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VULCAN

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One of the most interesting stories in astronomy concerns the history of what was once believed to be an intra-mercurial planet—Vulcan. The story begins in 1859 when the planet was "discovered" by Urbain Jean Joseph Leverrier.

Leverrier was born on March 11, 1811, the son of a French civil servant. His birthplace, Saint Lô, is now familiar to most of us as the place where the allies "broke out" after the Normandy landings in the last world war.

Jean Leverrier introduced a new concept into planetary discovery. As he was a mathematical, rather than an observational astronomer, there is some basis for the belief that he never looked through a telescope. He discovered planets while seated at his desk in the Ecole Polytechnique in Paris. His first discovery was Neptune; his second was Vulcan.

The theory of the motion of Mercury had always given trouble to astronomers and the planet seemed to exist for no other purpose than to plague them. The direction of the axis of its orbit around the sun was observed to rotate faster by about 40″ per century than the theory of gravitation permitted. Fresh from his triumph in predicting the presence of Neptune from irregularities in the motion of Uranus, Leverrier brought his powerful analysis to bear on the problem of Mercury, and on the 12th of September, 1859, he was able to announce to the French Academy of Sciences the terms of a

compromise between observation and calculation. The compromise involved the addition of a new planet to the solar system. He called it Vulcan.

Three months later, on December 22, 1859, the news of Leverrier's discovery reached the town of Orgères and a Dr. Lescarbault, physician and amateur astronomer. Lescarbault had been observing the sun, off and on, for twenty years in the hope that he might catch an unknown planet projected on the solar background. On March 26, 1859, he had seen what he had long waited for:—a small, perfectly round object slowly traversing the sun's disc. He had kept his findings to himself, however, in the hope that he could obtain a confirmatory observation. The news of Leverrier's discovery moved him to action and he sent the details to Leverrier immediately.

Leverrier hurried down to Orgeres from Paris to interview the physician. He presented himself to the modest amateur in this vein:

"It is then you, Sir, who pretend to have observed the intra-mercurial planet, and who have committed the grave offense of keeping the observation secret for nine months. I warn you that I have come here with the intention of doing justice to your pretensions and of demonstrating either that you have been dishonest or deceived."

Lescarbault explained what he had witnessed, and gave Leverrier a full description of the instruments he had used. His chronometer was a huge pocket watch with only hour and minute hands. He had counted the seconds with the aid of a pendulum consisting of an ivory ball attached to a silk thread which was hung on a nail in the wall. Having been shown such a primitive arrangement, it is no wonder that Leverrier began to suspect that the whole affair was an imposition or a delusion. At first, his suspicions seemed to be well founded when the physician could not produce his

original observations, but eventually the memorandum was found, "covered with grease and laudanum". Also, Lescarbault, being short of paper, made all of his calculations on a plank and used a wood plane for an eraser. Despite the crudeness of the equipment, Leverrier became convinced that Lescarbault had really seen Vulcan.

From the rough data supplied by the physician, Leverrier computed the constants of Vulcan's orbit. He found the period to be nineteen and three-quarter days and the mean distance from the sun to be thirteen million miles.

On March 20, 1862, Mr. Lummis, an amateur astronomer of Manchester, England, was examining the sun's disc when he was struck by the appearance of a spot which was moving too rapidly to be an ordinary sunspot. It was circular in form and the circumference was sharply defined. He followed the spot for twenty minutes and was then interrupted by "official duties". It would be interesting to know what official duties were important enough to interrupt observations which, possibly, confirmed Vulcan's existence.

Two French computers, Valz and Radau, deduced orbital constants for Vulcan from Lummis' short series of observations and they arrived at values very similar to those found by Leverrier from Lescarbault's data. From these orbital elements it was predicted that transits of Vulcan across the disc of the sun could only occur between March 25 and April 10 and between September 27 and October 14. There is no lack of references in astronomical literature to planet-like spots seen on the solar disc, not only between these dates, but at nearly all times of the year.

The agreement of the elements of Vulcan's orbit as determined from Lescarbault's observations with those found from Lummis' data led some astronomers to believe that the existence of the planet

was established. Both Lescarbault and Lummis, however, had their detractors.

Lescarbault's critic was a French astronomer, Liais, who was acting as director of the Brazilian Coast Survey. Liais asserted that he had watched the sun during the period in which the physician of Orgères professed to have seen the black spot, and that he was positively certain that nothing of the kind was visible although the telescope he used was considerably more powerful than that of Lescarbault. He heaped bitter criticism also on Leverrier for abetting such a scientific fraud. There is, however, such a malicious bitterness of tone in Liais' paper, which was presumably intended to annoy Leverrier whom he considered his rival, that the value of his testimony is greatly impaired.

Lummis' observations were attacked no less severely than Lescarbault's but on the basis of what appeared to be a stronger argument:—Prof. Christian H. F. Peters claimed to have identified beyond question Lummis' planet-like spot with a particular sunspot recorded by himself in America and by Sporer in Europe.

Reviewing the evidence, both pro and con, Leverrier, in December 1874, reiterated his announcement that the orbit of Mercury is perturbed to an extent rendering it necessary to increase the motion of the perihelion point by one-half minute of arc in a century. "The consequence," he said, "is very clear. There is, without doubt, in the neighborhood of Mercury, and between that planet and the sun, matter hitherto unknown. Does it consist of one, or several small planets, or of asteroids, or even of cosmic dust? Theory cannot decide this point."

Leverrier died in 1877 with the conviction that Vulcan had been discovered. Just one year later the second act of the controversy began. The *dramatis*

personae in the "rediscovery" of Vulcan were Mr. Lewis Swift and Professor James Craig Watson.

Lewis Swift was born on February 29, 1820. Because of an accident in his twelfth year he was lamed for life. It was this accident, however, that enabled him to attend school since as a healthy child he would have been forced into the constant labor demanded of the young as well as the mature of the time. In 1872 he was the prosperous proprietor of a hardware business in Rochester, New York, and an enthusiastic amateur astronomer. He was forced to use his telescope in a back alley where he could see only a portion of the sky but a friendly owner of a nearby cider-mill, known as Duffy's, permitted him to use the roof of his tavern for an observatory. Lewis Swift became, truly, the astronomer of Duffy's Tavern. In 1892, Mr. H. H. Warner of New York built an observatory especially for Swift and the citizens of Rochester presented him with a sixteen-inch telescope. He was the discoverer of twelve comets and hundreds of nebulae. His last comet was discovered when he was seventy-nine years old.

Professor James Craig Watson was born in Canada, of American parents, on January 28, 1838. He was the director of the observatory of the University of Michigan and, later, of the Washburn Observatory in Madison, Wisconsin. Although primarily a mathematician, Watson was by no means a stranger to observational astronomy since he was the discoverer of twenty-three asteroids. At the time of his death, in 1880, he was constructing a special observatory at the University of Wisconsin, to aid in the search for Vulcan.

The setting for the "rediscovery" of Vulcan was the total solar eclipse of July 29, 1878. The scene was the western United States. Swift, stationed near Denver, Colorado, and Watson, at Separation, in the Wyoming Territory, were not there for any

other purpose but to search for the intra-mercurial planet in the neighborhood of the sun. The function of the eclipse was, to them, merely to cut out the glare of the sun. The results were a little better than either observer bargained for since each saw not one, but two Vulcans.

The astronomers were equipped with maps of the star field near the sun so that in their "sweeps" they could eliminate known stars as they found them. Anything that appeared in their telescopes that was not on the map was a new object—a comet, an asteroid, or a planet. Both observers found two strange objects; both claimed the discovery of two intra-mercurial planets.

The discoveries were hotly disputed and their authenticity questioned. The most hostile critic was, again, Dr. Christian Peters. When the dust had settled and the astronomers had published their accounts of the observations, there were at least three different and possible interpretations:

1. Swift's observations, as they stood, were irreconcilable with Watson's and if we assume the reality of Swift's two objects then the two observers discovered four planets between them. This would seem, *a priori*, improbable to the highest degree.

2. If Swift's observations of the two planets were arbitrarily corrected by the same amount, then, from their relative positions, it is possible that both Swift and Watson discovered the same two objects.

3. Peters' contention was that, due to the haste and excitement, Watson made a mistake in reading the position circles on his telescope. He dealt with Swift's report in still more summary fashion, charging him with describing objects which he did not see at all, and implied that Swift had concocted his alleged discovery after the publication of a telegram from Watson.

Watson's and Swift's replies to Peters' critical

blast were as dignified as they were emphatic. Since both men were thoroughly competent observers, it is of interest to read their own words on the subject. Watson said:

"Whether or not the two new objects which I observed were intra-mercurial planets I cannot positively assert; but I certainly have the right to express my honest belief that they are."

Swift was just as positive; . . . "Astronomers are left no alternative but to conclude that I saw at least one, and probably two, intra-mercurial planets."

It should be kept in mind, when evaluating the observations by Swift and Watson, that observations such as these are made under unusual circumstances at an eclipse. In rare cases the eclipse path passes over an observatory but usually the astronomer is forced into the field with makeshift and temporary equipment. Furthermore, the total phase of the eclipse is very short, being only two minutes and forty seconds for the eclipse of July 29, 1878, as seen in the western United States, and observations are made under anything but leisurely conditions. The sense of urgency, combined with the temporary and unfamiliar nature of the equipment, can create hazards that are not met with in regular astronomical observations.

Nevertheless, as a result of the observations made at the solar eclipse of 1878, we have the positive statement, by two outstanding American observational astronomers, that, in their belief, intra-mercurial planets exist.

It was generally felt that the controversy generated in Wyoming and Colorado in 1878 would be resolved in the South Pacific in 1882. The eclipse of 1882 was to be of the almost unprecedented duration of five minutes and twenty-three seconds of total obscurity. During those precious five minutes, two astronomers, Trouvelot and Palisa, con-

ducted an exhaustive search for the intra-mercurial planets. None were found.

One more extensive campaign was made to rediscover Vulcan. At the solar eclipses of 1901, 1905, and 1908, C. D. Perrine of the Lick Observatory applied the relatively new technique of photography to the problem. He concluded, from photographs of the area around the sun at all three eclipses, that no planet with a diameter of twenty-five miles or greater, existed within the orbit of Mercury.

In recent years thousands of photographs of the sun under the best possible conditions with powerful telescopes have failed to reveal an object such as Vulcan.

The whole story of Vulcan began with Leverrier's attempt to explain a residual in the motion of the perihelion of Mercury. The continued lack of a satisfactory explanation of this anomaly is what held many astronomers to their belief that an intra-mercurial planet was the only way out of the difficulty. Some explanation was necessary for the integrity of the gravitational theory.

The mathematical necessity for Vulcan was established by a French astronomer at his desk in Paris. The necessity was removed by a German mathematician at his desk in Berlin, 500 miles distant and 55 years later. In 1915, Albert Einstein formulated his Theory of Relativity. One of the natural consequences of this theory was that the perihelion of Mercury should move, quite without the intervention of another planet, in the same direction and by the amount actually observed, entirely as a result of the slight modification of simple gravitational motion that is required by the Theory of Relativity.