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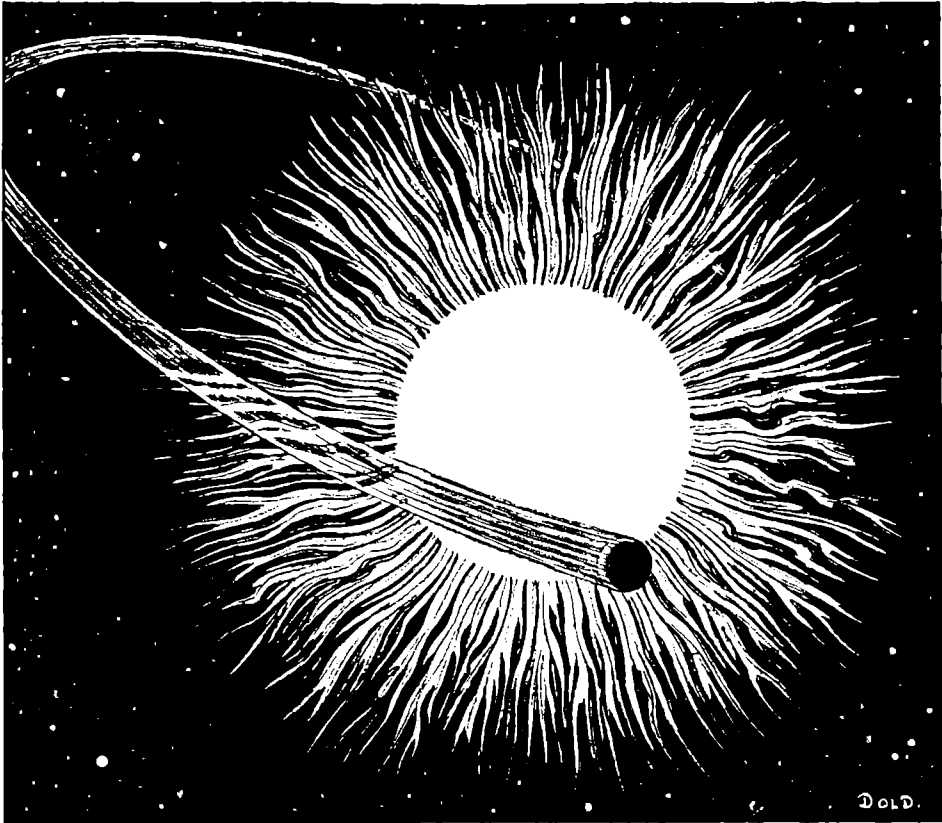
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Article Number 3—in a series which
embraces the entire Solar System



MERCURY

by John W.
Campbell, Jr.

INCREASING ACCURACY was the bugaboo of theories in astronomy. Kepler's law showed the Sun always to be found at one of the two foci of the elliptical orbits of the planets. And Newton, but a few years later, showed *why* the Sun was to be found there. Gravity! The motivating principle of the universe was discovered. In a year—astronomers considered Newton's theories precisely as clear as the mud of the Thames Basin—with the

mud having a bit of an edge, perhaps.

There was no wild rush to apply Newton's laws—partly because, though astronomy is a mathematical science, in applying his laws Newton had invented a complete new system of mathematics he claimed wonderfully useful. The astronomers decided this calculus of Newton's worked on the principle that zero multiplied by infinity is anything you want.

Not only that, but while Newton's

gravitational theory would solve the position of any two bodies, and the theory itself was good enough, there wasn't, and isn't yet, a mathematics that would handle three simultaneously—and the astronomers sadly pointed out that they had seven planets, one Sun, nearly a dozen Moons, and lots of showy—and so far as they knew then, massive—comets to deal with. "Thank you kindly," decided the Astronomer's Guild in general, "we've already had enough."

They used it though, the leaders among them, and simplified the methods. They generally realized that though there were a lot of bodies in the system, when you stacked the whole raft of planets—Moons, comets and what not—against the Sun, they didn't count. The combined planets rolled into a lump, with the comets and meteors added in, would not equal one thousandth the mass of the utterly incomprehensibly huge Sun. Further, those other things were so spread out that their effects didn't amount to much because of lack of teamwork.

The Sun's effect is so absolutely, unquestionable paramount that they got practically correct answers by using it alone in their calculations. But, by considering first the Sun, then the next nearest planet, then the next, and so on, as the second of the two bodies they *could* handle, they got results progressively more and more accurate.

Then it began to dawn on them what a terrific method of analysis Newton had given them. They pried secret after secret from the heavens with it as a lever; more and more rapidly they advanced. They knew *why* the orbits were as they were, not only why the planets go around the Sun on their invisible wires, but why the whole, bent-wire loop circled very slowly about the Sun.

You can't tell whether a circle is spinning around its center or not, because it is featureless, but an ellipse—and an elliptical orbit therefore—has two more

or less pointed ends, readily distinguishable. If the Earth and the Sun were alone in space, the Earth would follow a single track, forever repeated, a single ellipse about the Sun. But it isn't; there is Mars quite near, and farther out there is Jupiter, with its tremendous mass. Beyond there is more matter, and all of it affects Earth a bit, to the extent that the whole orbit itself moves slowly about the Sun.

When this was discovered and accounted for, the astronomers were naturally pleased. But one very small gadfly still buzzed unpleasantly, for they hadn't perfectly accounted for the fact that Mercury's orbit advanced quite so rapidly. They thought that there might be another undiscovered planet causing this perturbation. They thought that better telescopes might show it to be merely an error, for it was a very small quantity.

Better telescopes did not eliminate it; they outlined it in brighter and better light; they pinned it down to very sharp limits. They did succeed in eliminating another planet interior to Mercury, though. And Mercury still advanced some 40 seconds of arc per century. They could get that with immense accuracy—because Mercury, being nearer the Sun than Earth, transits the solar disk occasionally, giving in effect a line of sight not the length of the telescope tube but a full ninety million miles long! And Mercury did *not* comply with the law of gravity!

BY THIS TIME—it was about 1890—the astronomers were sure of Newton's laws, and they knew that they could not be wholly wrong, for they had explained too many things. But evidently they did not need correction; just a very slight error existed.

So Mercury's orbit gave the first and oldest proof of the correctness of Einstein's new modification of the law of gravity. Curiously, Newton's law is ex-

act on Earth—but inapplicable on Mercury. Mercury is Einstein's world—a world so close to the immense mass of the Sun that the laws of Nature we know do not apply.

Space—a curious sort of physical space that is not empty, but rather to be thought of as an invisible, impalpable, but indubitably present sort of thing—is distorted, its very nature changed under the colossal strain of the Sun's gravity. Space is a real thing, but not a substance; it is as real and tangible as a magnetic field, and quite as transparently invisible. The space I shall refer to generally is this sort of space—not emptiness alone, but the stuff a magnetic field is woven of.

On Mercury, basic laws we know would need modification. The power of two magnets would not be the same, the attraction between two electric charges changed. They would not obey the laws of normal space, for the Sun has changed those laws.

But Mercury is a weird world. Almost exactly three thousand miles in diameter—so small beside the enormous bulk of its primary and so near—it gave up all struggle ages since, and waves listlessly at the bidding of its master. Always the same region faces the Sun, as nearly as it may, its rotation relative to the Sun dragged to a halt by the mighty tidal strains and friction the Sun sets up, over the two thousand millions of years it has circled there. Once in 88 days it makes one circuit of the Sun—one year. Once in 88 days it turns on its axis. Thus it keeps always the same face to the Sun.

A simple way to demonstrate that this is necessary: Face the center of a round table, standing up beside it. Walk around it completely, always facing the center of the table, and just keep in mind as you make the circuit a doorway, a chair, or some exterior object. When you have made the circuit of the table, think back and you will realize

that progressively you faced the doorway, had it on your left, then directly behind you, on your right, and wound up facing it again.

But because its orbit is not a circle, Mercury cannot face the Sun exactly. To illustrate this, take the old table illustration, and, instead of walking around the edge of the table, walk half around it close in, then go off at a tangent to some distance, finally walking back to the table on the other side to complete the circuit.

If you turned around your own body axis at a constant rate, you couldn't face the table all the time, since it took, say, four times as long to walk off at a tangent and back as to do the remainder of the orbit. You did half the circuit of the table in a fifth of the total time, so, though you turned around once in one circuit of the table, turning at a constant rate you couldn't face the table all the time.

MERCURY'S ORBIT is not this extreme, though its distance from the Sun varies by several millions of miles—nearly seven, in fact. This shifting of the exposed face due to eccentricity of its elliptical orbit is called libration.

The Moon faces Earth in much the same way as Mercury faces the Sun, and similarly has slight librations.

In the case of Mercury, the libration is about 23 degrees, or about equal in amount to the tilt of Earth's axis, and produces what poor seasons Mercury has, as Earth's axial tilt produces ours.

But where our seasons vary from north to south, Mercury's vary from east to west. Since the libration is 23.7 degrees each side, there is a total of about 47 degrees, or more than an eighth of the planet's surface affected. As a result, only 133 degrees are permanently dark.

But what horrendous summers Mercury has! With a minimum distance from the Sun as low as 29,000,000 miles

—less than one third the distance Earth enjoys—poor Mercury receives nine times the heat. (Since radiation intensity falls off as the square of the distance increases.) Further, Earth is a cloud-wrapped planet, but Mercury is light—so light that the surface gravity is only about a quarter that of Earth.

Hot gases tend to expand, and with the Sun pulling, pulling forever so close by, the gases of Mercury's atmosphere expanded away and left the planet—unless some faint trace remains forever frozen on the incredibly bleak, dark side. For while the Sunward side registers a temperature of 650 degrees Fahrenheit, the dark side is close to the utter cold of space—absolute zero, say 400 degrees below Fahrenheit zero.

On the Sunward side, lead, tin, sodium, potassium, gallium, and, of course, mercury, would run in puddles; metals would all be liquid. Water vanished eons ago. Mercury is a planet-size annealing oven, maintained at a steady furnace temperature by the furiously incandescent Sun looming in its jetlike airless sky nine times as large as we see it.

Whatever frightful contortions of utterly dark, jagged rock the frozen dark side may exhibit, unweathered by wind-blown sand where there is no wind, unworn by rain where there has been no water in a thousand million years, uncracked by repeated frost, since frost there is not repeated, but a thing enduring all time, we can guess what the Sunward side looks like.

We stand on a vast, rolling plain of grayish dust, drooping swiftly over the near horizon of a tiny world. The enormous Sun shines bluer in its airless sky of black, with flames two hundred thousand miles tall licking slowly out into space, vast scarlet tongues that leap out with an apparent slow majesty, though they move a hundred miles a second. It hangs motionless in the sky, apparently, while even near it the stars

are visible for all its searing brilliance. There is no flying dust, no scattering air to spread its light into hazing brightness.

Clearly, near stars are visible, but they writhe and move visibly as the Sun creeps slowly through them, seeming to bend and sway to his coming. Einstein's world, where starlight bends visibly in the immense distortion of the Sun's fields of force! Even light has mass, and, passing near the gravitational arms of the Sun, is drawn aside.

On that vast plain straight lines are not straight; there are no lines. The mass of the Sun is near, and draws the straightness and the possibility of straightness out of space. Space—the space of magnetic fields—bends under the pull like an immense beam stressed near its breaking point, and even on Mercury we can detect that un-Earthliness, that unnormal curvature.

There are no racked, jagged rocks here. The Sun has seen to that, too. In that oven heat the rocks we know would crumble to dust in a week. Gypsum rock contains water—water of crystallization. That would go first. Many rocks contain this chemically combined water, and fall to dust without it. What refused to yield to this age-long baking would yield yet to the lashing radiation that expanded them swiftly at the surface, so that they cracked in flaky dust.

It might take time; but the Sun is not, and never has been, in a hurry. It took perhaps a billion years to stop the struggling rotation of the little planet to a dead following of the blazing sun. Then for another billion years it has chipped at the rocks with its hammer of lashing radiation and the chisel of brief cooling as the Sun swung momentarily some 47 degrees from the vertical, so the slanting rays were less fierce.

AIRLESS, utterly waterless, heated to furnace heat on one side, and chilled to the cold of space on the other, Mer-

cury is dead forever. When the Sun itself dies at length, nothing can return the air, the water that might bring life to Mercury again. And then it would be too late; for if the planet were endowed now with water and air, in a month it would be found frozen on the cold side, for there it could deposit to remain undisturbed. But Mercury has no store there, for once it rotated, and long ages before it ceased rotating it lost every trace of gaseous stuff.

We can see Mercury easily. Only two things in the heavens are brighter than that planet: Venus and the great sun Sirius, discounting, of course, the Sun and Moon. But Mercury, so close in fact to the sun, is never more than 28 degrees of an arc from it in our sky, visible thus only at dawn and dusk.

Curiously, astronomers find full daylight the best available time for observing Mercury. The surface has never been seen under good conditions; for if we observe at twilight or dawn, the planet is so low on the horizon we must look through hundreds of extra miles of air, due to the long slant our line of sight makes through the atmosphere. All this air wavers and moves with heat and cold; it is hazy with dust and mist

—so the astronomer finds daylight, with Mercury directly overhead, a better time to observe.

Mercury is bright only because it is so near the Sun, receiving such enormous floods of light, and because it is never more than 130,000,000 miles from us, at times less than 55,000,000 miles as both Earth and Mercury are on the same side of the Sun.

Mercury's dead, dull surface of gray dust is not highly reflective, expressed astronomically by saying its albedo is low. It cannot be seen when nearest the Earth, of course, because then Earth, Mercury and the Sun are in almost a straight line, and the dark surface is near us.

Since the plane of Mercury's orbit is at a slight angle to the plane of Earth's, they do not line up exactly each time; if they did, we would have a transit of Mercury about four times a year, and be able to see it as a minute, black dot on the face of the Sun. Actually, they occur in a series at 7, 13, and 46 years, then starting over again. The next will be on May 10th of next year. But it will take special equipment to see this black carcass of a dead planet across the Sun's incandescent disk.

Next Month: Venus

