A Short Note on Newton's Theory of Gravitation

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Short Communication

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ABOUT THE STUDY

In 1684, Newton sent a manuscript to Edmond Halley titled De motu corporum in gyrum, which provided a physical justification for Kepler's laws of planetary motion. Halley was impressed by the manuscript and urged Newton to expand on it, and a few years later Newton published a ground-breaking book called Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy). In this book, Newton described gravitation as a universal force, and claimed that "the forces which keep the planets in their orbs must reciprocally as the squares of their distances from the centers about which they revolve[1].

Newton's Principia was well received by the scientific community, and his law of gravitation quickly spread across the European world. More than a century later, in 1821, his theory of gravitation rose to even greater prominence when it was used to predict the existence of Neptune[2]. In that year, the French astronomer Alexis Bouvard used this theory to create a table modeling the orbit of Uranus, which was shown to differ significantly from the planet's actual trajectory[3]. In order to explain this discrepancy, many astronomers speculated that there might be a large object beyond the orbit of Uranus which was disrupting its orbit. In 1846, the astronomers John Couch Adams and Urbain Le Verrier independently used Newton's law to predict Neptune's location in the night sky, and the planet was discovered there within a day[4].

Eventually, astronomers noticed an eccentricity in the orbit of the planet Mercury which could not be explained by Newton's theory; the perihelion of the orbit was increasing by about 42.98 arc seconds per century[5]. The most obvious explanation for this discrepancy was an as-yet-undiscovered celestial body, but all efforts to find such a body turned out to be fruitless. Finally, in 1915, Albert Einstein developed a theory of general relativity which was able to accurately model Mercury's orbit[6].

In general relativity, the effects of gravitation are ascribed to space-time curvature instead of a force. Einstein began to toy with this idea in the form of the equivalence principle, a discovery which he later described as "the happiest thought of my life”[7]. In this theory, free fall is considered to be equivalent to inertial motion, meaning that free-falling inertial objects are accelerated relative to non-inertial observers on the ground. In contrast to Newtonian physics, Einstein believed that it was possible for this acceleration to occur without any force being applied to the object. Einstein proposed that space-time is curved by matter, and that free-falling objects are moving along locally straight paths in curved space-time[8]. These straight paths are called geodesics. As in Newton's first law of motion, Einstein believed that a force applied to an object would cause it to deviate from a geodesic. For instance, people standing on the surface of the Earth are prevented from following a geodesic path because the mechanical resistance of the Earth exerts an upward force on them. This explains why moving along the geodesics in space-time is considered inertial[9]. Einstein's description of gravity was quickly accepted by the majority of physicists, as it was able to explain a wide variety of previously baffling experimental results. In the coming years, a wide range of experiments provided additional support for the idea of general relativity. Today, Einstein's theory of relativity is used for all gravitational calculations where absolute precision is desired, although Newton's inverse-square law continues to be a useful and fairly accurate approximation[10].

CONCLUSION

In modern physics, general relativity remains the framework for the understanding of gravity. Physicists continue to work to find solutions to the Einstein field equations that form the basis of general relativity, while some scientists have speculated that general relativity may not be applicable at all in certain scenarios.

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