Galaxy
SCIENCE FICTION

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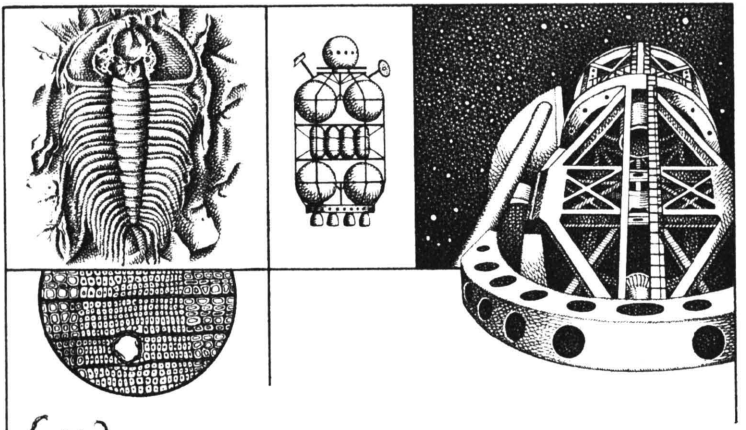
THE MAN WHO WAS SIX
By F. L. Wallace



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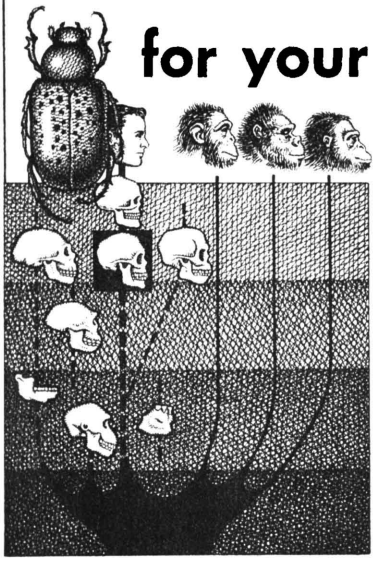


By WILLY LEY

THE SOUTHERN CROSS

IF science fiction, as one definition has it, is literature based on known scientific facts and the extrapolation of accepted scientific theories, one of the great works of world literature has to be classified as science fiction—or at least a small portion of one of its three parts. I am speaking of Dante's *Divina Commedia.* In Part II, *Purgatorio,* there are a few lines that have intrigued

scientists for a long time. As important a personage as Alexander von Humboldt devoted a section of one of his books (*Examen critique de l'histoire de géographie,* vol. IV, Paris, 1836) to a searching appraisal of these lines.

Since quite a number of readers know Italian (as well as the fact there is an Italian edition of this magazine), I'll give the original wording first and follow it with the English translation:

Jo nu volsi a man destra, e posi mente
All' altro polo, e vidi quattro stelle
Non viste mal fuor ch'alla prima gente,
Goder pareva il ciel di lor fiammelle,
O settentrional vedovo sito
Poi che privato se' di mirar quelle!

At right, in the direction of the southern pole
I saw the lights of a quadruple star
Which the first couple only was to see,
The heavens gloried in its radiation,
O you poor widowed barren North,
You never see the marvel of this constellation!

SOMEBODY who does not know the background might dismiss these lines with the remark "Well, why not?" or words to that effect. The point here is that the dates involved do not seem to match in a spectacular manner.

Dante began the *Divina Commedia* in 1307; the above lines were written about ten years later. They unmistakably refer to the constellation now called the Southern Cross. But the Southern Cross was "discovered" by the Venetian explorer Alvise da Cadamosto, sailing for Prince Henry of Portugal, in 1455!

To make the case even more mysterious, Dante stated that "the first couple," meaning Adam and Eve, could see it. They were supposed to have lived in the Euphrates Valley, from which the Southern Cross is not visible, not now and not in Dante's time. But theological reasoning put the creation of the world and the time of Adam and Eve at about 6,000 years ago—*and, at that time, the Southern Cross could be seen from the Euphrates Valley in present-day Iraq and even from points in Central Europe!*

How could Dante know these things?

For a man of his time, he traveled a great deal, but mostly to the north of his native Florence. Even if he had gone as far south as is possible in Italy, he could not have seen it, for the toe of the Italian boot just touches the 38th parallel of northern latitude and, in order to see the Southern Cross at all, one has to be south of the 30th parallel of northern latitude. To see it clearly in the sky some distance above the horizon, one has to be south of the 15th parallel of northern latitude.

This means that Dante should have had to travel at least to

Upper Egypt or to the southern portions of the Red Sea and the Arab peninsula. For good visibility, he should have had to go to Ethiopia or to Ceylon. (For corresponding areas in the Western Hemisphere, one needs a trip to Mexico or Cuba to see the constellation at all, and to Nicaragua or the Canal Zone for a good view.)

THE fact that Dante obviously had not seen the Southern Cross himself accounts for his exaggeration, because the Southern Cross is a comparatively small constellation that does not measure up at all against the Big Dipper or Orion. Nor is it a particularly good cross — the two arms do not form a right angle and the effect is marred by the presence of a fifth star.

Interestingly enough, it took some time until it was even referred to as a cross. Its "discoverer" Cadamosto did not call it a cross and Amerigo Vespucci referred to it as "rhombus." Even the intensely religious Dante himself merely spoke, as we have seen, of the *quattro stelle,* the "four stars."

What makes the whole case so intriguing is that Dante's lines are literally the earliest mention of the constellation.

At the time of Homer (about 800 B.C.), the Southern Cross was still visible from the Mediterranean, but low on the horizon. It cannot have been conspicuous because the *Odyssey*—which, in one section now referred to as "Kalypso's sailing instructions," goes into constellations for navigational purposes with great detail—does not mention it at all. Nor did Ptolemy. At the time he lived in Alexandria, the star *alpha* of the Southern Cross still climbed to a little more than six degrees of arc above the horizon of his city. But he seems to have added it to the constellation of Centaurus.

The only place where it was probably mentioned as a separate constellation is in the Bible, in the Book of Job (9:9) where Job says that the Lord "maketh the Bear, Orion, and the Pleiades and the Chambers of the South." At the time this book originated (4th century B.C.), the Cross was still visible from southern Palestine, but the term "chambers of the south" is obviously no helpful description to somebody who did not know it in the first place.

BUT while Dante could not have derived his information from older books, which were silent on this point, there were other sources for such knowledge. It is known that soon after the year 1200, an Arab by the name of Caissar ben Abucassan had a

globe of the sky made in Egypt, on which the Southern Cross was entered. A later globe—made in 1279—also of Arab origin, is still in existence. It is known furthermore that Emperor Frederick II of Hohenstaufen acquired an Arab tent in 1229 that was a revolving map of the sky (actually the first known planetarium), although no details exist.

In addition to these globes and star maps, there were enough people in Dante's time, mostly Arabs but also Europeans, who had traveled to places where the Southern Cross is clearly visible.

One thing indicating that Dante relied on an eyewitness story is that, immediately following the lines quoted, he says he glanced back to the north "where the Wain had disappeared."

As everybody knows from personal experience, the "Wain" (Big Dipper) is the most conspicuous constellation of the northern sky. Europeans always felt uneasy when they came to areas where their main "sky mark" was no longer visible. The soldiers of Alexander the Great are the earliest men known to have complained about this. Even Marco Polo, who does not seem to have had any interest in the sky and never mentioned it, succumbed at one point by saying that Polaris cannot be seen from Sumatra.

Though Dante could (and obviously did) find out about the existence and appearance of the Southern Cross, it is hard to see where he could have learned about the visibility of that constellation in higher northern latitudes at an earlier period.

True, the precession of the equinoxes responsible for this phenomenon had been discovered long before him by Hipparchos of Nicaea, but later astronomers had paid little attention to it. In fact, only the Arabs seem to have believed in what is now called "trepidation of the equinoxes," a wrong theory that assumed the precession would accumulate and then swing back.

Dante, of course, did not have to decide which theory was right. He only had to learn somewhere that astronomers knew of a steady displacement of the stars in the sky. He might then simply have been convinced that one of the attributes of Eden had been to see all the stars in the sky.

But whether he reasoned on the foundations of a then current theory or simply guessed, it so happened that he was right!

EARTH'S OTHER MOON(S)

DR. Clyde Tombaugh, the discoverer of Pluto, who now lives near the White Sands Proving Grounds, and Dr. Lincoln La

Paz, director of the Institute of Meteoritics at Albuquerque, New Mexico, are engaged in a project that more than fifty years ago was half-heartedly started in Europe, but then petered out for lack of success and financial support. This time, the support comes from the U. S. Ordnance Department. As for the probable chances of success, with the much better instrumentation now available, they might have had some between the writing and the publication of this column.

The project: To find out whether Earth has more than one moon.

As mentioned in the opening sentence, the problem is not exactly new. My own teacher, in fact, was fond of saying that his teacher used to say that *his* teacher considered it highly probable that Earth might have several tiny moons. Possibly, he added, Earth might even have a very faint ring. And the man who made this statement, the astronomer M. Wilhelm Meyer, asserted in turn that he was more or less quoting casual opinions of *his* teacher, Prof. E. F. W. Klinkerfues. Since Klinkerfues died in 1884, this succession of opinions has carried us back quite far, but not to the beginning of the idea, which originated in France nearly a century ago.

The original paper by one F. Petit of Boulogne may be classified as "forgotten," but the idea was not because Jules Verne read it (or read about it) one day and utilized it in his second novel about the cannon-shot to the Moon.

This book, entitled *Autour de la Lune*, appeared in 1870, five years later than the first book, *De la Terre à la Lune*. If you have read it, you might remember that the three inhabitants of the Moon projectile—Barbicane, Nicholl and Ardan—have managed to recover from the shock of the firing. Since they, in Jules Verne's opinion, cannot tell whether they are moving or not —actually they could not possibly miss the sensation of being in free-fall—they look out of the window to see whether they are in space.

> When Barbicane was about to leave the window his attention was attracted by the approach of a brilliant object. It was an enormous disk the colossal dimensions of which could not be estimated. Its face which was turned in the direction of the Earth was very bright. One might have thought it a small moon reflecting the light of the large one. It approached with a high velocity and seemed to travel in an orbit around the Earth which would intersect that of the projectile . . . The object passed several hundred yards from the projectile and disappeared.

In response to a surprised remark made by Michel Ardan, Mr. Barbicane launched into one

of his usual short lectures:

"It is a simple meteorite, but an enormous one, retained as a satellite by the attraction of the Earth . . . But this second moon is so small and its velocity so great that the inhabitants of Earth cannot see it. It was by noticing disturbances that a French astronomer, Monsieur Petit, could determine the existence of this second moon and calculate its orbit. According to him a complete revolution around the Earth takes three hours and twenty minutes."

"Do all astronomers admit the existence of this satellite?" asked Nicholl.

"No," replied Barbicane, "but if, like us, they had met it they could no longer doubt it . . . But this gives us a means to determine our position in space; its distance is known and we were, therefore, 4650 miles above the surface of our globe when we met it."

It is this encounter, Jules Verne explained, that made the projectile deviate from its trajectory and miss the Moon, to the great good fortune of the travelers.

Since 1870, the story, in various languages, has been read by perhaps five million people. At least one hundred professional astronomers must have been among those five million. Yet it took until 1952 before somebody noticed that Jules Verne's figures for distance and period of revolution do not jibe.

It was Dr. Robert S. Richardson of Mt. Wilson Observatory who did, but what he really wanted to check was whether the gravitational field of the second moon would be strong enough to deflect the projectile from its path. (It wouldn't.) In looking for clues to the size of the second moon, he noticed the discrepancy. (See: *Bull. Pacific Rocket Soc.* Vol. 5, No. 10; Oct., 1952.) Either the period was three hours and 20 minutes, when the distance from the surface would have to be 3,114 miles, or else the distance was 4,650 miles, when the period would have to be four hours and 30.7 minutes.

This goes for orbits that are circular or very nearly so, as implied by Jules Verne. Of course, if Petit had an elliptical orbit in mind, both figures can be true. The body might have an orbital period of three hours and 20 minutes and reach the distance of 4,650 miles at one point of its orbit. Nothing is actually said about the size of the satellite, but the idea seems to have been that it was at least a mile in diameter.

WE can be certain that a second moon of Earth of the type postulated by Petit and popularized by Jules Verne does not exist.

If it did, it would take one hour and 21 minutes to cross the sky from horizon to horizon, incidentally rising in the west and setting in the east. Not quite half of that time, it would be invisible inside the Earth's shadow. But,

while rising, it would be above the horizon for 23 minutes before it entered the shadow and it would need another 23 minutes from leaving the shadow until it disappeared below the horizon on the other side.

Even if its surface, like that of the Moon, were quite dark (think of lava or dark slate for the proper color value), the satellite would reflect enough sunlight to look like a very bright star and a careful observer could actually see it move.

If Earth had a second satellite like that, its existence would have been known since the days of the Babylonians. This would still be true even if it were twenty times as far away as postulated. A one-mile satellite would be visible to the naked eye at a distance of 100,000 miles. It would be faint, certainly, but one would notice that this faint star does not occupy the same position among the fixed stars that it did an hour ago.

Even cutting down its size to a mere five per cent of a mile, the satellite would be likely to be known if it were near enough. A satellite of that size (again assuming that its surface is as dark as lava) would still be visible to the naked eye at a distance of 1000 miles. It would no longer be a conspicuously bright star, but it would give itself away by its fast movement.

If this 1/20th-of-a-mile satellite revolved at a distance of 10,000 miles, it would have remained undiscovered prior to the invention of the telescope. But it certainly would have been found during the last hundred years, because it would show in any good portable instrument.

All of this implies that a second satellite of Earth, to escape discovery until now, would have to be small, less than a hundred feet in diameter. At that size, it would be too small to be seen without a telescope. Even with a telescope, it would be too faint to be conspicuous.

One has to bear in mind that an observer usually looks for a specific thing and may therefore pay little attention to other objects. Besides, in telescopic observations, the field of vision is small. Something quite spectacular could be going on just "outside the telescope" and not be noticed as long as it is invisible to the unaided eye. This applies to direct observation.

The widespread use of photography in astronomical work imposes another condition for still undetected satellites. They must not only be small—they must also be near, so that they move fast. If they do that, they may escape detection by appearing to be something else.

ANY telescope of reasonably large size, with or without photographic attachment, is moved by a clockwork mechanism "to follow the stars"—more precisely, to compensate for the rotation of the Earth. This means, of course, that the mechanism compensates for the apparent movements of objects that rise in the east and set in the west.

But a *near* satellite would seem to go the other way across the sky.

It would not only be quite fast by itself; it would appear even faster because the telescope moves in the opposite direction. The inevitable result is that such a satellite, accidentally photographed, would leave a trail from edge to edge of the plate. But so does every bright meteor.

While a meteor trail across a plate is of some casual interest, not much lasting attention would be paid to it. In the first place, the picture has been taken for another purpose. In the second place, a photograph of a meteor track, unless taken with a special camera and preferably with two cameras simultaneously, teaches very little.

In short, the hypothetical satellite track would be mistaken for a meteor track. Even if somebody was suspicious, there would hardly be a way of proving the suspicion.

Just how Drs. La Paz and Tombaugh will try to catch the minor satellite(s) has not been disclosed. But the principle is fairly obvious. Although such a small satellite could have an orbit lying in any position compared with the ecliptic—the orbit of the Earth around the Sun—the probability is that the satellite orbit would be near the ecliptic. This narrows the search down to a specific band or zone.

Furthermore, as we have seen, such satellites must be fairly near, probably less than 10,000 miles at the most. This determines, in approximation, the speed of their movement.

Now if a telescopic camera, aiming in the direction of the ecliptic, were clockwork guided to run opposite to the usual direction, the plates would be full of star tracks. They could easily be identified as such because the star tracks would all be of the same length.

But if one of these tracks appeared much shorter than the others, it would indicate an object rising in the west. The speed of its apparent movement could easily be calculated from the length of its track, compared with the length of a star track. And once such an object has been "caught," it will not be lost again.

Since the unknown moons of Earth are likely to be quite small,

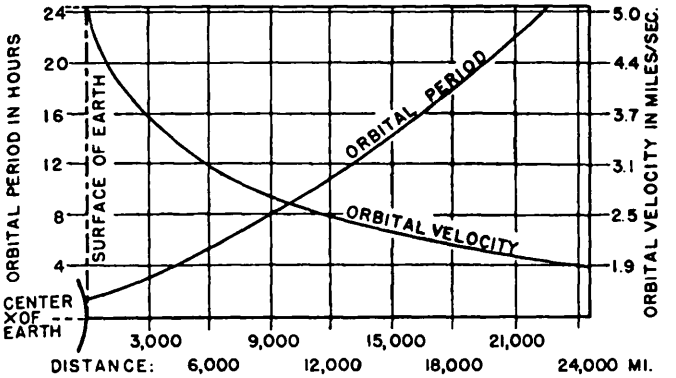


Diagram of the relationship between orbital velocity, (refer to right-hand column), orbital period (refer to left-hand column) and distance from the surface of Earth (bottom row). It is unlikely that moonlets of any noticeable size would have remained undiscovered if they circled Earth at distances greater than 25,000 miles. (Adapted from a diagram by Arthur C. Clarke)

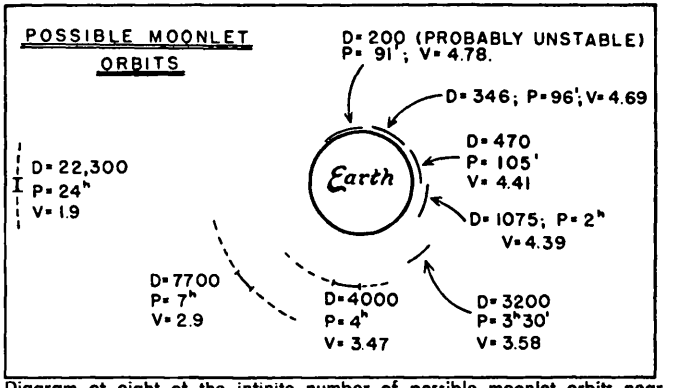


Diagram ot eight ot the intinite number of possible moonlet orbits near Earth. In each case, *D* gives the distance from the surface in miles, *P* the period in minutes (') or hours (h) and *V* the orbital velocity in miles per second. The length of the piece of orbit shown in the diagram represents the movement in ten minutes.

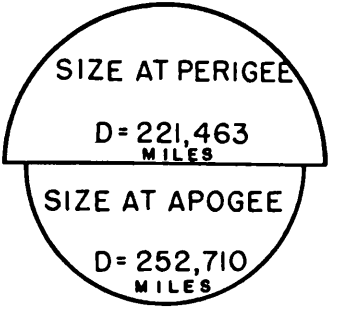
they may not offer any practical advantages. But it will be useful to know that they exist and where they are.

ANY QUESTIONS?

In your book, The Conquest of the Moon, *I find a table which says that the Moon can be, at times, more than* 30,000 *miles farther away from the Earth than at other times. If this is correct, shouldn't the Moon look larger sometimes?*

Lawrence M. Marten
122 N. Baker St.
Topeka, Kansas

Yes, it should and it does. Here's a comparison of the apparent sizes at the two extreme distances.



But since the apparent diameter of the Moon is only about 1/2 of a degree of arc, this difference of not quite 15 per cent in apparent diameter is unlikely to be noticeable to the naked eye.

It does show on photographs, however.

How high would a rocket have to go to be out of the Earth's gravity?

George F. McManus
1403 W. 27th St.
Brooklyn, N. Y.

This is one of the two questions—the other is, "What are the Flying Saucers?"—I always try to bet on with the chairman of a lecture committee prior to a public lecture.

My bet is simply that one or both of these questions will be asked. But apparently I sound so confident when making the proposition that no chairman has ever accepted the bet.

Well, to come to the point, there is no such thing as a distance at which a gravitational field will suddenly stop.

For every star, planet or moon, the rule is the same: If the gravitational field at the surface of the body has a strength of 100, the strength will be 25 at a distance of one radius from the surface. At a distance of two radii, it will be 11. At three radii, 6.3. At four radii, 5. At five radii, 2.5. At six radii, 2 and at seven radii 1.6 or still a little more than 1-1/2 per cent of the surface value. And in the case of Earth, seven radii amount to more than 27,650 miles.

In other words, a gravitational field does not stop somewhere. It slowly peters out, just as a powerful light, if you move away from it, grows fainter and fainter without suddenly disappearing (except that, on Earth, it may be cut off by the horizon).

Therefore, a gravitational field "disappears" only if you are an "infinite" distance away. In practice, however, there comes a point where another gravitational field is equally powerful and, beyond that point, more powerful than that of Earth.

For example, at a distance of 162,000 miles from the surface of Earth, the field of Earth and that of the Sun are of equal strength. More than 162,000 miles from Earth, the gravitational field of the Sun is stronger than that of our planet.

One might say, then, that Earth's field forms a "bubble" some 325,000 miles in diameter inside the immense gravitational field of the Sun.

—WILLY LEY

FORECAST

Next month brings SPY, a dazzlingly devious novella by J. T. McIntosh. Corvey lived, laughed, loved, killed and died a thousand times . . . but which one of all these lifetimes was actually his own? Don't bother guessing; live through Corvey's experiences with him!

Philip K. Dick comes up with a novelet called A WORLD OF TALENT . . . and no title ever fitted a story more exactly . . . in the startling novelty of its ideas, in freshness of treatment and the eye-popping ending!