



Science News-Letter

The Weekly Summary of Current Science

A Science Service Publication



Edited by **Watson Davis**
Vol. XI No. 306



10¢ a copy \$5 a year
February 19, 1927

ASTRONOMY

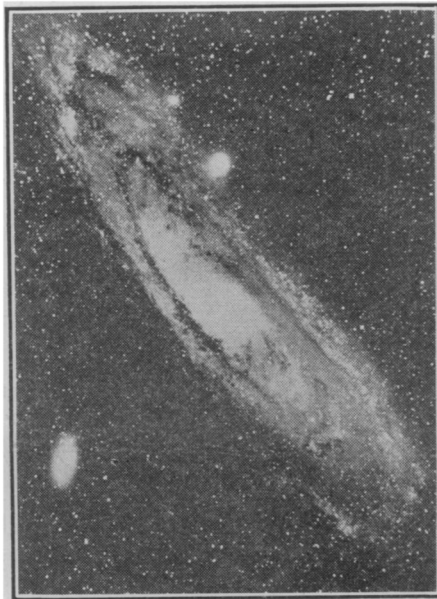
Eye May See Large Part of Whole Universe

By JAMES STOKLEY

Eight hundred and forty million million miles—that is the inconceivably vast distance that the sensitive eye of the most powerful telescope—the great hundred-inch reflector of the Mt. Wilson Observatory—can see. And when a telescope 300 inches in diameter, already planned, is completed, it will be possible to see as far as six thousand million million miles, and to see these vastly distant objects with light that left them a thousand million years ago, when the earth itself was still young, and nearly a thousand million years before the first form of man appeared on the planet.

But not only would such a giant telescope reveal these inconceivably remote objects. It would actually reveal a considerable portion of the whole universe, if modern ideas are correct. It used to be thought that the universe was infinite—that if one could keep on travelling forever, he would never reach any boundary. But the idea of an infinite universe has several objections. For instance, it has been said that if this were the case, no matter which direction one travelled, he would eventually run into a star, and if stars were in all directions, the night sky would be bright.

However, Einstein, with his theory of relativity, offered a solution of the problem with his idea of an infinite, yet boundless, universe. Though this may seem a contradiction in terms, it has been compared to a sphere, on the surface of which some small animal, such as an ant, might travel forever, and never come to any end of the surface. The universe, say the supporters of Einstein, is similarly curved, not as a sphere, but in some fourth dimension of which our limited human faculties are unable to make us aware. But there are means for guessing the size of this super-spherical universe,



GREAT SPIRAL NEBULA IN ANDROMEDA. one of the stellar systems or galaxies like the one of which the sun and Milky Way are part, but outside its limits. This was one of the first of the distant objects studied by Dr. Hubble.

and it is supposed to be about a million million million miles in diameter. If one could travel away from the earth, in what we call a straight line, but which is really curved on the surface of this spherical universe, for something like 3,141,600,000,000,000,000,000 miles, he would then be right back where he started. Or, if he had a telescope that could see this far, he would be able to see the back of his head, or rather his remote ancestors could see it, for the light reflected from his head would travel 520,000,000,000 years before it came back to its starting point!

Such ideas as these represent a far cry from the ancient days when the earth was considered to be at the exact center of everything, and the other day in Washington, Dr. Edwin Hubble, of the Mt. Wilson Observatory, an eminent astronomer who

has himself helped in a large measure to push back the boundary of observation, told of some of these advances.

"The history of astronomy is a history of receding horizons," he said. "Early investigations were concerned almost entirely with the system of the planets. Beyond was the visible boundary of the universe—a spherical shell studded with the fixed stars, at a distance of 80,000,000 miles from the earth. This barrier fell before the assaults of modern science. The stars came to be accepted as far away suns, scattered through the depths of space according to their faintness. Horizons receded as telescopes grew until finally evidence of another boundary began to appear. Dimly seen at first, they accumulated and grew legible until now it is realized that the stars themselves form a definite system, at least 100,000 light years in diameter, but quite isolated in space.

"The study of this, the galactic system, and its constituent stars, has developed with accelerated pace until within the last 30 years it has become the commanding feature of astronomical research. The study of the planetary system, although still fruitful and fascinating, has lost its unrivalled position in the new perspective.

"The methods first used for investigating the galactic system were those developed in the study of the planetary system. The astronomy of position, however, has outlived much of its first urgent necessity and has been largely replaced by the new and more powerful methods of astrophysics. These were calibrated by the older methods, but once established, they have pushed out into regions far beyond the reach of the micrometer.

"These points have their analogies in the latest phase of astronomy. For history is repeating itself. Once the limited nature of the galactic system

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CLASS STUDY HELPS

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 Biology—111, 115, 117, 121, 123
 Chemistry—111, 119
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Sees Part of Universe

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was realized, the question immediately arose as to space beyond the Milky Way. Speculation flourished. Assuming the uniformity of nature, men supposed that, scattered through space, there must be numberless other systems of the same order as our own. Unresolved nebulae were seized upon as visible evidence; the grand vague theory of island universes was launched upon its career. Controversies naturally arose, but the arguments on both sides were largely speculative. The observational data, scanty and indecisive at best, were interpreted to suit the occasion.

"Meanwhile the empirical study of nebulae progressed. The galactic star clusters, all resolved by the larger telescopes, were weeded out, and around them grew up a separate department of research. Among the unresolved objects, the diffuse nebulae and the planetaries were recognized as constituent members of the galactic system—clouds of dust and gas mingled with the stars. The controversy simmered down to the question of the spirals and other small symmetrical bodies which inhabit the regions of high galactic latitudes. Were these nebulae galactic or extra-galactic?"

Dr. Hubble himself has supplied the answer to this problem, for his photographs made with the great Mt. Wilson reflecting telescope, have at least revealed that these spiral nebulae actually are systems of stars like our own galaxy, but outside its boundaries. For the first time, these photographs revealed some of the actual stars of which they consist—not all the stars in them, it is true, for only the largest and brightest, the giants, as astronomers call them, will make their presence known. But they were stars just the same as those of the galaxy, their images on the plates were just as sharp and small, their colors showed

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News-Letter Features

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SCIENCE NEWS-LETTER, The Weekly Summary of Current Science. Published by Science Service, Inc., the Institution for the Popularization of Science organized under the auspices of the National Academy of Sciences, the National Research Council and the American Association for the Advancement of Science.

Publication Office, 1918 Harford Ave., Baltimore, Md. Editorial and Executive Office, 21st and B Sts., N. W., Washington, D. C. Address all communications to Washington, D. C.

Entered as second class matter October 1, 1926, at the postoffice at Baltimore, Md., under the act of March 3, 1879. Established in mimeograph form March 13, 1922.

Subscription rate—\$5.00 a year postpaid. 10 cents a copy. Ten or more copies to same address, 6 cents a copy. Special reduced subscription rates are available to members of the American Association for the Advancement of Science.

Advertising rates furnished on application.

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Sees Part of Universe

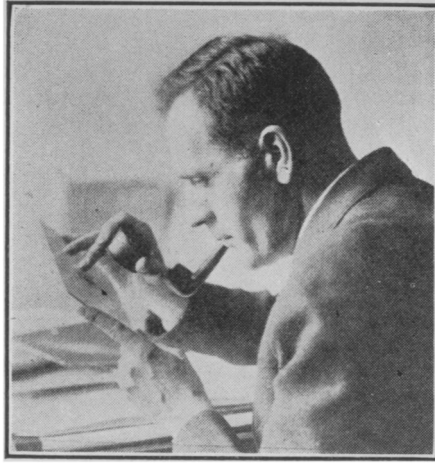
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the same range, some varied in light, while some novae, or "new stars" were found. "On the whole," said Dr. Hubble, "there is not the slightest reason to suppose them different from galactic stars.

"The importance of this conclusion lay in the fact that it permitted the application of the powerful methods of stellar research perfected in the study of the galactic system itself. Stars are familiar objects and may safely be assumed to exhibit the same general characteristics wherever they are found. This assumption, moreover, is supported by the consistency of an ever increasing mass of observational data and is of an entirely different nature from that involved in a mere speculation."

But such methods as these do not reach the limit. By studying the stars in the nebulae, astronomers can reach out as far as five million light years—or about thirty million million miles. Light travels at a speed of about 186,000 miles in a second, and the distance that it will go in a year, about six million million miles, is a light year, one of the astronomer's units of measurement.

"For the further exploration of space," Dr. Hubble continued, "it has been necessary to develop new methods, applicable to nebulae in general. The extra-galactic nebulae form a homogenous group in which numbers increase rapidly with diminishing apparent size and brightness. Four are visible to the naked eye; 49 are found on the Harvard sky maps; 300,000 are estimated to be within the limits of a photograph with an hour's exposure through a 60-inch reflecting telescope. The progression indicates a wide range in distance or in absolute dimensions and it is necessary to disentangle these factors before venturing further on the study of cosmography. The objects are so varied and so numerous that statistical methods are required in order to make certain that the conclusions will be based upon normal nebulae and not upon exceptional cases. The first step, therefore, has been the investigation of a list of several hundred nebulae which is complete for the brighter objects and thoroughly representative for the fainter, down to a definite limiting luminosity. The investigations were necessarily restricted to data which could be derived from simple photographs—the forms of the images, the angular



DR. EDWIN HUBBLE, astronomer of the Mt. Wilson Observatory whose observations of spiral nebulae have revealed stellar systems by light that left them 140 million years ago.

diameters and the apparent brightness. These were sufficient to establish surprisingly simple and general relations, which could be calibrated with the absolute data known for our nearer neighbors.

"In observing the most distant nebulae, we are witnessing scenes and events which actually happened in past ages. Recent history is on its way travelling with the speed of light but only a daring prophet would expect man to be still on earth to receive it. In a very real sense, then, extra-galactic nebulae can be classified in a geological time-scale. The nearest of them all, the Magellanic Clouds, are photographed in the light that left them more than 100,000 years ago. We see them as they actually were, say in the third interglacial epoch. No other nebulae can be referred to the Pleistocene period in the earth's history. The conspicuous spirals belong to the Pliocene period and stars can probably be detected as far back as the Miocene. Nebulae of the twelfth magnitude are perhaps Oligocene objects and those at the limit of the counts, representing an hour's exposure on fast plates with the 60-inch reflector at Mt. Wilson, are Cretaceous.

"Unless the density law breaks suddenly just at the limit of the 60-inch reflector, the 100-inch should reveal most of the two million or so nebulae which are within 140 million light years of our system.

"A sphere of this radius represents the observable region of space. In time, it goes back to the Carboniferous. Exceptionally bright objects could be detected at still greater distances, but normal nebulae must await faster plates and larger telescopes.

Within this sphere the average distance between nebulae is of the order of 1,800,000 light years, although in the clusters it may be a tenth and less of this amount. The mean density of space is of the order of one nebulae in 3,700,000 million million cubic light years.

"Beyond the observable regions of space are the legitimate realms of speculation. The principle of the uniformity of nature appears to operate as far as telescopes can reach. The great discontinuity is at the borders of our own stellar system. Once that is bridged, no other is encountered within range of existing instruments. The ultimate barriers therefore are of a mechanical nature and it will be possible to push them back to several times their present distances. Meanwhile we can rely on the principle of uniformity and suppose that beyond the barriers, for a while at least, space is much the same as within the known region. This, however, cannot continue indefinitely. In the absence of internebular absorption, a uniform distribution of equally luminous nebulae would eventually produce a luminous background to the sky. No such phenomenon is observed. Moreover, it is well known that Newton's law of gravity cannot be reconciled with an infinite universe unless the latter is constructed in a very special manner.

"The general theory of relativity, however, avoids both of these difficulties by postulating a universe which is finite, although boundless.

"The total apparent luminosity of this universe of nebulae, as seen from the earth, would be somewhat less than that of the stars in the galactic system. Hence, the difficulty of a luminous background is avoided.

"The range of the 100-inch reflector for normal nebulae is about one twelve-hundredth of the diameter, hence even now we are observing an appreciable fraction of the Einstein universe. With larger telescopes and faster plates, such as are believed to be thoroughly practical, exceptionally bright nebulae might be detected at distances of the order of a twentieth of the diameter—might be photographed with light which started on its journey a thousand million years ago when the earth itself was young.

"But such speculations concern things beyond the horizon. A veil of obscurity divides them from the realm of the known and while vague shadows are sometimes glimpsed, it is

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Sees Part of Universe

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difficult to tell from which side of the veil they are cast. These dim shapes will always hover along the last horizon, stirring the imagination, beckoning the searchers to new and far adventure. None who follow the call may win to the ultimate goal, but slowly through the ages, their reports are accumulating. And slowly there is emerging a definite conception of the nearer regions of the universe in which we live and think and dream."

Science News-Letter, February 19, 1927

Concrete is now sprayed on building surfaces.

An omelet from an ostrich egg will feed eight persons.

Sacred bulls in Egypt were mummified and buried with great ceremonies after death.

In Roman days, the crater of Vesuvius was a favored hiding place for escaped slaves and brigands.

More than 1,000,000 ounces of silver are recovered from waste film and photographic solutions in a year.

Hawaiian soil is entirely volcanic lava.

The bald eagle is not bald, but has a white head.

A discovery of iron ore in the Italian Alps has been reported.

Germany is trying iron carbonyl as an anti-knock compound for gasoline.

Builders say that 63 per cent of the cost of a house is spent in putting the parts together.

"Bootleg" seeds of an inferior grade, mislabeled, have been causing trouble to farmers of some states.

More than 25,000 children in Georgia have been immunized against diphtheria in the past two months.

An Arizona canyon where Indians once held their ceremonies is to be made into a stadium seating 25,000 people.

Descendants from one pair of meadow mice, if all lived and bred, would number over a million mice at the end of a year.

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