Hooke's claim on the law of gravity

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14.01.2019

Sfetcu, Nicolae, "Hooke's claim on the law of gravity", SetThings (January 14, 2019), DOI: 10.13140/RG.2.2.16867.81441, URL = https://www.telework.ro.com/en/hookes-claim-on-the-law-of-gravity/

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Excerpt from the book:
Sfetcu, Nicolae, "*Isaac Newton vs. Robert Hooke on the law of universal gravitation*", SetThings (2019), MultiMedia Publishing (ed.), DOI: 10.13140/RG.2.2.19370.26567, ISBN: 978-606-033-204-6, URL = https://www.telework.ro/en/e-books/isaac-newton-vs-robert-hooke-on-the-law-of-universal-gravitation/

Hooke's claim on the law of gravity

Since ancient times, Aristotle has represented the universe as transparent concentric spheres, with the Earth in the center, then, outwardly, the spheres of the Moon, the planets, and the fixed stars. But he did not try to give any explanation to the power that provided stability to this cosmic system. He just stated that there is something, somewhere, a primal energy, later interpreted as a belief in a creative God. Aristotle considers that each sphere has an equal number of gods for which they care for it. Then Copernicus replaced the geocentric cosmological system with a heliocentric system, and Kepler systematized mathematically the laws of the planets movement around the Sun. But neither of them has said a word on the force that holds this huge

system in balance. Descartes tried to answer these questions mechanistically, through the force of impact and the existence of an invisible substance - the Cartesian vortex.

During the second half of the seventeenth century there was a plethora of thinkers of the Scientific Revolution, such as Robert Boyle, Christiaan Huygens, Robert Hooke, Isaac Newton, Gottfried Wilhelm Leibniz, etc., starting many controversies about intellectual property and disputes about the scientific priority on new discoveries and concepts. (Guicciardini 2005)

The modern theory of gravity began with the work of Galileo Galilei, with his famous experiments of the balls falling from the tower of Pisa and left to slip on an inclined plane. He found that gravity is the same for all objects, the differences occurring only due to different resistances to the air during the fall. (Bongaarts 2014)

Based on Galileo's experiments, Newton develops the theory of gravity in his first book *Philosophiæ Naturalis Principia Mathematica* ("*Principia*") of 1686. Immediately after, Robert Hooke accused Newton of plagiarism, claiming that he unduly assumed his "notion" of "the rule of the decrease of Gravity, being reciprocally as the squares of the distances from the Center". But, according to Edmond Halley, Hooke agreed that "the demonstration of the curves generated by it" belongs entirely to Newton. (Nauenberg 2005)

Thus, the question arises as to the extent to which Isaac Newton was "inspired" by Robert Hooke's previous works, and to whom the priority of universal gravity law should be given. Some historians of science highlight Newton's mathematical genius without which the law of gravity would never be finalized, while others noted the contribution of the "mechanical genius" (Hooke) to whom the Westminster Abbey place was denied by a puritan tyrant (Newton).

A long debate from then on to our day.

Robert Hooke's contribution to the law of universal gravitation

Robert Hooke published his ideas about gravity in the book "*The System of the World*" in 1660, and then read before the Royal Society in 1666 a work "*On gravity*", "inflection of a direct motion [inertial motion] into a curve by a supervening attractive principle," developing it in another work in 1674. (“An Attempt to Prove the Motion of the Earth from Observations,” n.d.) He announced that he intended to "explain a system of the world very different from any yet received." (Purrington 2009) Thus, he presented in a clear way the reciprocal attractions between the Sun and planets, inversely proportional to the distance between the bodies, together with a principle of linear inertia.

But Hooke's exposure was not universal, and he did not offer mathematical demonstrations. Hooke himself stated in 1674: "Now what these several degrees [of attraction] are I have not yet experimentally verified" ... "This I only hint at present," " having my self many other things in hand which I would first compleat, and therefore cannot so well attend it " ("prosecuting this Inquiry"). (“An Attempt to Prove the Motion of the Earth from Observations,” n.d.) On January 6, 1679[1], writing to Newton, Hooke expressed "supposition ... that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocal, and Consequently that the Velocity will be in a subduplicate proportion to the Attraction and Consequently as Kepler Supposes Reciprocal to the Distance." (Newton, Correspondence of Isaac Newton, Vol 2 (1676-1687) 1960) (Inference of speed was incorrect. (Wilson 1989)) Hooke mentioned in this correspondence, on November 24, 1679, an approach of "compounding the celestial motions of the planets of a direct motion by the tangent and an attractive motion towards the central body." (Newton 1960)

[1] Calendar (New Style) Act 1750

Isaac Newton's contribution to the law of universal gravitation

In 1687, Isaac Newton published *Principia*, where he demonstrates that the force of attraction between two bodies is proportional to the product of the masses and inversely proportional to the distance between them, namely the law of universal gravitation: "I deduced that the forces which keep the Planets in their Orbs must be reciprocally as the squares of their distances from the centres about which they revolve : and thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the Earth, and found them to answer pretty nearly.": (Chandrasekhar 2003)

$$\mathbf{F = G \cdot m_1 m_2 / r^2}$$

where F is the force, m_1 and m_2 are the masses of the objects that interact, r is the distance between the mass centers and G is the gravitational constant.

Robert Hooke's claim of his priority on the law of universal gravitation

In a memo titled "*A True state of the Case and Controversy between Sr Isaak Newton and Dr Robert Hooke as the Priority of that Noble Hypothesis of Motion of ye Planets about ye Sun as their Centers*," (Gunther, n.d.) not published during his life, Hooke described his theory of gravity. To support his "priority," Hooke cites his lectures on planetary movements of May 23, 1666, "*An attempt to prove the motion of the earth from observations*" published in 1674, and the correspondence with Isaac Newton in 1679. (Newton 1960) Edmond Halley asked him to produce a different demonstration from Newton. It can be seen from Figure 1 that Hooke's geometric construction is practically the same as that described by Newton (see Figure 2). (Newton, n.d.)

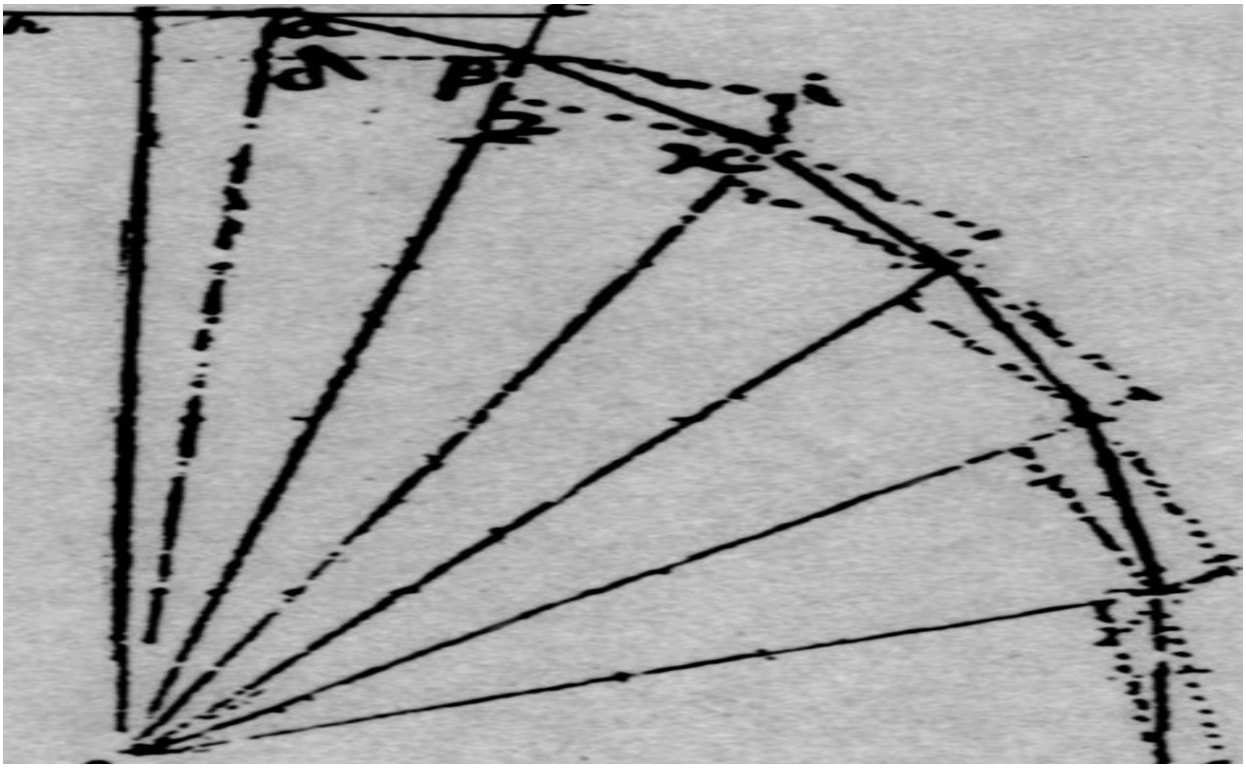

Figure 1: Hooke's partial diagram of Sept. 1685 for a discrete approximation to an elliptical orbit.

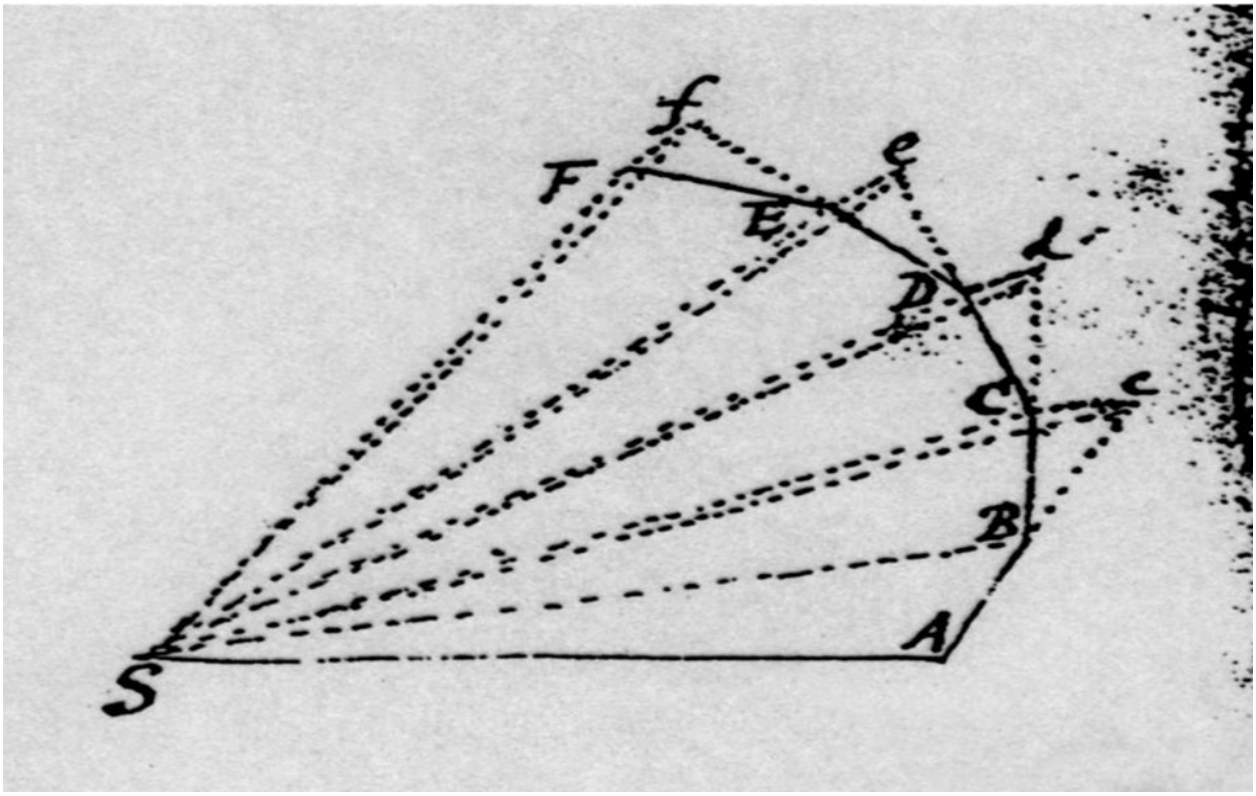

Figure 2: De Motu's diagram associated with Newton's proof showing the construction of a discrete orbit.

In his memoir, Hooke said that he already suggested in 1666 that the motion of planets around the sun can be understood by the "inflection of a direct motion [inertial motion] into a curve by a supervening attractive principle," the gravitational attraction of the sun. (Hooke, n.d.) In his monography of 1674, Hooke stated the assumption of universal gravitation law as well:

> "all celestiall bodys whatsoever have an attraction or a gravitating power towards their own Centers, whereby they attract not only their own parts, & keep them from flying from them, as we may observed the Earth to do, but that they do also attract all the other Celestiall Bodies which are within the sphere of their activity.",
>
> assuming that
>
> "... not only the Sun and Moon have an influence upon the body and motion of the Earth and the Earth upon them, but that Mercury, also Venus, Mars, Saturn and Jupiter by their attractive powers, have considerable influence upon its motion as in the same manner the corresponding attractive power of the Earth hath a considerable influence upon every one of their motions also."[2] (Hooke, n.d.)

Newton's defense

Newton denied that Hooke had to be credited as the author of the idea. Among the reasons, Newton reminded that the idea was discussed with Sir Christopher Wren before Hooke's letter of 1679. (Newton 1960)

Newton said that even if he had previously heard of Hooke's inverse proportion, he would still have certain rights in his demonstrations with accuracy. Hooke, without evidence in support of his assumption, could only guess that the law of squares is roughly valid at great distances from the center.(Newton 1960)

In addition, the manuscripts written by Newton in the 1660s show that Newton himself, until 1669, came to evidence of the reverse-square relationship with the distance from the center. (Whiteside 1991)

[2] This book is titled *The System of the World*, which are the same words Hooke used to introduce his theory of universal gravity into his 1674 tract, *An Attempt to Prove the Motion of the Earth by Observations*.

On the other hand, Newton acknowledged in *Principia* Hooke's contribution along with other scientists: "yet am I not beholden to him for any light into that business but only for the diversion he gave me from my other studies to think on these things & for his dogmatism in writing as if he had found the motion in the Ellipsis, which inclined me to try it ..." (Newton 1960)

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