paradise.

Though non-responsive to Paradise gravity, this force-charge of space, the ancestor of all materialization, does always respond to the presence of nether Paradise, being apparently circuited in and out of the nether Paradise center.

15:4.2 The Paradise force organizers transmute space potency into primordial force and evolve this prematerial potential into the primary and secondary energy manifestations of physical reality. When this energy attains gravity-responding levels, the power directors and their associates of the superuniverse regime appear upon the scene and begin their never-ending manipulations designed to establish the manifold power circuits and energy channels of the universes of time and space. Thus does physical matter appear in space, and so is the stage set for the inauguration of universe organization.

15:4.3 This segmentation of energy is a phenomenon which has never been solved by the physicists of Nebadon. Their chief difficulty lies in the relative inaccessibility of the Paradise force organizers, for the living power directors, though they are competent to deal with space-energy, do not have the least conception of the origin of the energies they so skillfully and intelligently manipulate.

15:4.4 Paradise force organizers are nebulae originators; they are able to initiate about their space presence the tremendous cyclones of force which, when once started, can never be stopped or limited until the all-pervading forces are mobilized for the eventual appearance of the ultimatonic units of universe matter. Thus are brought into being the spiral and other nebulae, the mother wheels of the direct-origin suns and their varied systems.

VII: BEYOND THE MILKY WAY  
(Baker 123)

There is an interesting sequence in the forms of all these galaxies, which Hubble and others have taken as the basis for their descriptive classification. At one end of the sequence we have the most nearly globular of the elliptical nebulae. Thence we follow along through forms of increasing ellipticity to the flattest of the spindles, where the spirals begin; and the sequence separates into two branches, the normal and the barred spirals. [Etc.] (B 130-31)

Whether this sequence represents successive stages in a vast scheme of evolution is neither established nor disproved (B 131).

In outer space there may be seen ten different forms of nebulae,

phases of primary universe evolution,

and these vast energy wheels had the same origin as did those in the seven superuniverses.

15:4.5 Nebulae vary greatly in size and in the resulting number and aggregate mass of their stellar and planetary offspring. A sun-forming nebula just north of the borders of Orvonton, but within the superuniverse space level, has already given origin to approximately forty thousand suns, and the mother wheel is still throwing off suns, the majority of which are many times the size of yours. Some of the larger nebulae of outer space are giving origin to as many as one hundred million suns.

15:4.6 Nebulae are not directly related to any of the administrative units, such as minor sectors or local universes, although some local universes have been organized from the products of a single nebula. Each local universe embraces exactly one one-hundred-thousandth part of the total energy charge of a superuniverse irrespective of nebular relationship, for energy is not organized by nebulae—it is universally distributed.

15:4.7 Not all spiral nebulae are engaged in sun making. Some have retained control of many of their segregated stellar offspring, and their spiral appearance is occasioned by the fact that their suns pass out of the nebular arm in close formation but return by diverse routes, thus making it easy to observe them at one point but more difficult to see them when widely scattered on their different returning routes farther out and away from the arm of the nebula. There are not many sun-forming nebulae active in Orvonton at the present time, though Andromeda, which is outside the inhabited superuniverse, is very active.

## VI: THE FATE OF THE UNIVERSE (Swann 232)

[contd] Silhouetted against the sky in the constellation Andromeda is a tiny patch of light, hardly visible to the eye. It is the great nebula of Andromeda—one of the giants of the universe ...

This far-distant nebula is visible to the naked eye,

and when you view it, pause to consider that

but so far away that this light takes nearly a million years to reach us, so that we see that nebula not as it is today, but as it was a million years ago (S 232).

the light you behold left those distant suns almost one million years ago.

## VI: THE SYSTEM OF THE MILKY WAY (Baker 100)

In more southern latitudes [the **Magellanic Clouds**] are plainly visible to the unaided eye on a clear moonless night as **luminous patches** comparable with the brighter parts of the Milky Way (B 118).

The **globular clusters** appear in the **outskirts** of the galactic system (B 103).

From the new point of view [*i.e.* Shapley's theory of the Milky Way system] the **star clouds** of the galactic system are to be **regarded as individual galaxies**,

and to be **compared** with the **separate external** systems (B 107-08).

## V: STAR CLOUDS AND DUST CLOUDS (Baker 80)

[In 1864, William Huggins] observed that the light of certain nebulae—the nebulae having bright lines in their spectra—comes not from assemblages of stars, but from glowing gas. Thenceforth, **gaseous** nebulae and star clusters were sharply set apart (B 89-90).

15:4.8 The Milky Way galaxy is composed of vast numbers of former **spiral** and other nebulae, and many still retain their original configuration. But as the result of internal catastrophes and external attraction, many have suffered such distortion and rearrangement as to cause these enormous aggregations to appear as

gigantic **luminous masses** of blazing suns, like **the** **Magellanic Cloud**.

The **globular type of star clusters** predominates near the **outer margins** of Orvonton.

15:4.9 The vast **star clouds** of Orvonton should be **regarded as individual aggregations of matter**

**comparable** to the **separate** nebulae observable in the space regions **external** to the Milky Way galaxy.

Many of the so-called star clouds of space, however, consist of **gaseous** material only.

The energy potential of these stellar gas clouds is unbelievably enormous, and some of it is taken up by near-by suns and redispached in space as solar emanations.

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1. The hundreds of millions of stars within the reach of modern telescopes do not form a chaotic mass; nor do they extend uniformly to infinite distances. They occupy, rather, a disklike, or **watch-shaped**, figure in space... (Forest Ray Moulton, "Astronomy," in *The Nature of the World and of Man* [1926, 1927], p. 24).

Astronomers tell us that the stellar system or galaxy (= aggregate of stars under one gravitative control) has roughly the shape of a very flat pocket **watch** (Charles Schuchert, *A Text-book of Geology, Part II: Historical Geology, Second, Revised Edition* [1924], p. 111).

## CHAPTER VI

## THE SYSTEM OF THE MILKY WAY

p. 3.1 **T**HE galactic system, or the system of the Milky Way, is the concourse of stars, bright nebulae, and dark dust clouds around us, whose dominating feature is the Milky Way. Symmetrical arrangement with respect to its central line is the badge of membership by which the various classes of celestial objects within our system are distinguished from the exterior galaxies, in general, millions of light years beyond.

Three different theories of the construction of the galactic system have received the attention of astronomers during the past few years. It is probable that no one of them is entirely correct. It is equally probable that all three contain viewpoints of permanent value, which will be incorporated in another, more nearly complete account in the near future. For the present, it seems unwise either to neglect any one of these theories, or to urge the unreserved acceptance of any particular one. Three different representations of the galactic system are therefore before us for inspection.

The first of the three may be called the classical theory, although it is scarcely more than a dozen

years old. It regards the system of globular clusters as the superstructure of the galactic system, which outlines its form and sets an upper limit to the size that can be assigned to it. According to this view the center of the cluster system is the center of the assemblage of star clouds which it encompasses. b. 4.8

As we have seen, the globular clusters are scattered through a thick stratum which is symmetrical with respect to the galactic plane. They occupy a region of space between two and three hundred thousand light years in diameter, depending on the number of stragglers that are included, whose center is 50,000 light years away in the direction of Sagittarius. Since these clusters are more numerous around the center, they are located almost entirely in the hemisphere of the sky in which Sagittarius is central.

Counts of stars, as we have seen also, place the center of the entire galactic system in the same direction and presumably at the same distance; but, as Seares has clearly pointed out, the statistical method does not determine such distances accurately. The local system, some ten thousand light years across, and having its center three hundred light years away in the direction of the constellation Carina, stands out clearly in the statistical results as the particular star cloud to (15:36)

(15.3.4) which our sun belongs. Probably it resembles the more distant clouds which together form our Milky Way.

15.3.5 Recent surveys at the Harvard Observatory place the center of the great Sagittarius star clouds at the distance of 50,000 light years, thereby identifying them with the massive nucleus of the galactic system, around which the other star clouds are arranged in a much flattened structure. Analogy with the external galaxies of spiral form, such as the "pinwheel" nebula Messier 33 in the constellation Triangulum (Plate 2), finishes out the picture.

15.3.5 The classical theory, therefore, views the galactic system as a flat spiral organization some 200,000 light years in diameter. From opposite sides of its nucleus formed by the Sagittarius clouds two streams of star clouds emerge and coil around in the same sense. Our local star cloud, in which the sun has a fairly central position, is situated in one of the arms of the spiral, about halfway from the center toward the edge.

15.3.2 From our station near the central plane of the greater system we see the other star clouds in projection as the luminous band around the heavens, which we call the Milky Way, whose brightest part in the direction of Sagittarius includes the star clouds of the central nucleus. The majority of

the stars which form our constellations, most of the open star clusters, bright nebulae, and dark dust clouds are members of the local system around us. The globular clusters appear in the outskirts of the galactic system. The external galaxies lie far beyond, themselves milky ways. (15.4.8)

Such is the first of three current pictures of the system of the Milky Way which we have to examine. That our sun is a long way from the center of the picture does not impress us unfavorably. The importance of a central position in the galactic system, or of this system again in a higher system of galaxies is not so urgent for us as it might have seemed to the ancient astronomers. [Indeed, the location of the center of the physical universe can not now be assigned.] It is not even certain that this term has any meaning.] Criticism of the classical theory arises from other considerations.

It is by analogy with the external spirals, and not from observation of the galactic system itself that the spiral form is inferred. This statement has somewhat greater significance when we notice, in later pages, that not all external galaxies are spirals. Three or four per cent, of which the Magellanic Clouds are examples, are quite irregular in their construction; the numerous elliptical nebulae also show no evidence of spiral form. 15.13.3

But the outstanding difficulty in viewing our system as a *single* galaxy of any form whatever is owing to the vast size that has been assigned. The diameter of 200,000 light years is five times greater than that of the spiral of Andromeda, among the largest known of the external systems; and it is forty or fifty times greater than the diameter of the average galaxy beyond the Milky Way. We are scarcely willing to believe that our system is the "world's greatest." Our doubt is engendered by considerations of probability, and not by modesty. It exhibits very well the change which has come about in the mind of man concerning his physical status in the universe.

While the static view of the galactic system may well represent its practically unchanging appearance from day to day, we must not lose sight of its dynamic features. It is in fact a mighty moving picture. But to be exhibited as such, the exposures of the film must be separated by thousands of years. One characteristic to be confidently expected in the moving picture of our system is its rotation. The flattening of the system suggests flattening at the poles, and its great extension along the galactic plane may be regarded as the equatorial bulge.

The rotation of the galactic system can scarcely resemble the turning of a wheel whose different

parts complete their circuits in the same period. This would be the case only if all parts of the system were joined, or if its material were distributed evenly. But on the theory that the Milky Way system is a single great galaxy, a large part of its mass appears to be concentrated near the center. Thus the rotation of the surrounding portions of the system should resemble more nearly the revolutions of the planets around the sun; the greater the distance from the center, the slower is the motion, and the longer the period of the revolution.

Oort, in Holland in 1927, showed that the observed motions of the stars are as we should expect them to be if the galactic system is rotating in this way (Figure 5). Stars in the direction of the center of the system are passing by the sun; those farther from the center than the sun's distance are falling behind us. Strömberg's discovery, at the Mount Wilson Observatory, [that the globular clusters are speeding away from a point in the constellation Cepheus finds a simple explanation as their apparent backward drift owing to the sun's swift revolution in the opposite direction.] Lindblad, in Sweden, has raised the interesting question as to whether the wider departure of the globular clusters from the plane of the Milky Way may not be ascribed to the slower rotation and

NO. 3  
Andromeda  
is 41500

consequently less flattening at the poles of the cluster system.

Interest in the problem has been wide spread. And the available evidence has been generally

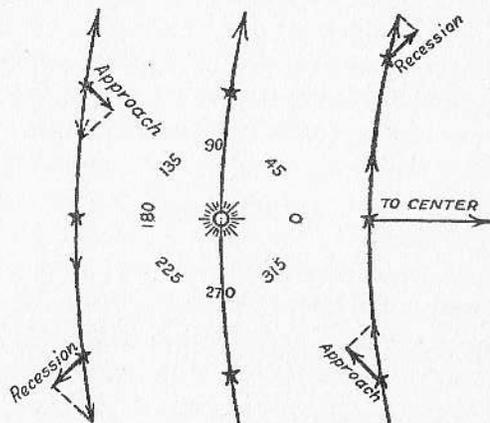


FIG. 5. Rotation of the Galactic System. Observations with the spectroscope show that stars along the Milky Way differing  $45^\circ$  and  $225^\circ$  from the direction of Sagittarius are, on the average, receding from us; stars on the other diagonal are approaching. This would be true if the galactic system is rotating around the Sagittarius cloud at speeds diminishing with increasing distance from the center. (From *Astronomy, An Introduction*, by permission of D. Van Nostrand Company.)

taken to mean that the galactic system is rotating around the center of the Sagittarius cloud.] As its share in the rotation the sun is taking us along at the rate of two hundred miles a second in the

direction of Cepheus. Those who adhere to the theory that the galactic system is a single spiral structure find further evidence of its rotation by analogy with the exterior systems. The remote spirals, such as the "great nebula" in Andromeda are known to be in rotation.

In the first theory, therefore, we have viewed the galactic system as a single spiral structure surrounded by a setting of globular clusters. Resembling the external spirals in its assigned form, in its rotation, and in some other features, it greatly surpasses even the largest of them in size and stellar population. If the external systems are "island universes," then, as [Shapley has remarked, our Milky Way system must be a continent. Later reflection led him, in 1930, to the proposal that it is instead a group of "islands."]

This is the second of the three theories we are examining. The new construction is accomplished simply by divesting the classical structure of its spiral form. By this modification, the assemblage of star clouds becomes a supergalaxy, or perhaps a part of one, resembling the groups of external systems whose description is found in Chapter VII.

From the new point of view the star clouds of the galactic system are to be regarded as individual galaxies, and to be compared with the separate

same?

15.4.9

15.4.9

external systems. If we accept the preliminary measurements, [the Sagittarius cloud,] around thirty thousand light years in diameter, is somewhat smaller than the Andromeda spiral and the other giant external systems. The local system, whose diameter has been estimated as ten thousand light years, resembles with these dimensions other star clouds of the galactic system, and perhaps the majority of the external systems.

Historically, "galaxy" may not be the most fortunate name for these great building blocks of still greater systems. Originally the word was employed to denote the Milky Way itself, and not the separate assemblages which form it, and which also lie beyond it. A new generic term may eventually come into use. It is not yet the time to formulate a permanent structural nomenclature.

Nor has there been sufficient time since the proposal of the supergalaxy theory to decide definitely whether it will be acceptable as a working theory for the future. The separate star clouds of the galactic system seem now to be comparable in size and luminosity with the external galaxies. In this respect the newer view is the more convincing. On the other hand, the system is collectively much smaller and also more flattened than some of the exterior supergalaxies, as we see in Chapter VII. Both discrepancies disappear, however, if the

Magellanic Clouds and others among the nearest of the galaxies hitherto considered as external are instead members of our own supersystem.

Just as the members of the planetary system received the special attention of the earlier astronomers, so until a very few years ago the members of the local system of stars were the principal objects of sidereal research. Details of the galaxy immediately surrounding us, they occupy the foreground of the celestial scene beyond the solar system. To this galaxy belong the majority of the brighter stars, open clusters, and the more conspicuous bright nebulae and dark dust clouds.

It is by no means certain that the local system has a spiral form. A number of considerations suggest, in fact, that it is an irregular assemblage of lesser groups, resembling the Magellanic Clouds. In such an assemblage it could scarcely be expected that all classes of objects would congregate along the same circle of the sky. While the belt of bright stars is inclined  $12^\circ$  to the galactic equator, the nebulae are concentrated, according to Hubble, both along this equator and in a belt inclined  $20^\circ$  to it; and Trumpler has shown that the open star clusters are crowded toward a circle of the sky whose inclination to the galactic equator is slightly more than two degrees.

South, etc.  
Andromeda

15.5.6

But a number of astronomers have not been favorably impressed by the large dimensions assigned to the Milky Way. And the proposal to divide it into separate galaxies does not solve their difficulty. They have preferred, often without convincing evidence to support the preference, to adhere to the original "island universe" theory of Kant, that the external systems are galaxies in the first sense of the word—milky ways like our own. Our system, as they view it, is not a "continent."

This is the third of the three theories to be specially noticed. It assigns to the Milky Way dimensions comparable with those of Herschel's "grindstone" or of the "Kapteyn universe," and occasionally depicts it as a spiral. Nearly ten years ago, before the great spirals were definitely established as external systems, McLaughlin drew a tentative picture of the Milky Way system as a spiral structure not more than forty thousand light years across. It was an amplification of Easton's earlier picture. In this spiral the sun occupies a fairly central position. Far away in the direction of Sagittarius is the center of the much larger system of the globular clusters. This construction reappears in Trumpler's picture of 1930, supported now by newer evidence which he has assembled, and to which we have already referred in Chapter IV.

Trumpler concludes that the majority of the open clusters are arranged in the form of a flat disk whose diameter is about 30,000 light years, and whose thickness is a tenth as great. Two thirds of the clusters are within three hundred light years of the equatorial plane of their system, which is inclined a little more than two degrees to the central plane of the Milky Way. The whole assemblage has the aspect of a great open cluster of clusters.

These clusters are strongly concentrated around the center of their system, which is somewhat more than a thousand light years distant from the sun in the direction of the constellation Vela. Differing only about ten degrees from the direction assigned to the center of the local system, it may be said for the present to be in practical agreement with it. There is no evidence of special concentration of the clusters in the direction of Sagittarius.

Assuming that the Milky Way system is co-extensive, in general, with the system of the open clusters, Trumpler views it as a flat spiral structure having a diameter of thirty thousand light years and a thickness about a fifth as great. Accordingly, our stellar system is less flattened than the system of open clusters, which in turn is less flattened than the hazy stratum, on the existence of which this whole construction depends.

But the larger galactic system of the other theories is more flattened than the assemblage of globular clusters which encloses it. The whole question of the degree of concentration of the various classes of celestial objects toward the Milky Way is of the greatest interest.

In the theory we are examining, the spiral system of the Milky Way is a prominent feature of our super-cluster. It lies near the edge of the throng of globular clusters whose center, as before, is 50,000 light years away in the direction of Sagittarius. Far to the south, the two Magellanic Clouds are other associates. And it is possible, as Lundmark points out, that a "hidden system" of undetermined extent and form may lurk behind the obscuring material of our own system.

Such, in brief, is the present state of our knowledge concerning the structure of the galactic system. It was only six or eight years ago that the system of the Milky Way was first set definitely apart from the external systems. Remarkably rapid progress in the explorations has been made in this short interval, and equally rapid progress may be expected. The succession of dramatic disclosures of the past few years prepares the way for others. That the account is still far from complete adds interest and not disappointment.

To promote the clearest description, we might

have selected one of the current theories of the galactic system and constructed the story around it. Instead, we have presented all three. The reader is left either to choose the view that seems to be the most reasonable, or to reserve final judgment, and as astronomical discoveries of the next few years come forth, to notice which theory seems best to represent the new evidence. In summary, the three theories are:

(1) The system of the Milky Way is a single spiral structure some 200,000 light years in diameter, outlined by the globular clusters. The sun is near the center of one of its star clouds, the local system, about halfway between the massive center and the edge of the great system.

(2) It is a supergalaxy outlined as before by the globular clusters. The local system and other star clouds are separate galaxies comparable with the external galaxies.

(3) It is a single spiral around 30,000 light years in diameter, comparable with the largest external spirals. The sun is not far from its center. It is coextensive with the open clusters, and near the edge of the great system of globular clusters. A hazy stratum only a few hundred light years in thickness extends along its principal plane.

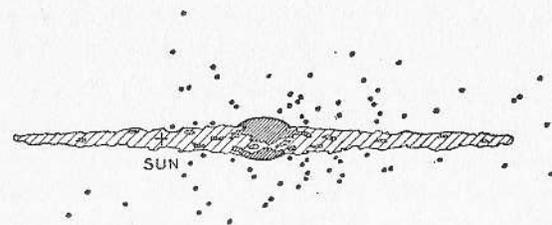
Let us imagine ourselves suddenly transferred from the earth in the direction of the constella-

tion Carina to a point a million light years away. We look around at a black starless sky, perfectly black except in one region where we see a ghostly glow. It is the galactic system. There are other systems in other directions far away in the blackness of the intergalactic spaces, but we can see nothing of them with the naked eye.

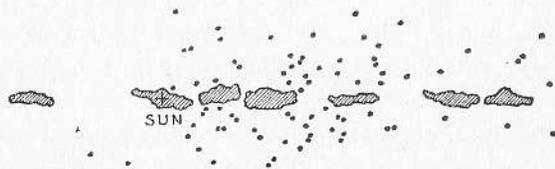
The glow we have noticed is elongated; it extends perhaps four times the apparent diameter of the moon, and near it we discern one or more smaller hazy patches. But the view is very indefinite. It is fortunate that a large camera has been brought along. We photograph the glow with a long exposure.

As the exposure proceeds there is ample time to reflect on its significance. Away off there in the distance, near or actually within this glowing area, astronomers on the tiny earth are combining forces to solve one of their outstanding problems. The problem is to obtain a true picture of the vast system of the Milky Way from the observations made within it. What would be its appearance to an outside observer? Our photograph should solve the great problem. Its development would make possible a decisive astronomical discovery.

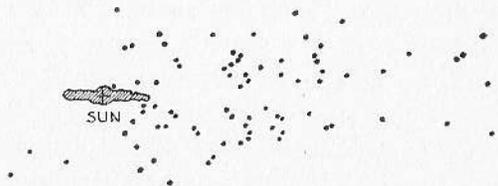
If one of the three foregoing theories of the Milky Way system is correct, our picture will bear some resemblance to one of the three sketches in



(1) Single Great Galaxy



(2) Supergalaxy



(3) Single Smaller Galaxy

FIG. 6. Three Possible Distant Views of the Galactic System

Figure 6. (1) It will be the picture of a spiral nebula viewed edgewise. The glow that first attracted attention comes then from the nuclear

15.3.4  
 star clouds of Sagittarius. Probably a narrow dark band will be shown stretching nearly centrally across the nucleus, and out across the arms as well. (2) The extent of the system will be the same; but instead of an edgewise spiral we shall see a group of more or less isolated star clouds. In either case the flattened system will be concentric with a much less flattened assemblage of star-like objects on the photograph, which are really the globular clusters. (3) The glowing patch will be delineated as a smaller edgewise spiral bisected by a narrow dark band, and located near the edge of the larger cluster system.

But it is not possible for the present to develop this important photograph. We return to the earth and observe how the astronomers are proceeding systematically from within toward the successful solution of the problem. Their program requires, first, a more thorough exploration of the galactic system, and a more complete understanding of absorption effects within it. Second, further studies are required of the galaxies beyond the Milky Way; these are described in Chapter VII.

Until very recently, the investigations of the structure of the galactic system, apart from analogies with characteristics of the external systems, have depended on counts of stars, or on the observed distributions of the globular and open star

clusters. The usual statistical method, however, smooths out the irregularities in which we are specially interested, while any conclusions from the distributions of the clusters are open to the objection that the clusters do not fairly represent the distribution of the star clouds. The present task is the accurate survey of the star clouds themselves, a project whose completion will require from ten to twenty years.

Extensive photographic explorations of the Milky Way are in progress at the Harvard Observatory. Altogether, as many as a hundred thousand photographs will be employed, and it is expected that twenty thousand variable stars in the Milky Way will be discovered and studied. It has been explained how the distance of a Cepheid or a cluster type variable star can be determined. By the detection and observation of many variable stars in the star clouds, it will be possible to establish the distances, dimensions, and forms of the separate clouds, to show how they are related, and finally to combine the conclusions into the picture of the galactic system which we seek.

In the present stage of the inquiry into the nature and extent of the galactic system the Magellanic Clouds occupy a sort of celestial no man's land. Having the appearance of attached portions of the Milky Way, they show, however,

no evidence of connection with it. The Large Cloud is more than a third of the way and the Small Cloud is nearly halfway in the sky from the central line of the Milky Way toward its southern pole. Yet they are nearer the earth than thirty per cent of the globular clusters which have been assigned to our system.

Their position in the middleground is of great strategic importance for the successful outcome of the present structural investigations. The Clouds are sufficiently remote to present a comprehensive view in which the relations of the different features may be clearly seen. At the same time, they are near enough to be resolved with the telescope into separate stars, star clusters, and nebulae. Thus they form a valuable link between the star clouds immediately around us, where the relations between details are not so obvious, and the more remote galaxies whose details are not so easily discerned.

The Magellanic Clouds never rise above the horizon for observers north of the tropical zone. In more southern latitudes they are plainly visible to the unaided eye on a clear moonless night as luminous patches comparable with the brighter parts of the Milky Way. The Large Cloud spreads over an area seven degrees in diameter, having its center  $21^{\circ}$  from the south celestial pole,



PLATE 6. Large Magellanic Cloud. (Photographed at Arequipa station of Harvard Observatory.)

in the constellation Doradus. The Small Cloud is in Tucana; its diameter is about half as great, and its center is  $17^\circ$  from the pole.

Shapley's recent revision of his earlier measurements places the Large Cloud at the distance of 86,000 light years, and assigns to it a diameter of 10,800 light years. The Small Cloud is slightly farther away, at the distance of 95,000 light years; its diameter is 6000 light years. In the space of thirty thousand light years which intervenes between their edges there is nothing to suggest any material connection between the two aggregations. John Herschel's observation to this effect, a century ago, is fully confirmed. The approach to the Small Cloud in particular "is through a desert." It is set "in one of the most barren regions of the heavens."

The Large Magellanic Cloud (Plate 6) is approximately circular. It has the appearance of a faintly luminous and fairly uniform matrix of stars, in which brighter patches are distributed. Brightest of all is the "axis," south of the center; it is a dense cloud of stars five thousand light years in length and about a fifth as wide, with a still more densely populated nucleus. There are other bright regions of coarser texture which contain many open clusters and supergiant stars. According to Miss Mohr's estimates based on

careful counts in selected areas there are 214,000 stars in all brighter than zero absolute magnitude. Among them is the variable star S Doradus which is more than a hundred thousand times more luminous than the sun. It is the brightest star on record anywhere, aside from a few "new" stars at the height of their temporary grandeur.

Diffuse nebulae are present in the Large Cloud. And here again a record is established. The nebula 30 Doradus, in a coarse bright patch immediately northeast of the axis, is the largest and brightest of known nebulae of this sort; its diameter is 130 light years. Placed as near us as the great nebula in Orion, it would spread over practically the whole constellation and, as Shapley points out, it would be bright enough to cast strong shadows on the earth's surface. Dark dust clouds are certainly present as well. A hundred open star clusters and eight globular clusters, at least, are recognized in the Large Cloud. The former are themselves clustered, and they do not represent faithfully in their distribution the form and full extent of the entire cloud. The latter may well be in [the outskirts] of the system.

The two Clouds of Magellan comprise the same kinds of celestial objects that are found in the star clouds of the galactic system proper; they contain stars of the different varieties, star clusters, and

nebulae both bright and dark. They are representatives of a common type of celestial structure. If the Magellanic Clouds were in the galactic plane, there would be nothing to distinguish them from the other star clouds of the Milky Way. If they were more remote, they would be undistinguishable from the many irregular exterior galaxies, perhaps several tens of thousands in number within the reach of present telescopes, which are distributed among the great spirals and other external aggregations.

"If the grandeur of a planetary world in which the earth, as a grain of sand, is scarcely perceived, fills the understanding with wonder; with what astonishment are we transported when we behold the infinite multitude of worlds and systems which fill the extension of the Milky Way! But how is this astonishment increased, when we become aware of the fact that all these immense orders of star-worlds again form but one of a number whose termination we do not know, and which perhaps, like the former, is a system inconceivably vast—and yet again but one member in a new combination of numbers."

Thus Kant wrote nearly two centuries ago. At this time, when the universe had scarcely burst through the ancient sphere of the stars, when men were beginning to look past the planetary system

into the depths of interstellar space which appalled them, Kant was thinking in terms of galaxies of stars, and galaxies of galaxies. Conjectures they were, but in many respects remarkably fortunate ones, as modern researches have shown. Astronomers are now looking past the system of the Milky Way into the vaster depths of intergalactic space. Let us see what they have found.

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## CHAPTER VII

### BEYOND THE MILKY WAY

12:2.2

IF OUR galactic system with its associated globular clusters and Magellanic Clouds were suddenly erased, the sky would become almost blank. The sun, moon, and planets would vanish, of course. The stars and the Milky Way would entirely disappear. Of all the celestial scenery only two objects would remain, two faintly glowing patches near the place where the square of Pegasus stood—the “great nebula” in Andromeda and Messier 33 in Triangulum. These are the nearest of the external spiral systems, and the only ones visible to the naked eye.

12:2.2

Messier 33 (Plate 2), the fainter of the two, is the nearest of the great spirals. Its distance is 770,000 light years, and its diameter is 15,000 light years. On photographs with large telescopes it appears as a typical “spiral nebula” presented nearly flatwise to us. From opposite sides of the densely populated nucleus two streams of star clouds project and coil in the counterclockwise direction. Dark dust clouds, bright nebulae, and star clusters are included in its organization, in fact so far as can be observed, every kind of celestial object that we find in the system around us.