A Mercurial Orbit laid to rest by a Genius

"The Hunt for Vulcan: How Albert Einstein destroyed a planet and deciphered the Universe", by Thomas Levenson. Published by Head of Zeus. Price GBP 14.99. (2015)

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On February 22nd, 2017, NASA announced the discovery of seven earth-sized planets orbiting a star in our galaxy. The planets also happen to be all located in the habitable zone of the star- the region where water in its liquid form can exist. This has generated a lot of excitement amongst the scientists and the public at large. Maybe we are closer to finding the first signs of life at another place in the Universe. The hunt for planets (though not exoplanets as these newly discovered ones are) is not new.

5th July, 1687 saw the publication of a book which is arguably among the most influential books of all time. The author was a relatively unknown natural philosopher and mathematician, Isaac Newton. In this book, Newton formulated a theory of gravity which not only explained the motion of planets but also laid the foundations of what has been called the Scientific Revolution. It was, as Thomas Levenson puts it, "…the long struggle through which mathematics supplanted Latin as the language of science".

Newton's theory of gravitation explained the motion of all objects under the influence of gravity- from ripe apples falling to the ground to the motion of our Moon. It did more than that. Like all good scientific theories, it was universal and predictive. With the advances in instrumentation, astronomers tested the theory with observations of the heavens and found almost excellent agreement. The orbits of newly discovered comets turned out to be exactly those that were predicted by Newton's theory.

Almost a century passed before Herschel, a German émigré in England, in 1781 discovered a new object in the sky which turned out to be a new planet- the first planet to be added to the solar system since the times of the ancients. Uranus was a large planet beyond the orbit of Jupiter. This provided an excellent opportunity to test Newton's theory- if it was correct, one could use it to calculate and predict the orbit of Uranus. Some of the best mathematicians in Europe struggled with this problem but could not get the theoretical prediction of the orbit to agree with the observations. If the theory was correct, to explain the orbit of Uranus, one needed the presence of another planet even farther than Uranus.

This object was discovered in 1846 by a brilliant, enormously ambitious and arrogant French astronomer Le Verrier. Neptune, the eighth planet in the solar system was discovered in exactly the location as predicted by Newton's theory. This was remarkable- Neptune's discovery was "the inevitable outcome of subjecting matter to number" as Levensen puts it. Here was a heavenly object, which just popped out of the theory if one needed to explain the orbit of Uranus. It was a remarkable triumph for the theory since it is one thing to explain all the known facts and quite another to be able to predict accurately.

However, another problem reared its head soon. It turned out that the orbit of Mercury was also not exactly as one would expect from Newton's theory. Le Verrier and several other astronomers calculated the orbit taking into account the influence of all the known planets and the Sun on Mercury and found that there was an anomaly. And flush with the success of predicting (and discovering) Neptune, Le Verrier proposed that there was a planet between Mercury and the Sun. This planet was given the moniker, Vulcan- the God of Fire. The race was on among the astronomers to find this object and achieve name and fame.

"The Hunt for Vulcan" by T. Levensen is an immensely readable account of the search for this elusive planet. Part history and part science, the book also provides a succinct account of what modern science is and how it actually works. The writing style is easy and the scientific explanations, though not quite detailed are adequate to follow the story. He also seems to have taken Stephen Hawking's advice that every equation in a popular science book will halve the sales! The book has only three equations (not counting the well-known $E=mc^2$) – Newton's law of motion, Newton's theory of gravity and Einstein's equation in General Relativity. Newton's laws is standard high school physics. Einstein's equation, on the other hand, is fairly obscure even for many scientists not working in the field. This must be one of the few books on popular science which has it.

After the existence of Vulcan was proposed, the next three decades saw hectic activity among professional and amateur astronomers. Since the proposed planet was small and very close to the Sun, observing it was extremely difficult. It could be observed when it transits the Sun- that is when it passes between the Earth and the Sun. There were many sightings, including the most famous one by a country doctor and amateur astronomer in 1858. But all of them turned out to be false alarms. Finally in 1878, after it could not be seen during a total solar eclipse, the idea was finally abandoned. As Levensen pithily puts it, ".. the absence of evidence had finally accumulated to a point where it had become an evidence of absence".

Levensen writes about this quest for finding Vulcan in an engaging way bringing out the human element of the story. The petty squabbles among well-known scientists, their gigantic egos and their back stories are all described well. Being the director of the Science Writing program at MIT, he is obviously an extremely accomplished writer. However sometimes the colloquial style can be a tad jarring. Thus, " ….he could simply ramp up his math chops" or " .. who doesn't love a wreck!" seem a bit incongruous in the book.

The abandonment of the idea of another planet did not mean that the original problem had gone away. Mercury's anomalous orbit remained stubbornly intractable within the parameters of Newton's Theory. And as with many examples in science, when a prediction, given by a self-consistent, hitherto successful theory fails to find its match in nature, the scientists face a conundrum- does one junk the theory as incomplete at best or wrong at worst, or does one continue one's search in nature? The standard answer to this question is that the scientific method enjoins its practitioners to abandon the theory immediately since observations are the only judge. However, science is done by humans. And humans rarely behave as logic demands.

In this case, since observations had yielded nothing, the astronomers tied tweaking Newton's theory to fit the observed orbit of Mercury. The modifications were ad hoc and inelegant. The simplicity and elegance of Newton's theory seemed to be lost. And here things stood till a young patent clerk in Switzerland came up with what has been called the most beautiful theory in Physics.

Albert Einstein had already established himself by upturning notions of space and time, which had been established since Aristotle, with his theory of relativity in 1905. The theory of relativity that he had proposed was however restricted to describing uniform motion, that is bodies moving with a steady speed or at rest. Acceleration and in particular, motion of bodies under gravity was not in its purview. There was also the nagging issue of the orbit of Mercury which could not be explained by Newtonian theory. Einstein worked on extending the theory of relativity for the next decade and ultimately came up with what is called the General Theory of Relativity.

A theory of gravity which was consistent, elegant and applicable to the whole cosmos was a remarkable achievement. However, the problem was to experimentally verify it- all known observations, with the exception of Mercury's orbit were consistent with Newton's theory. Einstein set about calculating the orbit of Mercury as a first test for the theory. And lo and behold, the numbers which his theory gave matched the observations very accurately! He had finally laid the ghost of Vulcan to rest.

Levensen's book is an excellent account of the Vulcan saga- from its birth with Newton to its eventual death. In telling this story, he effortlessly weaves in observations about the scientific method as well as the way science is actually done. It is of course more of a historical and human story than a scientific book. But it is no less enjoyable because of that.

In 2016, almost a century after Einstein propounded his theory of gravity, the Laser Interferometer Gravitational Wave Observatory (LIGO) confirmed the existence of gravitational waves. These observations finally confirmed what every scientist had always believed- that Einstein's theory was so beautiful that it just had to be THE correct theory of gravity. Three centuries after Newton subjected nature to mathematics, human beings seem to be a step closer to understanding the physical universe.

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