Galaxy

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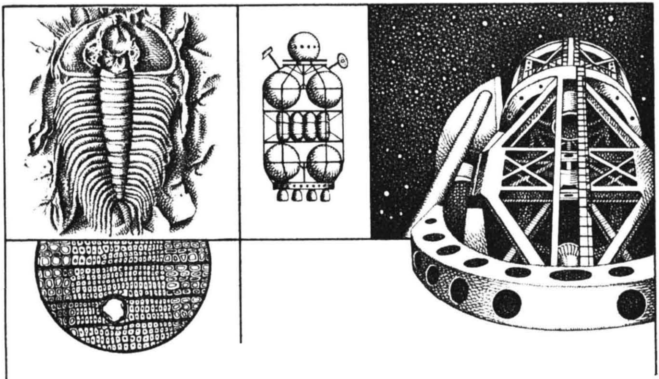
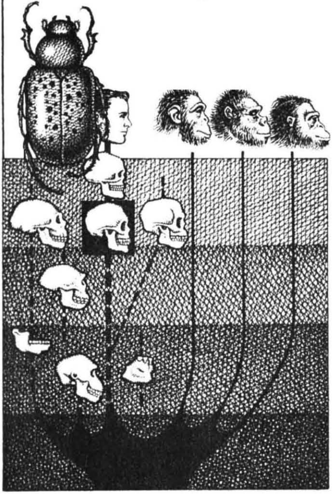
SCIENCE FICTION



for your information

By **WILLY LEY**

THE OTHER SIDE OF THE MOON



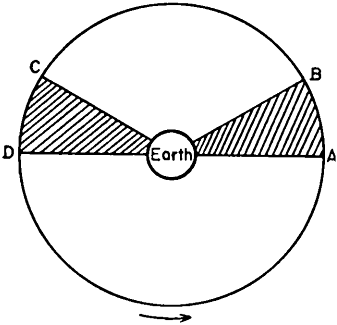
THE FULL Moon is hanging brightly over the Atlantic Ocean off the New Jersey shore and from this fact I derive for myself the right to reminisce a little. About thirty-five years ago — I was still in high school at the time — there was an astronomical exhibition in the old Urania Observatory in Berlin, the same observatory where the planetoid Eros had been tracked down. One of the items on display was a model of the Moon, some sixteen inches in diameter, made in years of painstaking work by a retired teacher. A white-haired gentleman in his seventies was talking to him and when he left, somebody said to me: "This gentleman still knew Professor Hansen."

This would have been more instructive by far if I had known at the time who Professor Hansen had been, but the name stuck in my mind and in due course I found out.

Peter Andreas Hansen, to use his full name, had been the author of a theory concerning the Moon. It was easily the most spectacular idea about the Moon anybody has ever had and it is almost sad that he was wrong. If Hansen had been right, science fiction authors would have a very nearly inexhaustible theme to play with and the first exploratory round-the-Moon ships would really have something to watch for and photograph.

THE WESTERN world began to realize that the Moon is an independent solid body in space at about the time of Christ. What people thought before that time is only imperfectly known; my guess is that most of them managed to do without any specific ideas.

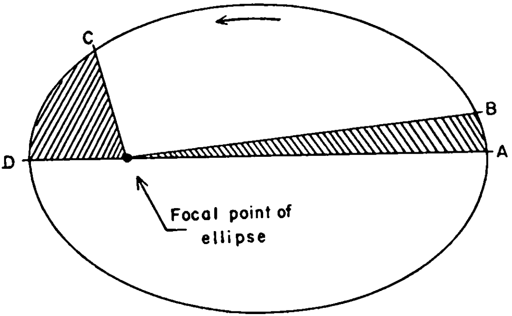
Pliny the Elder mentioned in his famous *Natural History* that



"the ancients" thought the Moon was a round silver shield in the sky. But there was disagreement about the nature of the spots that could be so clearly seen. One unknown philosopher declared that they were just dirt, atmospheric vapors which had condensed on the shiny silver. Another equally unknown philosopher held that no vapors had sullied the splendor of the heavenly disk, but that the spots one could see were reflections of the continents and seas of the Earth below.

One might study the geography of the Earth by looking at the Moon. The really difficult problem was to find out where the observer himself was located in this reflection.

Another early idea is embodied in a Hindu legend. According to it, the Moon was the round face of a lantern carried by a gigan-



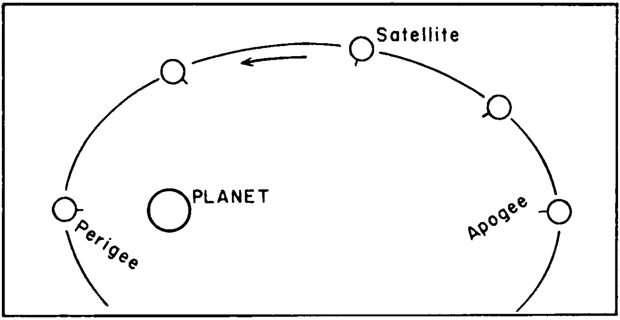
Kepler's Second Law. The areas swept over the *radius* vector must be equal for equal times. In a circular orbit P. 45, the angles would be equal, too. In an elliptical orbit (right), they are decidely unequal

tic (and invisible) Heavenly Watchman.

In the classical West, as I have mentioned, the Moon was recognized as a "second Earth" some two thousand years ago. It was understood that the Moon was considerably smaller than Earth, but this was taken to be the main or even the only dissimilarity. Like the Earth, it indubitably had continents and seas, mountains and valleys, rivers and forests. These ideas are still reflected in the astronoomical names for some of the lunar features. The largest of the dark blotches is still called *Oceanus procellarum*, the Ocean of Storms. Another feature is still spoken of as the *Sinus iridum*, the Rainbow Bay, and another section is labeled *Palus nebularum*, the Misty Swamp.

When Galileo Galilei looked at the Moon, he still thought he saw seas and continents, but it needed only slight improvements of the early telescopes to realize that the "seas" could not be seas. And familiarity with the surface of the Moon quickly convinced the observer that he could always see everything there was to be seen, that his vision was never obscured by lunar cloud patches. The astronomers of the first half of the seventeenth century might not yet be able to make up their minds on whether there was an atmosphere on the Moon or not, but they could tell that it was a cloudless atmosphere.

Later in the same century, the case was already decided. The



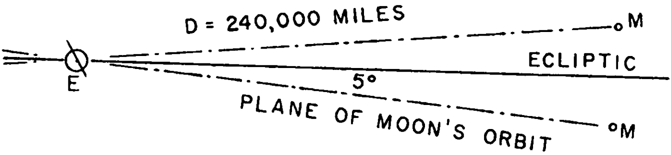
How an elliptical orbit causes "libration"

Dutch astronomer and mathematician Christian Huyghens, who died in 1695, stated it categorically in his book *Cosmotheoros*: "on the Moon, there are no seas, no rivers, nor clouds, nor air and water." The same book, incidentally, contains the statement that the moons of Jupiter and of Saturn always turn the same side to their planets, just as our moon does with us.

FOR A layman, Huyghens' verdict may well have dispelled whatever interest he had had in the Moon before. As far as astronomers were concerned, their work was just beginning. The first and most obvious and incidentally rather tedious job was a complete mapping of the visible hemisphere. If any changes should take place on the lunar surface, one had to have a detailed map to recognize them.

While they were at it, astronomers began to realize that our moon is extraordinary in size. The Earth-Moon system is *almost* a double planet, something we know to be theoretically possible, even though our own solar system happens not to offer an example. True, our moon is not the largest satellite in the Solar System. Its diameter of 2160 miles is surpassed by three of the four large moons of Jupiter (namely by Io, Ganymede and Callisto), by Titan, the largest of Saturn's moons, and by Triton, the larger of the two known moons of Neptune.

But while Triton has a diameter of around 3000 miles, the diameter of its planet is 26,800 miles. Earth's diameter is a little over 7900 miles, so that the diameter of our moon is, in round



The extreme positions above and below the ecliptic the Moon can assume, permitting a look over its poles

figures, one-quarter of the diameter of the planet to which it belongs. Still, the Earth-Moon system is not quite a double planet because the common center of gravity of the system is still inside the body of the Earth, about 1000 miles below the surface.

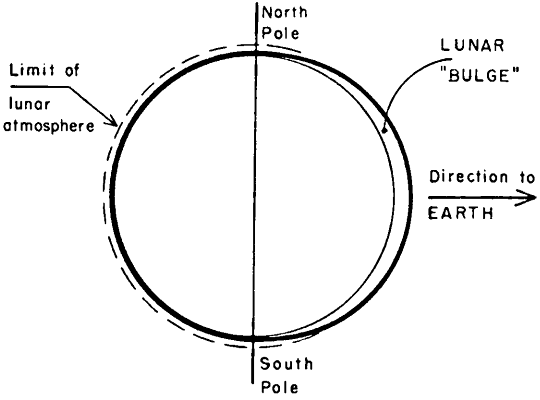
Although nobody ever experienced any trouble locating the Moon in the sky, provided it was visible at all, the calculation of the Moon's orbit happens to be a very difficult job. One might say that any perturbation of its movement that is possible at all actually does take place. For quite some time, astronomers looked for some unknown factor influencing the Moon's movement. And this is the point where Professor Peter Andreas Hansen entered the picture.

Hansen had been born in Denmark exactly one hundred years after Huyghens died in Holland. Before he became an astronomer, he had been an instrument maker, but he became involved in an astronomical venture — the measuring of a meridian. He was working at Altona Observatory then, but only a few years later, in 1825, he was offered the position as director of the Seeberg Observatory.

Hansen's special interest was the computation of orbits and he was fascinated by the perturbations of orbits. Small wonder that he tackled the problem of the orbit of the Moon. While working at it, he thought one day that he had spotted that unknown factor other astronomers had been talking about. Much could be explained if one assumed that the Moon was not a perfect sphere.

OF COURSE many planets are not perfect spheres. Everybody knows that the Earth has a rather marked equatorial bulge. And Jupiter's equatorial bulge is so enormous that it can be seen with even a small telescope. But this is not what Hansen meant when he said that the Moon was not a perfect sphere.

He did not think of equatorial



The shape of the Moon according to Hansen's theory

bulges and flattened poles. The idea was rather that the Moon was slightly egg-shaped, that it had two equatorial diameters, one when measured from rim to rim of the visible disk and another and larger one when measured from the center of the visible disk to the center of the hemisphere, which is invisible from Earth.

Instead of having an equatorial bulge all around the equator, like a quickly rotating planet, the Moon, in Hansen's opinion, had a large equatorial bulge in only one spot, something like an enormous high plateau, large enough to accommodate whole mountain chains and deep valleys. The center of this enormous bulge was supposed to coincide with the center of the visible disk of the Moon. In fact, all we could see from Earth was just this bulge, for the Moon's longer equatorial diameter was lined up with the common center of gravity of the Earth-Moon system.

If this was true, it not only explained the observed peculiarities in the Moon's orbital motion; it also shed an entirely new light on everything else that had been observed. If the visible lunar disk was an enormous mountainous plateau, lifted to stratospheric heights, the observed absence of air and of water was only the logical result of such elevation. There was no observable air because the plateau was above the denser layers of the Moon's atmosphere. And there could be no water because it had run off the bulge thousands or millions of years ago.

It followed that no observation that had been made could be applied to the unknown hemisphere of the Moon. The most thorough knowledge of the Sahara Desert does not enable you to construct a picture of India or of Mexico just because they lie in the same latitudes. The Moon's other hemisphere probably did have an atmosphere and probably did have water. And where there are air and water, there are probably plants. And where there are plants, the presence of animals can be predicted with a fair chance of being right, because animal life is parasitic on plant life.

Nor did you have to stop along this chain of reasoning at this point. If there are animals, some of them will start preying on other animals after a while and become carnivorous. And some of them might become intelligent in time and represent what older poets had called the "selenites," the inhabitants of the Moon.

HANSEN'S colleagues listened with much respect because he was a deservedly famous astronomer. They listened with the greatest of interest, too, because it was a fascinating and novel idea. The next problem was to find out whether it was also true. Continued observation was still the means of doing it because nature had provided some help in the form of the phenomenon of libration.

I feel that I should digress from the main theme at this point for a fuller explanation of this phenomenon which, as I know from correspondence I receive from readers, is not well understood by many. As is generally known, the Moon turns around its axis in the same number of days and hours as it needs to go around the Earth once. It is as if you had a man walking around you in a circle, looking rigidly in the direction in which he is walking. That way, he turns around his own axis once every time he circles you and all you can observe is his left profile, with his left ear roughly in the center of what you can see of his head.

Well, if this is the case, what is libration and how does it enter into the picture? The proper answer is that it is caused by the fact that the Moon does not move around the Earth in a circle but on an elliptical orbit.

To explain this, let us first see what the Moon does *not* do (Fig. 1). Namely, it does not move around the Earth in a circle. Such a circular path is shown on the left in the diagram. If the Moon did move in a circular path, it would need precisely the same time to go from A to B as it would need to go from C to D. In reality, the orbit is elliptical, as shown with great exaggeration on the right in the diagram. Again it needs as much time to go from A to B as it does to go from C to D.

The sections of the orbit traveled are of markedly different length; what counts is that the shaded areas formed by the lines from the center of the Moon to the common center of gravity are equal. Technically, such a line from center to center is known as the *radius vector* and Kepler's Second Law states that the *radius vector* must sweep over equal areas in equal times.

When the Moon is closest to the Earth — in perigee, as it is called — it moves faster than when it is farthest away, or in apogee. Logically, then, since the areas covered by the *radius vector* have to be equal for equal times, the portions of the orbit traversed cannot be of equal length. The customary statement that the average velocity of the Moon is 0.65 miles per second is, of course, true, but the word "average" must not be overlooked. Actually, the Moon is faster than that in perigee and slower in apogee.

Before going on to the next step of the explanation, let me give the actual figures: The farthest apogee possible is 252,710 miles; the nearest possible perigee is 221,463 miles, both measured from the center of the Earth to the center of the Moon. The surface-to-surface distance is, of course, 5000 miles less.

KEEPING in mind that the velocity of the Moon along its orbit is *not* uniform, we only have to realize that the rate of rotation around its axis *must* be uniform to see what happens (Fig. 2). Both at apogee and at perigee, the same spot on the Moon — marked by a short line — forms the center of the visible disk.

But this spot is not in the center at intermediate positions. One might say that the rotation of the Moon lags somewhat behind its orbital motion for one-half of the orbit and is somewhat ahead of it for the other half. And if the spot which is in the center at apogee, and perigee is off center in between, it is obvious that a portion of what was visible, say, in apogee disappears from view over the left rim, while another previously invisible portion comes into view over the right rim.

This is part of what is called libration. The other part is caused by the fact that the Moon's orbit is slightly tilted as compared to the orbit of the Earth around the Sun, the ecliptic (Fig. 3). Depending on the position at the moment, we can sometimes peep over the lunar north pole into the area beyond, and sometimes over the lunar south pole.

The overall result is that, in the course of a number of years, we can see and map a total of 59 per cent of the lunar surface. Only 41 per cent of it is completely unknown and will remain so until the films taken by the first circumlunar rocket come out of the developer.

But a total of 59 per cent was enough to disprove Hansen's intriguing idea. If he had been right, we should have caught an occasional glimpse of the "lowlands," especially when looking over the poles. Moreover, at periods of maximum libration, the unusual shape of the Moon should be apparent to some degree to direct vision.

AFTER two decades of intensive research — much of it carried out by Simon Newcomb in Washington — all astronomers were agreed that Hansen's assumption did not conform with reality. Since the whole episode had taken place at a time when science fiction novels were few and far between, Professor Hansen's egg-shaped Moon was not exploited literarily.

With just one exception, that is, but this exception was written in Polish. It appeared decades after the idea had been abandoned in science, namely, half a century ago.

Its title was *On Silvery Plains* and the name of its author was Jerczy von Zulawsky. In the story, two or three ships, carrying cabins that can be used like automobiles, land near the center of the visible hemisphere of the Moon and then start the long trek "downhill" to the jungle of the lowlands. Near the end of his life, the leader of the expedition goes back in one of the automobile cabins to the place of the original landing where a mortar has been left behind to shoot the expedition's report back to Earth. The novel, of course, was supposed to be this report.

Since I last read the book in about 1928, I may have forgotten some details, but it seems to me that Hansen's name was not mentioned in it. Jerczy von Zulawsky probably never saw the original papers but received his inspiration from a second or third hand popular account in a general magazine or newspaper supplement.

Well, how *does* the other side of the Moon look?

The answer is: probably not

very different from the side we can see from Earth. What appears at the rim when the libration is favorable are the same types of formations so well known to astronomers. There are a number of craters, some of them quite large, a mountain range or two, and the edges of some *mare* plains.

Interestingly enough, we know the approximate locations of at least three craters that are deeply hidden in the inaccessible 41 per cent of the lunar surface. These craters have systems of "rays" as we know them from Tycho and Copernicus on the visible hemisphere.

On "our" side, all "ray" systems originate from large craters and the "rays" themselves are great circle lines. It is comparatively unimportant in this connection that we don't know the nature of the "rays" and have no idea of why some craters have them and others do not. What is important is that the "rays" from beyond the rim indicate the existence and locations of several large craters.

Some British astronomers have postulated that the unknown hemisphere may differ in degree from the known hemisphere, even though they must be fundamentally alike. They think that the unknown hemisphere contains a lesser number of craters and consists mostly of large *mare* plains. This reasoning is built, however, upon a foundation of hypotheses which, at the moment, are beyond either proof or disproof.

The only suggestion one can make here is to have patience. In about 20 years, if not earlier, we'll be able to look at films and see what the other side *actually* looks like.

SIC TRANSIT

As A result of the discussion of the "transits" of Venus across the Sun's disk, I received a number of letters from readers who wanted to know a lot of things I had failed to mention since, after all, my article did not concern transits specifically. The questions ranged all the way from requests for a table of Venus transits to inquiries about rules for transits of Mercury.

Because Mercury moves around the Sun in a much shorter time than Venus, a Mercury transit is a much more frequent phenomenon than a Venus transit. It can occur only in May and in November and the number of years between one transit and the next follows the sequence 13 — 7 — 10 — 3 — 10 — 3, a total of 46 years. The cycle then repeats.

Table I shows the transits which took place or will take place during the 19th and 20th centuries, with an additional entry for the next century because the last transit of the 20th century will be a mere grazing of the Sun's limb — almost a near miss, so to speak.

As regards Venus transits, they are listed on Table II and because they are so rare, we can cover a time interval of several centuries. Taking further strides in the medical sciences for granted, I hope that at least half of my readers will be able to see the next one scheduled and half of those the one after the next.

TABLE I

TWO CENTURIES OF TRANSITS OF MERCURY

1799	May 7	1907	Nov. 14
1802	Nov. 8	1914	Nov. 7
1815	Nov. 11	1924	May 7
1822	Nov. 4	1927	Nov. 9
1832	May 5	1940	Nov. 11
1835	Nov. 7	1953	Nov. 14
1845	May 8	1957	May 5
1848	Nov. 9	1960	Nov. 7
1861	Nov. 11	1970	May 8
1868	Nov. 4	1973	Nov. 9
1878	May 6	1986	Nov. 12
1881	Nov. 7	1993	Nov. 5
1891	May 9	1999	Nov. 15
1894	Nov. 10	2003	May 6

TABLE II

THIRTEEN CENTURIES OF VENUS TRANSITS

Year and Date:	*Duration*:
1631, Dec. 6	3 h 10 m
1639, Dec. 4	6 h 34 m
1761, June 5	6 h 16 m
1769, June 3	4 h 0 m
1874, Dec. 8	4 h 11 m
1882, Dec. 6	5 h 57 m
2004, June 7	5 h 30 m
2012, June 5	6 h 42 m
2117, Dec. 10	4 h 46 m
2125, Dec. 8	5 h 37 m
2247, June 11	4 h 16 m
2255, June 8	7 h 12 m
2360, Dec. 12	5 h 25 m
2368, Dec. 10	4 h 59 m
2490, June 12	2 h 4 m
2498, June 9	7 h 53 m
2603, Dec. 15	5 h 53 m
2611, Dec. 13	4 h 30 m
2733, June 15	short
2741, June 12	7 h 46 m
2846, Dec. 16	6 h 14 m
2854, Dec. 14	3 h 48 m
2976, June 17	very short
2984, June 14	7 h 25 m

— WILLY LEY