Galaxy

SCIENCE FICTION

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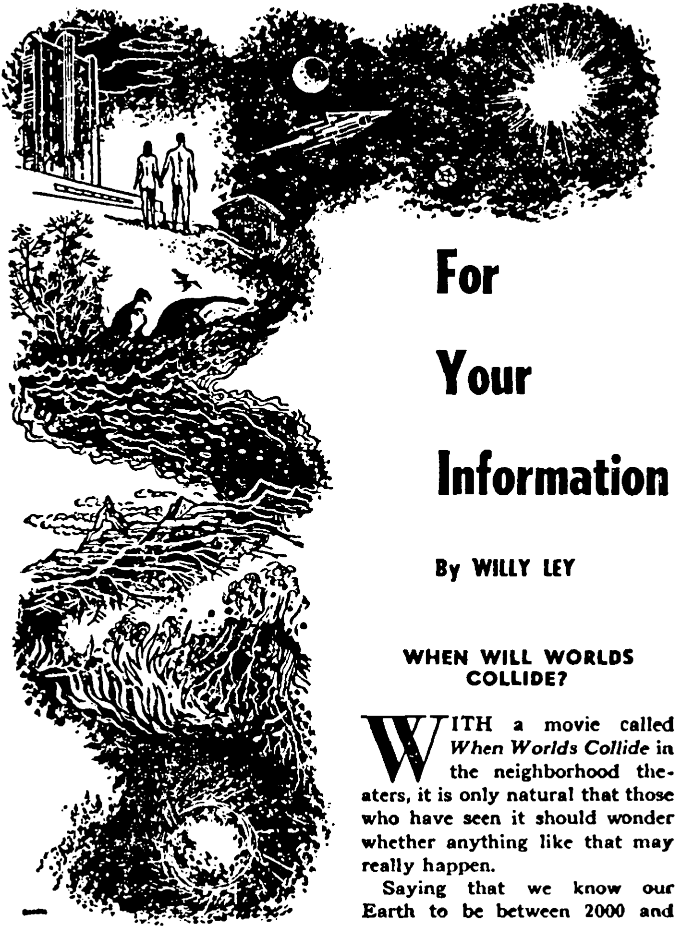


For Your Information

By WILLY LEY

WHEN WILL WORLDS COLLIDE?

WITH a movie called *When Worlds Collide* in the neighborhood theaters, it is only natural that those who have seen it should wonder whether anything like that may really happen.

Saying that we know our Earth to be between 2000 and

3000 million years old and that it is still in one piece does not invalidate the question: *Can* worlds collide?

Well, let's attack the problem systematically. First, a few fundamental astronomical facts. Nine planets, of assorted sizes, swing around the Sun. The closer to the Sun they are, the faster they move in their orbits. Their orbits are separated by many millions of miles. They all move around the Sun in the same direction, counter-clockwise if you look at the whole from the celestial north pole. And they all move in very nearly the same plane. If you made a precise scale model of the Solar System, it would fit into a round box which has to have a diameter of four feet, but would need to be only five inches deep. And if you left out Pluto and Mercury, the two that deviate most from the general plane of the Solar System, the box could be reduced to a height of three inches.

Under these circumstances, no collisions between members of our own solar system are possible. Even if we imagine that, for completely unknown reasons, one of the outer planets slowed down and approached the Sun, it still would not lead to a collision. For while the planes of the various planetary orbits are very close to the plane of Earth's orbit, the ecliptic, they are not precisely the same. The presumed new orbit of a slowed-down outer planet might cross the orbit of Earth, but because of the fact that the planes of the various orbits fail to coincide perfectly, the two orbits would cross *not* in the manner of two crossing streets, but more like a bridge crossing a street or a street crossing a tunnel.

Then what happened to the presumed Planet Five, which is now the Asteroid Belt? We can't be sure, but we are pretty certain that it was not a collision. The total mass of all the asteroids still makes only a very small planet, somewhere between our moon (2160 miles in diameter) and the planet Mercury (3100 miles in diameter) in size. And that very small planet happened to be nearest the largest planet of our system, Jupiter (diameter 86,700 miles). About 150 years ago, when only the four largest bodies of the Asteroid Belt were known, the discoverer of two of them, Heinrich W. M. Olbers, M.D., suggested for the first time that they may have originated by the explosion of one planet.

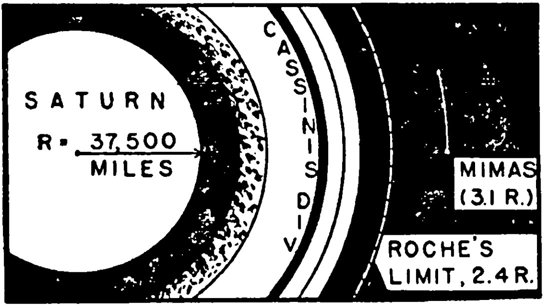
If that was really the case, it should be possible to reconstruct the orbit of the original planet from the orbits of the four big chunks of débris. And in the pursuit of that calculation one would also be able to fix the approximate date of the event. The calculation was not made then, partly because it would have been a difficult and exceedingly tedious job, partly because astronomers, both professionals and amateurs, kept adding and adding to the list of minor planets. But much later, only a few decades ago, Prof. K. Hirayama did go to work on the problem of calculating the original orbit of the presumed disrupted planet from the orbits of the presumed fragments.

Interestingly enough, Prof. Hirayama did not find a common origin. Instead, he found five different origins, one each for five so-called "families" of planetoids. There was the one named the Flora Family, after its brightest member. Flora (#8) is the member of a family of 57. Maria (#170) is a member of a family of 13; Koronis (#158) is a member of a family of 15; Eos (#221) is one of a family of 23; and, finally, Themis (#24) is one of a family of 25. For each of these families, a common origin could be calculated, but it was impossible to trace the story farther back, all of which seems to indicate that there never was an original Planet Five. Presumably, Jupiter's gravitational pull prevented it from forming and, instead of one planet, more than five tiny planets formed in that area, which later, one by one, were torn apart again by Jupiter.

Whether or not Professor Hirayama is correct with this conclusion matters little for our present purpose. The so-called Asteroid Belt did not originate by way of a collision—even though minor collisions in the Belt now are probably responsible for the meteorites that fall to Earth.

But why look to other planets for a collision? Aren't there some theories around which state that the Moon is slowly approaching Earth? And even though its diameter is only about one-quarter of the diameter of Earth, that should make a sufficiently destructive impact.

However, there are a few natural laws in the way which are usually referred to as "Roche's Limit," named after the French astronomer E. Roche of Montpellier, who made a certain calculation in 1850. The calculation was this: Suppose that a satellite slowly approached its planet in an orbit like a tightly wound spiral. (It couldn't have any other shape.) Then this satellite would raise stronger and stronger tides on the planet. But the planet would also raise tides in its satellite's crust. And since the planet is bigger and its gravitation stronger, it would win. Under the stress of the tidal forces exerted by the planet, the satellite would



Saturn and its rings seen from a point directly above Saturn's northern pole. The main division of the rings is known as Cassini's Division, the fine division in the outer ring as Encke's Division, both named after their discoverers. Mimas is Saturn's innermost satellite, well outside Roche's Limit.

break up, layer after layer would be peeled off and the débris would form a ring around the planet. The pieces forming the ring might still crash, but they would be just pieces, strong falls of meteoric matter, no shattering impact.

The distance at which this would take place would depend on several factors—the relative densities of planet and satellite and, to some extent, the tensile strength of the material forming the satellite. Roche calculated that a satellite of the same density as its planet and being liquid (in a loose sense of the word) could not exist within 2.4 radii from the planet's center.

Saturn's rings (see diagram) are well inside Roche's Limit. Again it is an open question whether the rings are the remains of a moon which was broken up by Saturn's tidal forces, or whether they are material which could not condense into a moon, because they were situated where no moon is possible.

Almost a century after Roche, Prof. H. Jeffreys undertook the job of finding out how small a rocky satellite would have to be to escape the forces which constitute Roche's Limit. In 1947 he announced that a satellite of solid rock would have to be larger than about 130 miles in diameter to be disrupted by the tidal forces

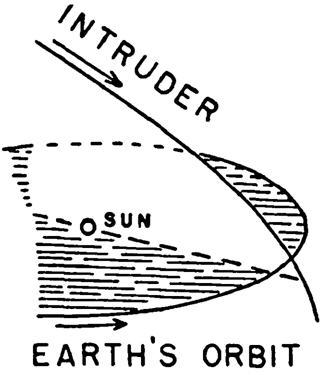


Diagram of the orbit of a hypothetical "Intruder" coming into the Solar System on an orbit almost vertical to that of the ecliptic. Some comets do have similar orbits, but none is known to have hit Earth. If one did, it would be a purely local catastrophe.

which Earth could exert upon it. But even a 100-mile satellite—if there were one—would not hit Earth as a whole. Since it would enter the atmosphere pretty nearly tangentially ("horizontal"), it would be shattered by unequal heating.

How, then, could another planet—say, the planet of another sun—hit Earth? Only if it approached in such a manner that there is no time for an effective interplay of tidal forces. The diagram shows a typical comet orbit, strongly inclined to the ecliptic, coming from "above." If such an orbit crossed that of Earth and if both Earth and intruder happen to arrive at the same spot in the same instant, there would be a collision.

But now let's see: the nearest other sun is, in round figures, 24 million million miles away. The average velocity of a sun moving through space is much less than one per cent of the velocity of light, usually somewhere between 0.01 and 0.025 of one per cent of that velocity.

Let's assume that the nearest star moved with a velocity of one per cent of that of light, which it doesn't, and that it were aimed for a collision point with our sun, which it isn't.

It would need four centuries to strike.

If one has to worry about something, there are more urgent problems than the possibility of cosmic collision.

THE SIX-LEGGED GHOST

I DON'T have any particular reason for talking about the insect *Myrmecophana*, but I don't see why I should need one. I am simply amused by what happened and the gist of the story is that there is no such insect.

It began quite harmlessly with a small box which the mailman handed to Herr Professor Dr. Brunner von Wattenwyl one day in 1883. Dr. von Wattenwyl was an entomologist and he didn't really have to read the letter that came with the small box. There were some insects in it, sent for proper classification. The insects were ants which had been collected in East Africa. They were new to the man who had collected them. Were they also new to science?

When Brunner von Wattenwyl looked at them carefully, he saw that they were indeed new to science. And they were not even ants. They were related to the locusts, but masqueraded as ants.

The thick body had a green triangle on each side, quite conspicuous against the background of a white sheet of paper. But if placed on a leaf, these two green triangles imitated the narrow "waistline" of an ant. Likewise, the legs were striped black and green lengthwise, so that only the black center stripe showed clearly. That stripe had the width of an ant's leg. Even the antennae, longer than those of an ant, were camouflaged. At the precise point where the feelers of an ant would come to an end, there was a white section which seemed to cut it off.

Brunner von Wattenwyl suspected—he could not know for sure, since he worked with dried specimens, but his suspicion was justified — that this camouflaged grasshopper also behaved like an ant when alive.

What remained to be done was to invent a scientific name. Well, here was an insect which did its best to look like an ant. One might say that it "ghosted" an ant. Hence, von Wattenwyl called it "ant-ghost," *Myrmecophana*.

That ended the story for an interval of more than two decades, when a traveling zoologist, one Dr. Vosseler (later director of the Zoological Garden of Hamburg), happened across *Myrmecophana* in East Africa.

It mingled with true ants, cavorting like them.

Vosseler, unaware of the earlier description, was struck by some minor differences, collected some of the "new species of ant" and took them with him, alive.

Kept in wire cages for later classification, the pseudo-ants seemed to be growing a little, though insects, once they have reached the adult form, rarely grow larger. And then, one day, they began to change. The pseudo-ants, as they changed shape, also changed their behavior. No nervous running any more, stately calmness instead. They had become leaf insects, now imitating the leaves of plants, sitting still if possible and moving slowly when moving became necessary.

And with that observation *Myrmecophana* became a "ghost" of another kind. For the finished leaf insect was already known to science under the label *Eurycorypha*. The pseudo-ant was recognized as the larval form of the pseudo-leaf. And its separate name was officially deleted.

MOON OF VENUS

READING over my first column about the moons of the Solar System, I find myself guilty of an omission: I didn't say anything about the satellite of Venus.

But Venus, you'll object, does not have a moon. I know that. However, the moon which Venus does *not* have has a story and I think it worth telling.

It began during the year 1645. Some thirty-five years earlier, Galileo Galilei had discovered the four large moons of Jupiter, and astronomers began to look for moons of other planets. In the year mentioned a Neapolitan, Francesco Fontana, announced that Venus had a fairly small, bright moon. Telescopes were still rare and weak, so other observers were not surprised if they failed to see it.

Some time later, Fontana's discovery was corroborated by as important a man as Jean Dominique Cassini. Cassini had discovered one of Saturn's moons (Japetus) in 1671 and had announced still another moon of Saturn (Rhea) in 1672, the same year in which he reported seeing the satellite of Venus. (Later Cassini found two more of Saturn's moons, Tethys and Dione.) Cassini said that he had seen something that might have been Venus's moon as early as 1666, but he had not been sure at the time.

After that the Venus satellite was "lost" again, but its reality could not be doubted—Cassini himself had seen it! Roughly a century after the original discovery by Fontana, several other observers went on record as witnesses for the existence of a moon of Venus. Short in England saw it in 1740; Mayer in Greifswald in 1759; Montaigne in Limoges, France and Rödkier in Copenhagen both observed it for several days in 1761. The angular distance from the planet, they reported, was between 20 and 25 minutes of arc. Three years later, in 1764, Horrebow in Copenhagen and Montbarron in Auxerre verified the observations of their respective compatriots, Rödkier and Montaigne.

There was just one uncooperative fact in the way. Since Venus is closer to the Sun than we are, it happens on rare occasions that the planet is in line of sight between us and the Sun, a performance technically known as a "transit." If Venus had a satellite, it should show up beautifully as a black spot against the blinding background of the Sun's disk. Venus transits are rare, but just at the period under discussion there were two of them, in 1761 and in 1769. They were observed carefully for many different reasons, but nobody detected even a trace of a Venus satellite.

The Viennese astronomer, Father Maximilian Hell, S. J., after whom Hell Crater on the Moon is named, drew the conclusion that Montaigne and Montbarron, Rödkier and Horrebow, Mayer and Short—and, yes, even the great Cassini — must have been mistaken. Venus is a very bright planet, bright enough to cause a reflection on the cornea of the eye of the observer. This reflection will be reflected, in turn, on the eyepiece of the telescope and then be "seen" by the observer. Of course, it will not coincide with the image of the planet, but produce a tiny bright spot nearby. Thus Father Hell in 1766.

But the satellite of Venus had too much momentum by then. Johann Heinrich Lambert—writing in French like a good German of his time—published an *Essai d'une théorie du satellite de Vénus* in Berlin in 1773 in which he tried to calculate the orbit of that moon. Frederick the Great of Prussia read it and decided that this was a fine opportunity to honor the philosopher and mathematician Jean Le Rond d'Alembert by naming the moon of Venus *d'Alembert*. If d'Alembert had not refused the honor —we don't know why — there would have been a royal degree to that effect.

By 1800, all astronomers were agreed that Venus did not have a moon. But they also agreed that Father Hell's ingenious explanation was not good enough. Though something like that might fool a beginner, the majority of those who had seen the satellite of Venus had been competent men. The puzzle was not solved until 1887 when a Belgian astronomer, P. Stroobant, reviewed the whole case. Stroobant asked himself the obvious question: "Just where was Venus located in the sky when the various observers thought they saw a satellite?"

Since precise records existed, this question was easy to answer. Stroobant simply looked up the positions of Venus for those days and entered them on a good star map. And he found that in every case there had been a relatively bright fixed star in the immediate neighborhood of Venus. On one occasion *mu Tauri* had been less than half a degree of arc from Venus. On other occasions it was 65 *Orionis* or 71 *Orionis*, just bright enough to be seen by the naked eye.

That was the end of the search for the moon of Venus.

—WILLY LEY

ANY QUESTIONS?

How many Jovian satellites would be visible to an observer on Jupiter, assuming that there are no clouds?

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He could see the four large satellites — Io, Europa, Ganymede and Callisto — with the naked eye. With a small portable telescope, he could also see Moon No. V, which is closest to Jupiter. All the others would need rather powerful telescopes because they are very small and comparatively slow-moving.

Isaac Asimov and other science fiction writers have used the word "parsec" on several occasions. What is a parsec and how is its value derived?

Is there any phenomenon known which would aid instantaneous or speed-of-light transmission of matter?

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Parsec means a distance which produces a PARallax of one SECond of arc, an apparent yearly shift of 1/3600th of one degree of arc. Expressed arithmetically, one parsec is 3.259 light-years.

No, we don't know of any phenomenon that would make transmission of matter possible, assuming you mean disassembling molecules in one place and reassembling them elsewhere. The speed is not very important at this point; achieving it at all is the problem. It seems somewhat unlikely at present. But so did atomic power in 1940.

I do not question the value of a space station as an observation point and for research, but why does every writer on the subject consider it invincible from a military standpoint? Why wouldn't it be just as easy for those on the ground to intercept missiles fired by the space station?

Joshua J. Ward
No Address

Suppose the space station belongs to the USA, involved in a shooting war with the Empire of Africa and Madagascar. The missiles from the space station would then be released while the station is over the Pacific, close to 180 degrees around the globe. The ground radars would not be able to pick up the missiles until too late, since they would come in over the horizon at a shallow angle. Also, they would not be able to tell whether the target is Cape Town, Tananarive, Libreville or Nairobi. But the people on the station would know what the target is going to be for any missile that rises from the atmosphere. Hence the station would have a much easier job of interception. It might not be completely invincible, but it certainly would have the advantage.

"Escape velocity" is my pet peeve. If we had a good enough fuel, we could creep out of this world at one mile per hour.

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Fort Lawton, Washington

Of course, *if* we had enough fuel, we could move out of the gravitational field of Earth as gradually as we please. The figure of seven miles per second for the escape velocity is merely one way of expressing the amount of work to be done. But it is another question of whether such "creeping out" would be practical.

Consider: in *Destination Moon* they assumed an average acceleration of six g which made the ship attain escape velocity three minutes and 60 seconds after takeoff, at which time the ship would be 800 miles above the surface. To climb to 800 miles at the rate of 1000 miles per hour would take 8/10ths of an hour or 48 minutes. During that climb to 800 miles altitude, Earth pulls the spaceship back at an average rate of about 30 feet per second for every second elapsed. This loss of speed must be made up by expenditure of fuel.

In the first case, the climb to 800 miles was accomplished in 230 seconds. In the second case, the climb to the same height took 2880 seconds. After figuring out how much effect Earth's gravity would have in either case, you'll probably stop wondering why rocket men insist in attaining escape velocity as quickly as possible.