ASTRONOMY

Yardstick of the Solar System

By JAMES STOKLEY

Astronomers Are Busy Photographing Eros, The Tiny Planet, Now on Its Nearest Approach to The Earth

DURING the year that is now closthe solar system has gotten somewhat more than its normal share of astronomical attention. The discovery of a new major planet was an event that had happened only twice before in astronomical history, and so, when Pluto was found by the Lowell Observatory in Arizona, the year 1930 promptly went down as an important one. In the last few months, Pluto has again come into view, after disappearing in the glare of the sun during the summer. It is traveling close to the path that was calculated for it last spring, after photographs made of it as early as 1919 had been found. These gave observations sufficiently widely separated in time to make an accurate orbit possible. Despite some questions at first by a few skeptics, Pluto has now taken its place as a respectable, though rather small, member of the solar system.

But even if Pluto is smaller than the earth, which is probably the case, it is still larger than any of the asteroids—the tiny planets that revolve in orbits mostly between the paths of Jupiter and Mars. More than a thousand are known, but most are of little importance. To be sure, they must be observed and track must be kept of them. Even so, one occasionally gets lost, and then may turn up again as a new discovery.

Just now, however, one asteroid is coming in for much more than its usual share of attention. This is Eros, a tiny object probably about fifteen miles in diameter, as compared with 8000 miles for the diameter of the earth and 2000 for the moon. But this winter Eros will come within 16,200,000 miles of the earth, closer than any permanent celestial object except the moon, and about a fifth of the distance of the sun. Then it will help astronomers tell how far the sun is from the earth, and how many tons of material is contained in the earth and the moon.

It is fairly easy to tell the relative distances in the solar system, to find, for example, that Jupiter is 5.203 times as far from the sun as the earth, or that Mercury is only 387 times as far. But to tell these distances in miles is a different matter. However, if one distance in the solar system can be obtained with precision, then, the proportions being known, the rest can be calculated.

The fundamental method of measuring actual, rather than relative, distance, is by what is known as parallax. Think of the moon when it is full, then it is directly opposite the sun. The sun is setting, and the moon rising, in Washington, so in Singapore, on the opposite side of the earth, it is now sunrise and moonset. Two astronomers, one in Washington and another in Singapore, photograph the moon through their telescopes, and determine its position among the stars. But the two astronomers are on opposite sides of the earth, so they are separated by nearly 8000 miles, the earth's diameter.

Finding the Moon's Parallax

The moon is about 240,000 miles from the earth, so if you could draw a triangle between the two observers and the center of the moon, its sides would be about 240,000 miles long, and the base 8000 miles. The angle at the tip would be about two degrees, or about four times the moon's apparent diameter in the sky. The stars beyond are practically at infinite distance, and so if the two astronomers took their photographs of the moon at the same instant and then compared them, they would find that in each, the moon obscured different stars. The photograph made at Singapore would show the moon displaced among the stars about four times its own diameter to the west from its position in the Washington plates. Of course the same thing would be true of photographs made at either one of the cities 12 hours apart, for then the earth would have turned the place from one position to another 8,000 miles away. But then, the motion of the moon among the stars would introduce another displacement, which would have to be considered.

Now suppose two such photographs are made, and on them we measure the displacement, which gives us the angle at the vertex of the long triangle to the moon. We know the diameter of the earth, so we can figure out the length of the sides of the triangle. They come out around 240,000 miles, so in this way the distance of the moon can be determined. The greater the displacement, the closer the object measured. The moon is so close, and the displacement, or parallax, as it is called, is so large that the measurement is easy. But the moon is so closely associated with the earth that it is necessary to measure the distance of one of the planets, or the sun. These are much farther away, the parallax is much smaller. The brilliance of the sun and its size make accurate measurements of it rather troublesome. Even a planet like Mars presents difficulties.

Now that Eros is coming close, it provides a convenient object to measure. It approaches so close that its parallax is fairly large, and it is so small that even then it appears as a star-like point of light. Incidentally, it is the fact that these objects appear as mere points of light that has given them their name, for "asteroid" is simply the Latin for "star-like." This name was suggested by the famous English astronomer, Sir William Herschel.

Because of its star-like character, photographs of Eros among the stars can be measured with great accuracy. Eye observations through telescopes to determine its position are also easy. Therefore astronomers throughout the world are now busily engaged in photographing it and measuring it, in almost every conceivable manner. No doubt many of these measurements are unnecessary, but it will be many, many years before it again comes as close. Therefore the astronomers are not taking any chances, but are doing everything they can with it.

After next spring, when the planet has passed from view, the work on these observations will commence. Then its parallax can be determined with high accuracy, and with this definite measuring rod, the other distances in the solar systems can be measured more precisely. And since it is the distance

from the earth to the sun that provides the base line for the minute parallaxes of the stars, their measurements also will be made more accurate.

Besides the distance of the members of the solar system, Eros will also help tell us the mass, or number of tons of material, in the earth and moon. The path of Eros is calculated, as it would move in space if our planet and satellite were not present. But Eros comes so close that the gravitational attraction of the earth and moon pull it out of its normal path, and from the amount of this deviation the mass of the earth-moon system can be found. With the moon constantly moving around the earth, the relative positions of the three bodies change, and the mass of the moon alone can be found. The difference is the mass of the earth.

Asteroids Filled Gap

In addition to all this, Eros is of interest in itself. Though many of the asteroids are of little importance, Eros, which marks the limits of the system, is important, and from its study we can doubtless learn much about these little planets.

The discovery of the asteroids and their subsequent history is a fascinating one. In the seventeenth century, Johann Kepler noticed that the gap between Mars and Jupiter was larger than between any of the other planets then known. Then, in 1772, what is now known as Bode's law was enunciated, giving the approximate relations between the distances of the planets. This also indicated that there was a missing planet between Mars and Jupiter. Nine years later, Herschel discovered the planet Uranus, and its distance corresponded so closely to Bode's law that it seemed more certain than ever that there was a missing planet.

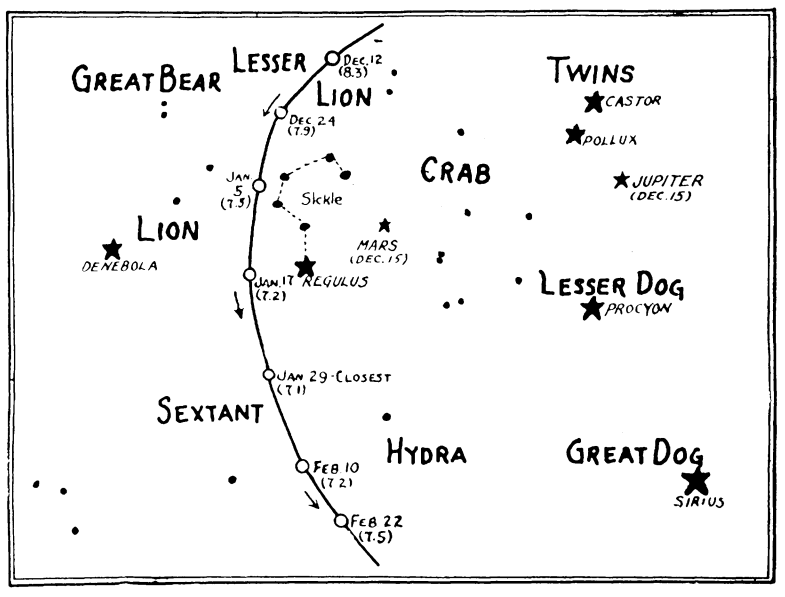
On the opening night of the nineteenth century, January 1, 1801, the Italian astronomer Giuseppe Piazzi was at work in his observatory in Sicily. He noticed what seemed to be a star in a place where he knew there had been no stars a few days before. He observed the strange "star" for several days, and each night it had moved a little, so it was obviously a planet. In honor of the tutelary goddess of Sicily he named it Ceres, and continued to observe it for several weeks, when he was taken ill. Upon his recovery, the planet had disappeared in the glare of the sun, and was apparently lost, for he did not have enough observations of it to calculate its path by the methods then in use. The German mathematical astronomer, Karl Friedrich Gauss, came to the rescue, and proceeded to invent a method of finding the orbit from only three observations, and with the method he calculated the path of Ceres. As a result the planet was picked up again in the autumn of 1801, and has never been lost since. Several other asteroids were discovered in the next few years. In recent years the photographic telescope has been used to search for them and now about 1,500 are known. Therefore it has been something of a problem to name them. The mythology of all nations has been exhausted, and cities, universities, lady friends, pets, and even favorite desserts have been perpetuated as asteroids.

Eros was discovered, in August 1898, by an astronomer named Witt, in Berlin. When its orbit was calculated it was found that sometimes it is as far as 165,630,000 miles from the earth, but at one place its orbit comes within 13,840,000 miles of the orbit of the earth, about half the least distance of Venus from us. This is the part of the earth's orbit that we occupy about January 22. The asteroid revolves around the sun once in 643¼ days, nearly 1¾ years, but the earth itself is moving also. Therefore, every 845 days, about 2⅓ years, Eros and the earth are the same direction from the sun, or in opposition. Mostly this happens at some time of the year other than January 22, but once in a long interval it occurs near this date, and then the earth and the asteroid are very close. Unfortunately, one of the closest oppositions occurred in 1894, before it was discovered. In 1901, it came within 30,000,000 miles, and was then widely observed, but this year it is even closer. At the end of January it will be only 16,200,000 miles from us.

Invisible to Naked Eye

Even when brightest, Eros is a little too faint to be seen with the naked eye. Only one asteroid, Vesta, the fourth to be discovered, ever becomes bright enough to be seen without some telescopic aid. The accompanying diagram shows the path of Eros during December, January and February. The numbers in parentheses under the dates give the magnitudes. Now it is getting into the constellation of Leo Minor, the lesser lion, which is overhead at this time of year about 4.30 A. M. Then it will move into the neighboring constellation of Leo, the lion, passing close to the familiar sickle. At the end of January it reaches the rather faint group of Sextans, the sextant, and then passes down into the more southerly constellations, so that it will be out of sight of northern observatories, but well placed for the great telescopes in South Africa. When brightest, it will be visible with such slight optical aid as a good pair of binoculars, but even then it will be hard to find unless you know exactly where to look for it, and even when you see it, it will not be more exciting than a faint star.

Though Eros will not come into naked-eye promi- (*Turn to page* 364)



THE PATH OF EROS DURING THE COMING MONTHS

Eros, the most important of 1500 asteroids, will soon be only 16,200,000 miles from the earth, ready to check the distance to the sun and to tell the mass of the earth and the moon.

Yardstick Of The Solar System

(*Concluded from Page 359*)

nence, two of the major planets are now decorating the evening sky. Look to the eastern sky this evening. High above is Capella, in Auriga, the charioteer. Below him the two stars Castor and Pollux, mark the twins, Gemini. Pollux is the lower and brighter, Castor is just above it. Almost directly east is Procyon, in Canis Minor, the little dog. These are all stars, with the typical scintillating light. But near the twins, in the direction towards Procyon, is a much brighter object of steady brilliance. This is the planet Jupiter. Below it, and a little to the north, is another planet, identified by its steady red light, though it is not as brilliant as Jupiter. This is Mars. Earlier in the evening, if you look to the southwest just after sunset, you will see Saturn, near the horizon in the gathering dusk. And about the twentieth of the month, for a few days before and after, Mercury will be nearby. But both of these planets are now so near the sun that they will be rather difficult to locate.

Nine first magnitude stars are now visible in the evening, all of which are shown on the semi-circular maps. Capella, high in the east, has already been mentioned. In the southeast is the famous group of Orion, the heavenly warrior, with the three stars in a row marking his belt. The bright star above the belt is Betelgeuse, the one below is Rigel. Low in the east is Procyon, in the little dog, Canis Minor. Sirius, the dog star, in Canis Major, the large dog, is just below the horizon as shown in the maps, and is visible in the southeast a little later in the evening. It is the brightest of all the stars. Aldebaran, red in color, marks the eye of the Bull, Taurus, high in the southeast, above Orion. Pollux, the brighter of the two twins, Gemini, has also been mentioned. It is in the eastern sky. In the west, now standing upright, is the northern cross, Cygnus, the swan, with Deneb at the top. Below it is Vega, in Lyra, the lyre, and still lower, near the horizon, is Altair, of Aquila, the eagle.

During December the moon is full on the fifth, when it rises in the east as the sun sets in the west. On the twelfth it is in last quarter. Then it rises at midnight. On the nineteenth it is new, directly in line with the sun, and a few nights afterwards will appear as a narrow crescent in the western sky. It reaches first quarter on the twenty-seventh. Then it is directly south at sunset, and around this time is conspicuous all evening.

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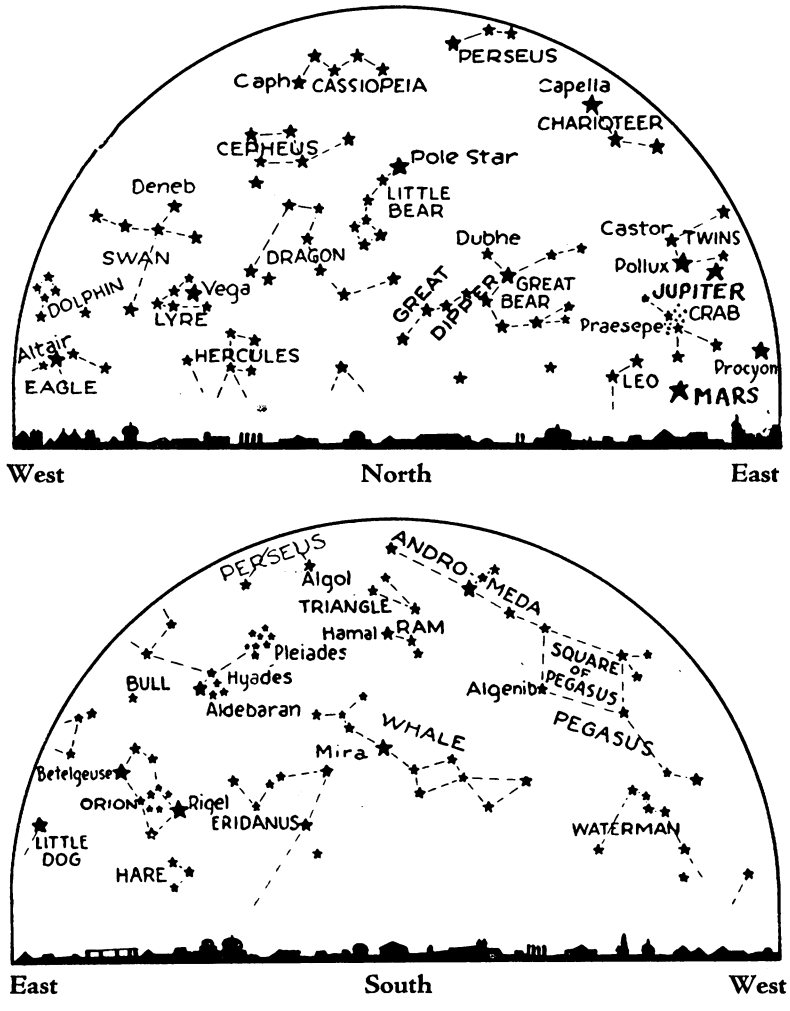

THE HEAVENS IN DECEMBER

Hopes of more caracul coats from American sheep are contained in the annual report of the Bureau of Animal Industry of the U. S. Department of Agriculture.

There are only a few Karakul flocks in this country but recent investigation by the bureau indicate that satisfactory pelts may be obtained by grading up Corriedale and Blackfaced Highland ewes with purebred Karakul rams. This discovery is good news for the women folk with whom caracul is a favorite fur.