1,800,000,000,000,000,000 Miles

Astronomy

By James Stokley

Our "universe" is eighteen hundred thousand million million miles across.

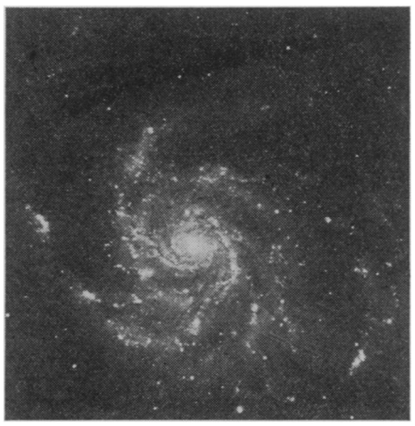
Such is the latest estimate of astronomers concerning the size of the Galaxy, the system of stars of which the sun, and all the stars that we can see, including those in the Milky Way, are part.

A figure as vast as that does not mean much to the astronomer or layman. Take another unit, the diameter of the earth, for example. The earth's diameter is about 8,000 miles. Therefore, if you could put 225 million million earths side by side, they would just about reach across the Galaxy. Or take the distance of the earth from the sun, about ninety-three million miles, called the "astronomical unit." Using this as a yard stick, it would be necessary to lay it down 19 billion times to measure the Galaxy's diameter.

To measure celestial distances without using inconveniently large figures, the astronomer often uses the light year. This is the distance that light, which travels fast enough to encircle the globe seven times in a second, will go in a year, or about six million million miles. This is 63,300 times the distance of the earth from the sun. It also happens that there are 63,360 inches in a mile, so that a light year is just about as big, compared to the astronomical unit, as the mile is to the inch. This possible diameter of the Galaxy, then, is about 293,000 light years.

This is the figure calculated by Frederick H. Seares, of the Mt. Wilson Observatory in California, and announced by him in a long and technical article that has just appeared in the *Astrophysical Journal*. It is the maximum, but his minimum estimate is equally impressive, for that is nearly 200,000 light years, or twelve hundred thousand million million miles.

Some place between these two figures, he believes, is the true size. Not only does he give us a new idea of how large our home galaxy is, but also of what it would be like if we could see it from outside. To us dwellers within the Galaxy, it is hard to secure an idea of what it looks like. We can't see the forest on account of the trees.



OUR GALAXY probably looks something like this, one of the spiral nebulae in which there is considerable resolution into condensations, or clusters of stars. This one is in the constellation of the Great Bear, and was photographed at the Mt. Wilson Observatory

A person in a small forest, however, might get some idea of his location within it, by studying the way the trees are distributed. If he looked one direction, and saw light spots between the trees, he would know that he was probably nearer one side than the other. So when the astronomer sees more stars in the sky in one direction than in another, he assumes that it is because the earth is located closer to that side of the swarm of stars than the other.

The thickest mass of the galactic system is in the direction of the Milky Way. It was the great English astronomer, Sir William Herschel, who suggested that the sun, together with all the stars that we see, is part of a grindstone-shaped cluster. When we look out toward the edge of the celestial grindstone, we see the stars much more closely packed than when we look towards one of the sides. This thick packing of stars is what we ordinarily call the Milky Way. Even a small telescope, or a pair of binoculars, will reveal that the apparently continuous cloud of light is really a swarm of stars.

For many years, the exact size of the galactic swarm has been a matter of more or less dispute among astronomers. Some have insisted that it must be so vast that light would take several million years to cross it from one side to the other. Light will go approximately six trillion miles in one year, so that this would make the diameter something like 12,000,000,000,000,000,000 miles! But other astronomers have just as vehemently insisted that this figure was perhaps a million times too large, and that it was only 25,000 or so light years across.

So the matter stood until recently. Apparently, there was just about as good evidence in favor of one figure as the other. The shape of the system was pretty well known. So also we knew which stars and other objects are the farthest from us. The relative proportions remained a conundrum.

Among the objects that, it was realized, must be pretty far away, were the so-called "spiral nebulae." Sir William Herschel was one of the first to see them, but his telescope was not good enough to show that they had the spiral structure. This was first demonstrated with the great six foot diameter reflecting telescope built in Ireland about 80 years ago by a nobleman, the Earl of Rosse. Only within the past fifteen years has this telescope been exceeded in size, though for many years astronomers have had instruments that worked better.

With one of the telescopes at the Lick Observatory in California, Dr. Heber D. Curtis, now the director of the Allegheny Observatory in Pittsburgh, made a series of photographs which revealed many thousands of spiral nebulae in the sky. From his, and other, researches, it became evident that they were far away. The question was then: "Are the spiral nebulae part of our galaxy, or are they separate systems outside its limits? Might it not be that the spiral nebulae themselves are systems like our galaxy, and that our galaxy is itself a spiral nebulae?"

So the controversy continued. One group of astronomers maintained that the spiral nebulae were actually parts of our system. Another insisted that they were beyond its limits, and that we are actually living in such a nebula. With good arguments on both sides, it looked as if it could hardly be settled, until Dr. Edwin P. Hubble, another Mt. Wilson astronomer, began to take photographs of two of the nebulae with the great 100 inch reflecting telescope. This is the world's largest telescope, (*Turn to next page*)

Our Galaxy Measured—*Continued*

and has been in use only since 1919. Previous photographs of spiral nebulae had showed them as continuous areas of light, just like the other nebulae. Dr. Hubble's photographs showed for the first time that the spiral nebulae consist of swarms of stars. Just as the Milky Way appears continuous to the naked eye while the telescope reveals the myriads of stars that constitute it, so the spiral nebulae appear to ordinary telescopes as continuous, while the world's largest telescope discovers the individual stars within. This made it certain that the estimate of the size of the galaxy that placed its diameter at millions of light years was definitely wrong, but still the size remained in question.

Now Dr. Seares has shown very definitely how large our Galaxy—or our home "spiral nebula"—really is. The method that he has used is one of statistics, rather than actual observations, for with so many myriads of stars as are included in the Galaxy it would obviously be impossible to measure the distances of all of them. Such would be the case even if most of them were not beyond the limits of direct measurements of distance. Statistical methods are accurate when a vast number of objects are considered although they could not be applied to find the distance of a single star.

One respect in which the spiral nebulae vary among themselves, and the way by which Dr. Hubble has classified them, is what is called "resolution." Some of the spirals are practically continuous areas of light, others are subdivided into smaller clusters, or condensations. Both of the spirals that Dr. Hubble studied particularly are thus resolved, so it may be that the condensations are the first signs of breaking up into individual stars.

Perhaps the more continuous nebulae are vast storehouses of the stuff stars are made of, and that after inconceivably great periods of time they may develop into stars. Possibly these stars may have inhabited planets, circling around them!

Dr. Hubble also discovered the distance of the spiral nebulae. This is the way he did it.

In the two nebulae he studied there were numerous members of the class of Cepheid variable stars, of which the Polestar is the most familiar. These are stars which periodically wax and wane, but do so in a peculiar manner, for they brighten suddenly, and then more gradually die out to less brilliancy.

Another thing about the Cepheid variables that astronomers have discovered is that the brighter they are on the average, the more rapidly their light changes. When an astronomer sees a star varying in this peculiar manner, he knows at once that it is a Cepheid. Then he counts the time between successive times of minimum light, and he can tell how bright it actually is. He knows how bright it appears. He knows how bright it is, and he knows how a star seems fainter when farther away. Then he can figure out its distance. This is what Dr. Hubble did with the two brightest, and presumably the nearest, of the spiral nebulae, and found that they were at the tremendous distance of about 900,000 light years. This would be something like fifty-four hundred thousand million million miles. The nearest star in the heavens, except the sun, is only about 4.2 light years, or twenty-five million million miles away, next-door, compared to these nebulae.

Astronomers realized that ours is not the only Galaxy in creation, that, scattered throughout the universe are thousands and thousands of stellar clouds similar to that of which the earth is such an insignificant part. Of all these nebulae, Dr. Seares thinks that it is one of the very highly resolved spirals that our galaxy most resembles. It is divided almost completely into stars, though here and there throughout its confines are gaseous nebulae, or huge clouds of glowing gases. Dr. Seares emphasizes the importance of another resemblance, our presence in a local cluster, smaller than the entire galaxy and similar to the condensations in the spirals. This local cluster is about a tenth of the diameter of the entire system, and some distance away from the center. Though this is much larger in proportion to the size of the complete galaxy than any known condensation in a spiral nebula, it is not impossibly great.

The work of Dr. Seares makes it now possible to picture the sort of a universe in which we live. The earth is part of the solar system, which consists of the sun, and the various planets, large and small, that revolve around it. The earth is about 93 million miles from the sun, and Neptune, the most distant of the known planets, is about two and three-quarter million miles from the sun. Leaving the sun, it is necessary to travel about twenty-five million million miles to reach the nearest star. But this star, and thousands of others around it, forming a cluster some 160 thousand million million miles in diameter, constitute a local cluster—the celestial equivalent of the state, perhaps. Our sun is near the center of this local cluster, only one-eightieth of the distance from the center to its boundary.

This local cluster, however, is some distance from the center of the Galaxy. Start at the center of the Galaxy, and travel a little less than half way to the boundary. Then you would come to the center of the local cluster. There is also, believed Dr. Seares, another condensation of stars at the center of the entire Galaxy. We cannot see it, however, because of the intervening presence of dark matter scattered through the system of stars. In other spiral nebulae, especially those which present to us their edges, this dark matter is seen. Dr. Seares thinks that we see an evidence of it in our own system in the fact that in one place the Milky Way seems to divide into two branches.

So we come to the confines of our celestial "nation," the galaxy. Nine hundred thousand light years, or about 5,400 quadrillion miles from its center is the nearest of its neighboring galaxies. As far as the eye, or the photographic plate, aided by the most powerful telescope, can see, extend these spiral nebulae. Not yet is the end in sight.

Science News-Letter, May 26, 1928

The rose is state flower in four states: New York chose the cultivated rose, Georgia the Cherokee rose, Iowa the wild rose, and North Dakota the wild prairie rose.

It is estimated that if a pair of insects destructive to plants should increase for three years without hindrance there would be around six million of the pests in existence.

Although the Chinese Republic has officially adopted a calendar based on the sun, landlords greatly prefer the old lunar calendar, because once in every three years there is an extra month on which they can collect rent.