"Super-Universes" Located

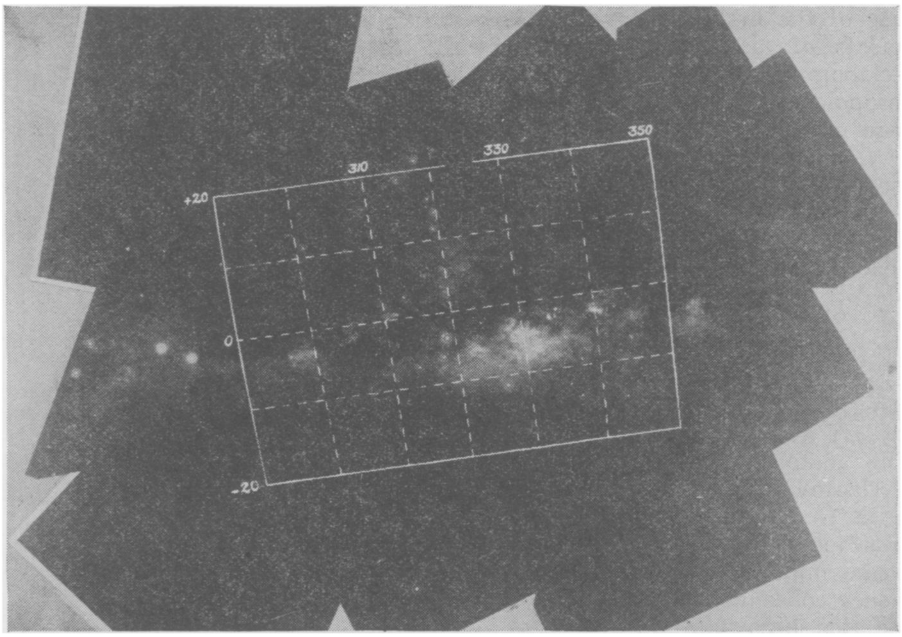
Astronomy

By James Stokley

From electrons up through the atoms they constitute, the various elements made up of atoms, the stars made of these elements, the star clusters consisting of swarms of stars, the "universes", such as our own, that are formed of hordes of the clusters, up to the "super-universes," or galaxies of galaxies, made up of a number of universes, and perhaps, to even more vast clouds made of these galaxies of galaxies, or "cosmons".

Such, in brief, is the overwhelming vista opened up to the scientist by the latest work of one of America's most famous astronomers, Dr. Harlow Shapley, the director of the Harvard College Observatory at Cambridge, Mass.

Though famous today, it hasn't been so many years since he was an unknown graduate student at Princeton. Here he studied under Prof. Henry Norris Russell, who also ranks among the leaders in any list of American astronomers. Dr. Shapley, having obtained his degree, went to Mt. Wilson in 1914, and began to attract favorable attention in astronomical circles.



JUST AS AN AERIAL PHOTOGRAPHER makes a composite map of a great city by combining a number of overlapping photographs made from an airplane, so does the astronomer combine photographs to reveal larger areas of the sky than he can photograph at once. This composite picture, made at the Harvard Observatory, shows the center of our home galacton, as determined by Dr. Shapley. The numbers refer to galactic latitude and longitude. The center is at 0° latitude and 327° longitude, but happens to be hidden by a mass of dark matter.

Up to 1919, perhaps the best known name in American Astronomy was that of E. C. Pickering. He had been director of the Harvard Observatory since 1877 and had inaugurated countless important researches that had brought him international fame. In 1919 he died, at the age of 73. Speculation was then in order as to who should succeed him. When Dr. Shapley, 35 years old, was appointed in 1921, many astronomers probably wondered whether he could live up to the standards set by his predecessor.

That he could, and did, has been splendidly shown by the work that has been accomplished in the seven years of his tenure—work that has probably made the Harvard Observatory even better known today than it was when he took charge, while he himself ranks in the same class as his teachers.

His latest work has introduced us to a new order of sizes.

Since the time of the early Greeks, there have been theories that all matter was composed of smaller units called atoms. Somewhat over a century ago, the English chemist, Dalton, put the atomic theory on a sound basis. But then it was thought that the atoms were solid, round balls, incapable of change or division.

Then came the discovery of radium, and knowledge of the fact that its atoms are continually disintegrating into other atoms. This, as well as other discoveries, showed that the atoms were far more complex than Dalton had supposed, and so there arose theories of the structure of the atom, with the electron as the units of which the atom is constructed.

For hundreds of years it has been known that our earth is part of a family of planets that revolve around the sun, and that the sun is a star, appearing different from the rest of the stars only because we happen to be close to it. Contemporaneously with Dalton, another English scientist was making a name for himself. This was Sir William Herschel, famous astronomer. One of the things for which he is remembered today is that he showed the shape of the system of stars of which our sun, and all the other stars that we can see, is part. Its shape is that of a watch, or a grindstone, that is, round, but flattened. When one looks in the direction of the edge of the grindstone, the cloud of stars seems much thicker. This causes the appearance of the Milky Way.

However, while the shape of our system of stars, or "universe", has been known for over a century, it has only been very recently that the size has been definitely determined. It was a decade ago, while he was at Mt. Wilson, that Dr. Shapley gave astronomers a new idea of the size of this galaxy. He found that the globular star clusters, which are, as their name implies, spherical swarms of stars, form an outline of the entire galaxy. In them he found a peculiar kind of variable star, known as the Cepheid variable. Many stars change their light more or less regularly, but the peculiarity of the Cepheid is that it gets bright rapidly, than diminishes gradually. Thus it can always be recognized. Furthermore, its average brightness, or "candlepower", depends upon the speed at which the light changes take place. The faster the change is, the brighter is the star on the average. The Pole Star, ancient friend of mariners, is a Cepheid variable. Thus, when the astronomer sees a Cepheid and measures the length of time it takes for (*Turn to next page*)

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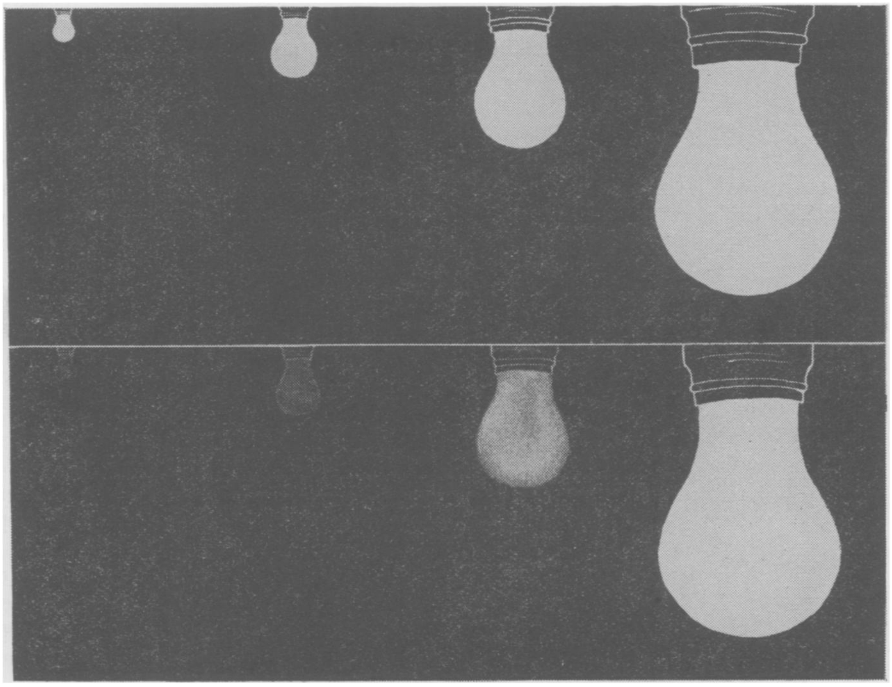

DR. SHAPLEY'S DIAGRAM showing how he proved the transparency of space. The upper half represents a row of frosted electric lights along a corridor, the farther away the lights, the smaller the image, but the surface brightness is the same. The more distant ones appear fainter because the area that they present to the eye is less. The lower half represents the same lamps when the corridor is filled with smoke or fog. The nearest lamp appears the same as before, but the more distant ones appear fainter as well as smaller. Study of the spiral nebulae, or galactons, showed that even the smallest and most distant have the same surface brightness as the nearer ones, so that there is apparently no cosmic fog between us and them.

one complete change of its light, he can measure its actual brightness, or candlepower. And then, if he measures the brightness that it seems to have, he knows that the difference is due to its distance, and so he can measure that. The case would be similar to that of a captain of a boat who judged his distance from land by the apparent brightness of a light on the shore. If he knew how bright the light actually was, he could estimate his distance.

So Dr. Shapley was able to measure the distance of the globular star clusters, and this gave an idea of the size of the galaxy. This turned out to be far greater than anyone had previously supposed—something more than 200,000 light years across. A light year—the distance that a beam of light will travel in a year—is equal to about 6,000,000,000,000 miles. The center of the galaxy, he found, is in the direction of the constellation of the Archer, and about 50,000 light years away. So, while we are not in the remote "sticks" of the galaxy, we do live in rather out-lying suburbs. In the last few years Dr. Shapley has performed further work which verifies this earlier result.

But our suburb does not stay put. It has been found within the last year or two that we are rather living on a merry-go-round. The galaxy is rotating. Since it is made up of separate units, and is not all of a solid piece, like the merry-go-round, the parts nearer the center turn faster. At our distance from the center it takes us about three hundred million years to make one trip around.

When Herschel made his observations with his great 48-inch telescope about 150 years ago, he was able to do more than show the shape of the galaxy. Another thing that he did was to study some of the star clusters and the nebulae. The star clusters, and what they are, have already been mentioned. To small telescopes, some of them appeared rather hazy, and it was not evident that they were made up of swarms of single stars. But with Herschel's telescope, the stars became apparent. So, when he looked at the nebulae, and saw that they looked much as the star clusters did with smaller telescopes, he concluded that they, too, were made of stars, and that still more powerful telescopic aid would resolve them.

Herschel was partly right. Some of the nebulae, those with rather irregular shapes, finally proved to be clouds of glowing gases, but there were others, later recognized as having a characteristic spiral, or pinwheel, shape, that still remained a puzzle. No telescopes were able to break them up into stars, that is, none could until 1919, when the 100 inch telescope of the Mt. Wilson Observatory, now to be dwarfed by one twice as large, was completed. With this great instrument Dr. Edwin Hubble, one of the Mt. Wilson astronomers, actually made photographs which revealed the stars of a couple of the nearer spirals. Further study, by Dr. Shapley, on the two Magellanic clouds, apparent in the southern sky and seeming like detached pieces of the Milky Way, showed that they too had some features in common with the spirals. A fifth object, very faint, and known only by a number, N. G. C. 6822, was similar. All consisted of swarms of stars, all were shown to be at vast distances, so vast that they are definitely outside our galaxy. In truth, they proved to be "island universes".

However, the term "island universe" is subject to some criticism. "Universe" is generally, and correctly, used to mean the entire cosmos, and to use the same name to designate merely a piece of it is rather misleading. So Dr. Shapley has suggested a new name for these galaxies that dot the sky by thousands and thousands — "galactons", similar to electrons, the smallest known units of matter. Such a name would be very useful, and deserves to come into wide use. Though only five galactons have been studied well enough so far to gain a very precise idea of their distance, many more will come into view of the new 200 inch telescope, and then our knowledge of them will be greatly extended.

Thus the scale of objects in the universe has been extended from electrons to atoms, from atoms to the elements, from the elements to the stars, from the stars to the galactons, and from the galactons to—what? Do the "island universes," the spiral nebulae, Magellanic clouds, and such group themselves together into any higher system?

It is to this question that Dr. Shapley, in some of his very latest work, answers, "Yes." There are such things as (*Turn to next page*)

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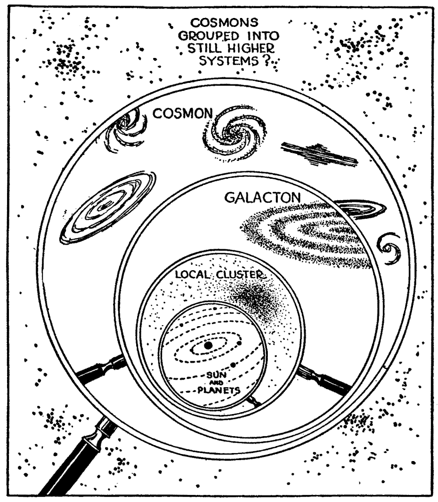
"universes of universes," galaxies of galaxies, but as these names are cumbersome he proposes that they be called "cosmons." So a cosmon may be defined as a cloud of galactons.

Nearly fifty separate cosmons have revealed themselves on the Harvard photographic plates, and the nearest is one in the constellations of Coma and Virgo, two adjacent groups that appear in the eastern sky in spring evenings. It is eleven million light years from us, it numbers 250 separate galactons, and is about two million light years across. Each of the galactons in it measures from five to twenty thousand light years in diameter, far smaller than our own system. All of the known galactons, whether part of a larger system or not, are much smaller than our own galaxy, except the Andromeda nebula. This is one of the two that Dr. Hubble measured, and it is only about a fifth as large as ours, or forty thousand light years in diameter. Furthermore our galaxy is apparently much more complex than any of the galactons that we see in the sky. What is the reason? One suggested by Dr. Shapley is that perhaps our galaxy was made from the condensation of a swarm of galaxies—a cosmon—into one vast system, unique in the sky, as far as we are aware at present. So perhaps that may be some small consolation for the dwellers on this insignificant earth, to know that our whole galaxy is the finest and best in the sky!

There is still another point about Dr. Shapley's latest researches which has an important bearing on the problem. All these measurements and estimates of distance assume that there is nothing between the things we are looking at and ourselves. But it is known that there are free electrons, dark clouds, and all sorts of things scattered around the sky that might get between us and act as a fog. A street lamp may appear faint because it is far away Or again there may be a dense fog, and a lamp across the street may appear as faint as one three blocks away on a clear night. How can we tell whether space is clear, or full of fog?

This is the way he did it.

Imagine a long corridor. Along the ceiling is a row of electric lights, spaced, let us say, at ten foot intervals. The nearer ones look large and bright. Those farther away are smaller and fainter. Those at the end of the corridor are barely seen as points of light, quite faint. Now measure their apparent size and apparent brigthness, and make a curve representing this relationship. It will be found that the size and brightness fall off at the same rate.



AN INFINITELY LARGE GIANT looking at the entire universe would find it made up of clusters of luminous objects—cosmons. If he looked at a cosmon through a magnifying glass, he would discover it to consist of galactons, "island universes." Applying his magnifying glass to a galacton, he would see a vast number of individual stars, and a more powerful glass applied to a part of a galacton would reveal the stars grouped into local clusters. And, finally, a look at a local star cluster through a glass magnifying a million million times, would show many "little" suns, some of them surrounded by a retinue of planets like the earth.

But suppose the corridor is filled with smoke. The nearest lamp looks nearly as bright as it did before. Farther away, the smaller the lamps appear just as they did before. However, the brightness of the lamps now falls off much more rapidly than their apparent size, because the farther away they are, the more smoke their light has to pass through, and the more light is absorbed. The apparent size of the lamps is unaffected by the smoke.

Dr. Shapley and his associates have measured the apparent size of the galactons in relation to their brightness. Of course, they are not all exactly the same size, but in taking a large number of them, individual variations will be ironed out, because some will be larger than the average, and some smaller. He has found that their brightness falls off just as rapidly as their size, but no more so, and thus proves that the space of the universe is not filled with some sort of cosmic smoke. The distances of objects far and near are entirely reliable.

Though it will be at least several years before the new 200 inch telescope in southern California is completed, already astronomers are beginning to think what they will be able to accomplish with it, and how far they will be able to see. Dr. Shapley's new researches remove one objection that might have been offered a few years ago, by people who thought that space might be foggy.

In fact, it has been suggested that with the new instrument astronomers will actually be able to see an appreciable fraction of all space!

It used to be thought that space was infinite—that if one started travelling in any direction, and kept on going forever, he would neither come to an end of space, nor retrace any of his former journey. Einstein, with his theory of relativity, has changed this view. Those who support his theory now hold that space is finite, but unbounded, which isn't quite as contradictory as it seems.

Imagine an ant on a globe. It can start in any direction and keep on going without ever coming to a boundary, but after it has made one circuit of the globe, it will be back where it started. Similarly, say the relativists, the universe is curved, in some higher dimension which we cannot comprehend. If we travel long enough, we will find ourselves back where we started from, or if we had a powerful enough searchlight, the beam of light would finally return and shine on our backs. Perhaps it would be better to say that it would shine on the backs of our remote descendants, for, in spite of the enormous speed of light, it would take about 520,000,000,000 years to return to its starting point!

In other words, the circumference of this curved space in which we live is somewhat over half a million million light years, and, if we can see that far, we can see all the way around. If a telescope will reach half as far, it will see all there is to be seen in the universe—assuming, of course, the validity of Einstein's ideas.

How near are we to accomplishing this?

Dr. Hubble, who penetrated deeper into space with (*Turn to next page*)

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the 100-inch telescope than did anyone before him, estimated that he could photograph galactons (only then he called them spiral nebulae) as far away as 140 million light years. With the 200-inch it will probably be possible to see for 500 million, or half a billion, light years.

Just what portion of the entire universe a sphere of half a billion light years will represent may be illustrated by radio reception on the earth. The circumference of the earth is about 25,000 miles. This will represent the entire universe. Scattered around the surface of our terrestrial globe are thousands of radio stations, just as the galactons are scattered around through space. If we have a set capable of hearing a station 12,500 miles distant, we can hear them in all places. But suppose that we have a set that will only bring in stations seven miles away—about as far as one can see on a level plain. That represents the 100 inch telescope, the best that the astronomical radio sets, called telescopes, that detect the tiny radio waves called light, can do at present. Now suppose that we are presented with a set that will tune in a station 25 miles away. Then we have the equivalent of a two hundred inch telescope.

Hearing stations 25 miles away as compared with a possible 12,500 miles seems pretty small, but at least it is an appreciable, though minute portion of the whole earth. So will the ability to see for half a billion light years enable us to see an appreciable portion of all of the universe. And just as radio research has brought all parts of the earth together, so will astronomers of the future be able to see farther and farther, until finally the entire universe is within hailing distance.

Science News-Letter, April 13, 1929

THE following table of the dimensions of the universe, from the electron to the entire universe itself, was prepared by Dr. J. S. Plaskett, director of the Dominion Astrophysical Observatory at Victoria, B. C. Each figure represents a dimension 100 times larger than the one preceding it. On the right is a column of objects that come within the order of size of the figure given.

.000 000 000 000 06 inch	Electron
.000 000 000 006 inch	
.000 000 000 6 inch	Atom
.000 000 06 inch	Atom
.000 006 inch	Soap bubble thickness
.000 6 inch	Tissue paper
.06 inch	
6.3 inches	Ordinary brick
.01 mile (633.6 inches)	Width of house
1 mile	
100 miles	New York to Philadelphia
10,000 miles	Diameter of earth
1,000,000 miles	40 times around the earth
100,000,000 miles	Distance earth to sun
10,000,000,000 miles	Diameter of solar system
1,000,000,000,000 miles	
17 light years, (100,000,000,000,000 miles)	Distance of nearer stars
1700 light years	Diameter of local cluster
170,000 light years	Diameter of galaxy
17,000,000 light years	Distance of nearer galactons or diameter of cosmon
1,700,000,000 light years	Six times range of 100-inch telescope
170,000,000,000 light years	Diameter of Einsteinian Universe

Recent examination of Chicago school children showed that 96 per cent. of the children had from one to fourteen bad teeth.

Knights of the Middle Ages were not always big fellows, judging by the size of some specimens of armor in museums.

A young Frenchman has given 117 pints of his blood in 264 blood transfusion operations.