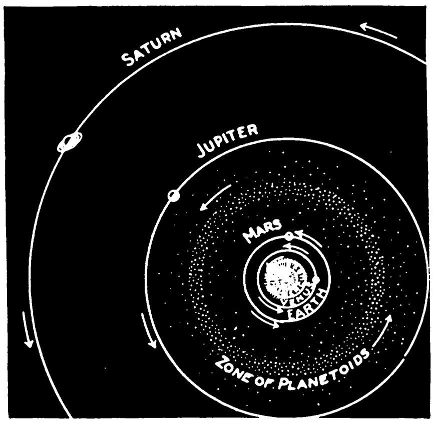


Discovery of the Asteroids —A Science Classic

Astronomy

If the discovery of one new planet in 1781 brought amazement to the world and lasting fame to its discoverer, Sir William Herschel, how much more it must have astonished astronomers some twenty years later to find a whole nest of planets, and those all in the same place, astronomically speaking. The diagram on the left shows the position of the belt of asteroids in comparison with the orbits of their neighbors in our solar system. More than one thousand asteroids are now known.

THE ZONE OF SMALL PLANETS BETWEEN MARS AND JUPITER. By Professor Elias Loomis, of the University of New York. In the Ninth Annual Report of the Smithsonian Institution. Washington, 1855.

Seventy-five years since, the only planets known to men of science were the same which were known to the Chaldean shepherds thousands of years ago. Between the orbit of Mars and that of Jupiter there occurs an interval of no less than three hundred and fifty millions of miles, in which no planet was known to exist before the commencement of the present century. Nearly three centuries ago the immortal Kepler had pointed out something like a regular progression in the distance of the planets as far as Mars, which was broken in the case of Jupiter. Being unable to reconcile the actual state of the planetary system with any theory he could form respecting it, he hazarded the conjecture that a planet really existed between the orbits of Mars and Jupiter, and that its smallness alone prevented it from being visible to astronomers. But Kepler himself soon rejected this idea as improbable, and it does not appear to have received any favor from the astronomers of that time.

An astronomer of Florence, by the name of Sizzi, took decided ground against all such innovations of doctrine. He maintained that since there are only seven apertures in the head—two eyes, two ears, two nostrils, and one mouth—and since there are only seven metals, and seven days in the weeks, so there can be only seven planets. These seven planets, according to the ancient systems of astronomy, were Saturn, Jupiter, Mars, the Sun, Venus, Mercury, and the Moon.

In 1772, Professor Bode, of Berlin, first announced the singular relation between the distances of the planets from the sun, which has since been distinguished by the name of Bode's law. This law exhibited in a striking light the abrupt leap from Mars to Jupiter, and suggested the probability of a planet revolving in the intermediate region. This conjecture was rendered still more plausible by the discovery in 1781 of the planet Uranus, whose distance from the sun was found to conform nearly with the law of Bode. In Germany, especially, a strong impression had been produced that a planet really existed between Mars and Jupiter, and the Baron de Zach went so far as to compute the orbit of the ideal planet, the elements of which he published in the Berlin Almanac. In the year 1800, several astronomers, of whom the Baron was one, formed an association whose object was to effect the discovery of the unseen body. For this purpose the zodiac was divided into twenty-four zones, one of which was to be explored by each astronomer. Soon after the formation of this society the planet was discovered, but not by any of those astronomers who were engaged expressly in searching for it. Piazzi, the celebrated Italian astronomer, while engaged in constructing his great catalogue of stars, was induced carefully to examine, several nights in succession, a part of the constellation Taurus, in which Wollaston, by mistake, has assigned the position of a star which did not really exist. On the first of January, 1801, Piazzi observed a small star which, on the following evening, appeared to have changed its place. On the third, he repeated his observations, and he now felt assured that the star had a retrograde motion in the zodiac. He continued to observe the star until the 11th of February, when he was seized with an illness which interrupted his labors. After the planet had approached too near the sun to admit of further observations for that season, Piazzi communicated to astronomers all his observations. Professor Gauss found that they might all be satisfied by an elliptic orbit, of which he computed the elements. The planet was rediscovered on the 31st of December, almost exactly in the place which had been predicted by Gauss; and it received the name of Ceres.

The distance of Ceres from the sun was found to be almost exactly the same as had been assigned by Bode's law. In this respect, therefore, the newly discovered planet harmonized with the other bodies of the system to which it belonged. The new planet was, however, excessively minute, its diameter, acording to Herschel's measurements, amounting to only one hundred and sixty-one miles.

The discovery of this planet was soon followed by another of a similar nature. Dr. Olbers, while engaged in searching for Ceres, had carefully studied the positions of all the small stars lying near her path. On the 28th of March, 1802, after observing Ceres, he swept over the vicinity with an instrument termed a "comet seeker," and was astonished to find a star of the seventh magnitude in a position where he was sure no star had been visible the preceding month. In less than three hours, he found that its place had changed. On the following evening he looked again for his star, and found that its motion was unquestionable. The elements of its orbit were soon determined by Professor Gauss, who found that its distance from the sun was nearly the same as that of Ceres; and it received the name of Pallas.

A comparison of the relative magnitudes of the planetary orbits had suggested the existence of an unknown planet revolving between Mars and Jupiter. Instead of one planet, however, two had been discovered.

Olbers remarked that there was a point where the orbits of these two bodies approached very near each other; and he conjectured that they might possibly be the fragments of a larger planet, which had been split in pieces by some tremendous catastrophe; and he intimated that there might be many more fragments which had not yet been discovered. He also inferred that, according to this theory, the orbits of all the fragments would have two common points of intersection situated in opposite parts of the heavens, through which every fragment must pass in the course of each revolution. He therefore proposed every month to search carefully the two points of the heavens in which the orbits of Ceres and Pallas were found to intersect each other. The speedy discovery of a third planet tended to confirm the truth of this hypothesis.

On the 1st of September, 1804, Professor Harding discovered a small star very near the place where Olbers had asserted that the fragments of the shattered planet must all pass. On the evening of the fourth he found that the star had changed its place. This planet was named Juno. Its orbit was computed by Gauss, who found its distance from the sun to coincide nearly with those of Ceres and Pallas.

Stimulated by this new discovery, Olbers continued with unwearied assiduity to explore the two regions of the heavens already referred to, and, after three years of laborious search, his perseverance was crowned with success. On the 29th of March, 1807, he discovered a small star in a place where none had been found in his previous examinations. He soon satisfied himself that this object was a planet; and it received the name of Vesta. The elements of the orbit were determined by Gauss, who found its distance from the sun to be a little less than that of Ceres, Pallas, or Juno.

Dr. Olbers continued his systematic examination of the heavens until 1816, but was rewarded by no further discoveries.

In 1825, a fresh impulse was given to researches of this nature by the resolution of the Berlin Academy, to procure the construction of a series of charts showing the position of all stars down to the ninth magnitude situated within fifteen degrees of the equator. Only about two-thirds of the charts contemplated in this great undertaking have yet been executed.

After the discovery of Vesta, succeeded a long interval of thirty-eight years, during which the excitement created by these first discoveries subsided, and the search for new planets was generally abandoned.

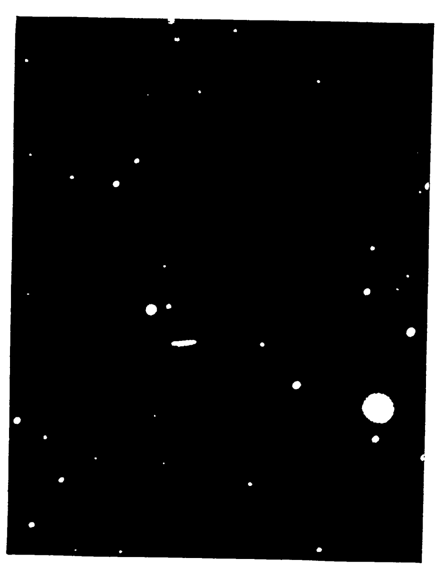
At length, in 1845, a fifth asteroid was announced by an observer hitherto unknown to fame, Hencke, of Germany. In 1847, the same observer announced a sixth asteroid, and from this time numerous observers in every part of Europe devoted much of their time, while some devoted nearly all of their energies to the search for planetary bodies: and discoveries at once multiplied with astonishing rapidity. Three new asteroids were discovered in 1847, one in 1848, one in 1849, three in 1850, two in 1851, eight in 1852, four in 1853, and six have been announced during the year 1854, making at the present time a total of thirty-three. Of these thirty-three, ten were first discovered by Mr. Hind, of London; seven by Dr. Gasparis, of Naples; three by Luther, of Bilk; while Dr. Olbers, of Bremen, Hencke, of Driesen, Chacornac, of Paris, and Goldsmith, also of Paris, have each of them discovered two asteroids; and Piazzi, Harding, Graham, Marth, and finally Ferguson, of our own National Observatory, have each discovered one. Moreover, in several instances, the same planet has been independently discovered by more than one astronomer.

In scarcely a single instance could these discoveries be termed the result of accident. They have been the result of a laborious search expressly undertaken for the discovery of these bodies. Mr. Hind, who has been the most successful explorer in this field, nearly ten years ago commenced comparing the Berlin charts with the heavens, and began to map down for himself the stars in other regions of the ecliptic, which did not fall within the limits of the Berlin charts. Any discrepancy between the stars on the maps and the stars in the heavens was carefully scrutinized; so that if a new star presumed to show itself within the limits of the charts, it was at once pounced upon as an unlicensed wanderer.

The discoveries of Gasparis were also made partly by comparing the Berlin maps with the heavens, and partly by a series of observations in zones of declination, made for the express purpose of finding new planets. Nearly all the asteroids have been discovered by a systematic comparison of the visible state of the heavens, with the state as recorded in charts.

The rapid discovery of twenty-nine new asteroids, after a barren interval of almost forty years from the discovery of Vesta, is calculated to excite surprise; but it is explained by the diminutive size of the new planets, and the great increase in the number of observers, as well as the use of more powerful instruments. Vesta appears like a star of the sixth magnitude, Pallas of the seventh, while Ceres and Juno are of the eighth. Of the twenty-nine asteroids more recently discovered none of them, with perhaps two exceptions, are larger than the ninth magnitude, while several are as small as the tenth, and one or two scarcely, if ever, rise so high as the tenth magnitude. The reason that Olbers was not more successful in his search was that he employed a telescope of too feeble power, and did not extend his examination beyond stars of the eighth magnitude.

Some may conclude that the number of asteroids already known is so great that the discovery of additional ones is a matter of no interest, and is unworthy the attention of astronomers. I regard the question in a very different light. If only one planet had hitherto been discovered between Mars and Jupiter, our idea of the simplicity and perfection of the solar system would have been satisfied; and there might have been found ingenious minds attempting to prove by a priori reasoning, that no other planets could possibly exist, unless beyond the limits of the orbit of Neptune. But our theory (*Turn to page* 374)



An asteroid made the trail in the center of the picture by moving during the time the plate was exposed. The fixed stars show as points of light. This photograph was made by Max Wolf, champion asteroid catcher.

Science Follows the Ponies—*Continued*

which Muybridge called the "electro-photographic exposor." In this an endless belt was suspended in front of the lens. The belt was of rubber cloth, wide enough to cover the lens, and having two holes which would pass each other as the belt was turned. The rate at which they would pass was determined by the number of rubber bands attached to pull the belt when the mechanism holding it was tripped. The tripping was accomplished by an electro-magnetic device actuated by a thread which the horse broke as he walked, trotted or ran along the course prepared for him. Like modern movie producers, Muybridge built sets for staging his drama of motion.

With Stanford's horses "on location" in Sacramento and in their Palo Alto home, Muybridge photographed them as they went through their various gaits—a bewildering number of "methods of locomotion" to a generation less familiar with horses. There was the walk, "a method of progressive motion with a regular individual succession of limb movements . . . its execution is regulated by the law that the movement of the *superior* limb precedes the movement of its lateral *inferior* limb." During the walk the horse has always two, sometimes three feet on the ground at one time. Then there was the "amble," sometimes known as the "fox trot." In this "the support of the body devolves alternately upon a single foot and upon two feet; the single foot being alternately a hind foot and a fore foot, and the two feet being alternately laterals and diagonals. At no time is the body entirely unsupported."

The trot, the source of the controversy which started Muybridge's researches, is described as "a more or less rapid progressive motion in which the diagonal limbs act nearly simultaneously in being alternately lifted from and placed on the ground, and in which the body of the animal is entirely unsupported twice during each stride."

In the rack "two lateral feet with nearly synchronous action are placed upon and lifted from the ground alternately with the other laterals, the body of the animal being in the intervals entirely without support." It is declared "an ungraceful gait of the horse, and disagreeable to those who seek comfort in riding."

Then follow descriptions of a different set of motions, the canter, the gallop and the leap. It is in representing these rapid actions that artists had gone so wide of the mark, showing the horse with legs outstretched and completely off the ground, while the photographs showed that "the only phase in which he has been discovered without support is one when the legs are flexed under the body.

Having analyzed the motion of animals, Muybridge next devised an instrument which would combine the pictures into the illusion of reality. He discovered that this depended on an optical law "which in the construction of a zoopraxiscope requires that the number of illustrations must bear a certain relationship to the number of perforations through which they are viewed.

"The popular number of thirteen having been selected for the latter, the same number of figures illustrate actions without lateral progressive motion.

"When the number of illustrated phases is less than the number of perforations, the successon of phases is in the direction of the motion, and the disc is necessarily revolved in a reverse direction.

"When the number of phases is greater than the number of perforations, the phases succeed each other in a direction contrary to that of the motion, and the disc is revolved in the direction of the motion. An increased or diminished number of figures will respectively result in an increased or diminished apparent speed of the object."

The Zoopraxiscope, like all the early forms of moving picture projectors, was absolutely limited in the number of pictures it could show, and consequently doomed its shadow actors to monotonous repetition of one series of acts. But movie audiences were not so sophisticated then as now. The press of the world rang with praise.

At a gala performance at the Royal Institution, attended by the Royal family and by Huxley, Gladstone, Tyndall and Tennyson, the *Illustrated London News* reported: "Mr. Muybridge exhibited a large number of photographs of horses galloping, leaping, etc. By the aid of an astonishing apparatus caled a Zoopraxiscope, which may be briefly described as a magic lantern run mad (with method in the madness), the animals walked, cantered, ambled, galloped and leaped over hurdles in a perfectly natural and lifelike manner."

And so the horse, though becoming more and more "a vain thing for safety," has played the leading part in at least two important programs of scientific research. The interest in variety of gaits, which seemed so important a half-century ago, has narrowed to an interest chiefly in speed today. The horse has been so far supplanted by the automobile as a means of "locomotion" that "horse transportation" trucks are no more incongruous than busses on our highways. The horses that ride in them are creatures of luxury with truly regal pedigrees, and a research institution becomes their college of heraldry as Science, the Monarch of Intellect, goes in for the Sport of Kings.

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Asteroids—*Cont'd*

of the solar system, although apparently simple, would not have been the true theory. Every new discovery shows the solar system to be more complex than we had supposed; and unless we prefer error (provided it has a show of simplicity) to truth, when it appears to our view complex, we shall value every new discovery in the solar system, because it promises to conduct us nearer to the true theory of the universe. Every new asteroid which is discovered is a new fact to be explained. The true philosopher, instead of regarding the rapidly increasing number of asteroids with indifference, will watch each new discovery with growing interest, in the hope that it may furnish the key to the true theory of the solar system.

Science News-Letter, December 14, 1929