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# Vortex Theories in the Early Modern Period

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## Related Topics

Cartesianism

Mechanical philosophy

Newtonianism

## 1. Introduction

In the early modern period, various philosophers and scholars have proposed the idea of the vortex, i.e., of a fluid in rotational movement around an axis, in particular Descartes, to explain the movement of the planets around the Sun, in the same direction and in approximately the same plane. Some of Descartes' disciples, the most prominent being Malebranche, generalized this idea by imagining the universe entirely filled with small vortices, of all sizes, in order to explain all physical and chemical phenomena. These theories were gradually abandoned in the first half of the eighteenth century in the face of the growing success of Newtonian mechanics. It was only in the nineteenth century that vortex flows were really understood by physicists.

## 2. Kepler and Descartes

In the early modern period, the vortex theory is standardly associated with Descartes, constituting the basis for his explanation of the movement of the planets. The idea of a fluid vortex dragging the stars along their paths and thereby explaining their movements is however an old one, as it was the ancient atomists who first used this concept. Kepler, in turn, used the idea of a vortex driven by the rotation of the Sun around its own axis to explain the movement of the planets in a heliocentric context. Unlike the vortex as conceived by Descartes, Kepler's vortex acts almost immaterially: it is an emanation ("species immaterial") radiating from the Sun and rotating with it, which drives the planets along their orbits. For Kepler, this vortex explains only the general movement of the planets around a circle centered on the Sun, while the variations in distance from the Sun during the orbital path — an ellipse in which the Sun occupies one of the foci — are explained by a magnetic force between the Sun and the planets.

Descartes provided the first description of his vortex theory in a manuscript that remained unpublished during his lifetime, *Le monde ou traité de la lumière* (Descartes 1664). This text, written in the early 1630s, was contemporary with the condemnation of Galileo's heliocentrism. As Descartes' theory implied the movement of the Earth around the Sun, he preferred to delay its publication and only put partial elements into print: *Dioptrique, Météores...* (Descartes 1637). It was only in 1644 that Descartes finally published his *Principia Philosophiae* (Descartes 1644), which gave a complete presentation of his vortex theory.

Descartes' goal, and one he shared with Kepler, was to replace the old explanations that the scholastics had given for the movement of the planets and so dispense with the crystalline spheres driven by mysterious cosmic forces that carried the planets in their orbits around the Earth. For Descartes, the vortex approach represents a way of "mechanizing" the explanation of celestial movements.

In this system, the matter in the Universe is divided into three types of elements. Most of the space is filled up with the round corpuscles of the second element. The first element, composed of very subtle, small, and mobile corpuscles, makes up the Sun and the stars. The corpuscles of this first element are "scrapings" resulting from the friction between the corpuscles of the second element, and they fill all the gaps between these larger corpuscles, as there is no void in the Cartesian universe. Finally, the Earth and the planets are made up of the much larger and coarser corpuscles of the third element.

Each star, including the Sun, is surrounded by a fluid vortex rotating around it, and this vortex is made up of particles of the second element. All the matter in a vortex tends to move away from the center (occupied by the star or the Sun) due to the centrifugal force generated by the rotation of the vortex. The indefinite expansion of any vortex is prevented by the presence of other vortices, allowing each one to reach a kind of state of equilibrium. This equilibrium is very relative, with some vortices being eroded or even ultimately destroyed by neighboring ones. More importantly, stars that have had their vortices destroyed become planets or comets, the former being captured by a neighboring vortex, while the latter, interstellar travelers, now move from one vortex to another. The matter of the vortices drags the planets along their paths and thus explains the revolution of the planets around the Sun (or the stars) and their orbits. In the case of the solar system, the matter of the vortex rotates more and more slowly as we get further away from the Sun, until the orbit of Saturn, the most distant known planet. Beyond Saturn's orbit lies the outer part of the vortex, by far the largest part. Starting from here, the law of motion is reversed: the further away from the Sun and the closer to the edge of the vortex we get, the faster the fluid rotates around the Sun. For Descartes, this is the domain of comets, which pass with great speed from one vortex to another.

It should be noted that Descartes aims to provide a global description of the Universe and is not, like Kepler, trying to explain the movement of the planets in detail. The matter of the first element, which constitutes the body of the Sun, arrives from the neighboring vortices via the poles of the solar vortex (hence from the north and south), while the same matter is subsequently expelled from the Sun along the plane of the ecliptic, from where it will nourish the neighboring vortices, and thus the neighboring stars, passing once again via the poles of their vortices. There is, therefore, a whole cycle of transport for this material from one star to another. According to Descartes, two neighboring vortices cannot be in contact through their poles. On the other hand, there are neighboring vortices whose poles are in contact with the

equator of another vortex, which enables the transport of part of the corpuscles of the first element between the stars. These corpuscles [which are in fact groups of corpuscles forming small columns] have a cross-section in the shape of a curvilinear triangle with concave sides. These concavities form “channels”, and these corpuscles are called “channelled” (or channelled parts), a shape that facilitates their movement. As the movement of these small columns of the first element from one pole to the center of the vortex combines with the rotation of the vortex, they describe a spiral trajectory.

Light comes from the action of the stars, according to two processes. First, the very violent agitation of the first element within the body of the Sun and the stars pushes out radially on the surrounding second element, which explains the emission of light in all directions. For Descartes, the propagation of light is instantaneous (infinite speed) and corresponds to the transmission of pressure within the second element. Then there is an additional cause of light emission in a star’s plane of rotation, which in the case of the Sun corresponds approximately to the plane of the planetary system, and that is the action of the centrifugal force that pushes the corpuscles of the vortex radially. In the terms of the Cartesian theory, we can say that the first element is the source of light, the second is its vector, and the third reflects light.

Descartes gives an explanation of gravity based on the fact that each planet is also at the center of a vortex of corpuscles of the second element. This vortex, embedded in the great solar vortex, helps to explain the movement of satellites such as the Moon or Jupiter’s four main satellites. At the surface of each planet, the vortex has a much higher velocity than the diurnal rotation, so that the centrifugal force of the vortex’s corpuscles is greater than that of “ordinary” matter (composed of the third element). The matter of the vortex that circulates beneath any single body separated from the earth’s surface rises above this body, and the body descends to occupy the place of the subtle matter. Moreover, according to Descartes, this rapid movement of the second element is not only in the form of a vortex, there are also many different motions of the subtle matter in every direction. The second element, repelled by the hardness of the earthly body, tends to move away from it, and to push the coarse matter toward the center of the Earth (Descartes 1647, Part IV, art. 27) (see Palmerino 2006, Schuster 2013).

### 3. After Descartes

The explanation of the Earth’s gravity was the topic of a significant debate at the Royal Academy of Sciences in 1669. This provided Huygens with the opportunity of transforming the qualitative hypothesis of vortices into a physico-mathematical model. After demonstrating with an experiment that a body immersed in a vortex of water is pushed back toward its axis of rotation, he applied theorems of centrifugal force to calculate that the velocity of fluid matter needs to be 17 times higher than that of a point on the equator to produce gravity. However, two facts needed to be explained, namely that heavy bodies are not driven horizontally by the subtle matter and that they are not pushed toward the axis of rotation of the vortex but toward its center. Huygens proposed that subtle matter was moving in circular motions in all directions on spherical surfaces and that under the influence of the very fast and diverse successive impulsions of the subtle matter, heavy bodies do not follow any specific circular motion, while the centrifugal force of the subtle matter produces a gravitational action in all planes of the spherical vortex, i.e., toward its center. In his *Discours de la cause de la pesanteur*, Huygens (1690) discusses the effect of the Earth’s rotation on the period of oscillation of a pendulum. He calculated that the diurnal motion of the Earth reduces the weight by  $1/289$  at the equator. Another expected consequence was that

the Earth should have the shape of an oblate spheroid. Using Newton's model, which consisted in studying the equilibrium of two fictitious channels leading from the center of the Earth to the poles and to the equator, Huygens calculated the ratio of the axes of the terrestrial spheroid, although he arrived at a different result because he assumed that gravity within the Earth was the same as on its surface. Although it was the best developed among all the Cartesian theories of terrestrial gravity, Huygens' approach failed to account for either universal gravitation or the inverse square law.

The influential Cartesians Regius, Rohault, and Régis faithfully adopted Descartes' vortices, making no new contributions to the theory of planetary motion. Like Descartes, they failed to take Kepler's laws into account, although most astronomers knew about them at the time. Rohault's *Traité de physique* (Rohault 1671) becomes the reference text for Cartesian physics, especially in Cambridge. The English edition, annotated by Samuel Clarke, was published in 1697 and did not feature any criticism of the vortices and did not even mention Newton's gravitational force of attraction. It was only in the notes added to the book in 1710 that the vortices were presented as fictions for the first time and only in the footnotes of subsequent editions that the editors raised the Newtonian objections to the vortices. In France, Fontenelle popularized the theory of vortices in his *Entretiens sur la pluralité des mondes* (1686), by associating it with his idea of a plurality of worlds.

#### 4. The Development of Vortex Theories

Leibniz also proposed a vortex-type theory of planetary motion, partly inspired by Kepler's theory (Leibniz 1689). For Leibniz, a planet's orbit resulted from two different motions: a circular "transradial" motion, centered on the Sun, which was due to the action of the vortex around the Sun, and a radial motion resulting from the action of two forces, namely a centripetal force of gravitation toward the Sun and a centrifugal force due to the planet's motion around the Sun. The gravitational force, he suggested, could be due to rays emanating from the Sun, which would explain why the gravitational force was inversely proportional to the square of the distance of the planet (light intensity also decreases according to an inverse square law).

Leibniz was the first author to try to provide a detailed explanation of planetary motion based on a vortex theory, and for a long time, his remained the only such attempt. It was only at the end of the first decade of the eighteenth century that others would try to do this again. This new era was initiated by the clergyman from Lyon; Philippe Villemot who, in 1707, published his *Nouveau Système ou Nouvelle Explication du Mouvement des Planètes* (Villemot 1707). In this short book, he tried to explain the main laws of planetary motion based on vortex theory, in particular Kepler's third law, which he explained on the basis of an equilibrium between the centrifugal forces of the successive concentric layers of a vortex. This explanation was later adopted by other authors and was elaborated by Privat de Molières from the late 1720s onward. Many theoretical but also experimental (like Nicolas Saulmon's — see Saulmon 1717) works attempted to give an explanation of terrestrial gravity using vortex theories. It should be noted that most of the authors who tried to develop this kind of theory between 1707 and the end of the 1730s lived in France (see Brunet 1931). This seems to be related to a growing awareness of the threat that Newton's doctrine posed to vortex theories and to Cartesianism in general, in a context where French scholars wanted to defend their fellow countryman. This awareness increased throughout the second decade of the eighteenth century, and was accentuated by the publication of the second edition of Newton's *Principia* in 1713 (Newton 1713) featuring Cotes' strongly anti-Cartesian preface. This second

edition was much more widely disseminated than the first edition of the book. Newton's *Principia* itself contained virulent attacks on the vortex theories, insisting that such theories were incompatible with Kepler's laws. Another important factor was the controversy between Leibniz and Samuel Clarke, where Leibniz argued that Newton's ideas posed a materialist and antireligious threat to society (see Shank 2008). Moreover, Newton's hypotheses concerning the existence of a void and action at a distance were generally not well received, with action at a distance suggesting the resurgence of the "occult ideas" of scholastics that Descartes had succeeded in banishing from natural philosophy.

## 5. "Small Vortices"

In his "Eclaircissement XVI" of *De la Recherche de la vérité* published in 1712 (Malebranche 1712), Malebranche introduced some major reforms in the Cartesian doctrine. Here, he proposed the particularly significant innovation of small vortices of subtle matter to replace Descartes' corpuscles of the second element. There was still no vacuum in this system, as the gaps between the small vortices were filled in by even smaller ones. These small vortices maintained equilibrium thanks to the reciprocal action of their respective centrifugal forces. Malebranche intended these small vortices to play a large role in the explanation of many physical phenomena, such as the hardness and elasticity of bodies, the propagation of light and heat, why heavy bodies fall... Indeed, this concept was adopted by many authors starting in the 1720s.

The theory of small vortices was significantly elaborated by Privat de Molières in his *Leçons de Physique* (Molières 1733-1739). Molières proposed that Malebranche's small vortices were themselves made up of even smaller vortices, suggesting a chain of small vortices of different orders. The equilibrium and disequilibrium among these small vortices could, it was hoped, be used to explain all physical phenomena, covering not only magnetism and electricity but also chemical reactions. However, the introduction of small vortices did not replace the large Cartesian ones, which continued to be used to explain the motions of the planets and their satellites.

## 6. The Twilight Years of Vortex Theories

In general, by the 1730s the supporters of vortex theories had become as virulent as they were dogmatic, although they did try to incorporate some Newtonian results into their conceptual framework. It was during this period that a "Newtonian party" emerged within the Royal Academy of Sciences in Paris around Pierre-Louis de Maupertuis, who with *A Discourse on the different forms of the stars* (Maupertuis 1732) became the first major French scientist to come out in support of Newtonianism and against the vortex theories. The trend of incorporating Newtonian ideas into vortex theories is clearly visible in the memoirs submitted for the Academy's prizes during this decade by scholars such as Jean and Daniel Bernoulli (see, e.g., Bernoulli 1752) and Pierre Bouguer (Bouguer 1734). Gamaches also adopted this approach (Gamaches 1740).

At the end of the 1730s and beginning of the 1740s, scientists generally abandoned the vortex theories following a generational change in France marked by the disappearance of those who had received their training in a Cartesian setting. Furthermore, expeditions to Lapland and Peru in order to determine the

shape of the Earth had a major effect in discrediting the vortex theories at this time. These expeditions provided evidence that the Earth is flattened at the poles as predicted and calculated by Newton and not elongated as predicted by supporters of vortex theories like the astronomer Cassini.

The early 1740s witnessed the triumph of Newtonian theory in France, with landmark publications in favor of the theory by Clairaut (*Théorie de la Figure de la Terre*, 1743) and D'Alembert (*Traité de dynamique*, 1743). The 1740 tidal prize stands as a significant indicator of a shift in stance by the *Académie Royale des Sciences*. For the first time, the judges of this prize accepted “Newtonian” submissions on the subject, although Fontenelle, the perpetual secretary of the Academy from 1697 to 1740, remained an adept of the vortex theory until the end of his life, publishing the last notable text in support of this theory as late as 1752 (Fontenelle 1752). This period also coincides with the production of texts that assessed the many objections that had been made against Cartesian vortices (Bouguer 1748), leading to the marginalization of explanations of gravitation in line with Descartes’ mechanical philosophy. Even other mechanical theories that bore no relation to vortex theory, such as Le Sage’s corpuscular theory (based on ideas that can already be found in Nicolas Fatio’s work), failed to attract any interest because of the absence of any plausible mathematical models.

For more information on vortex theory see the publications by Brunet (1931), Aiton (1972), Guerlac (1981), Shank (2008) and Borghero (2011); also see the introduction to Crepel and Schmit (2017).

## Cross-References

Action at a distance  
Attraction  
Clarke, Samuel  
Descartes’ Mechanical Philosophy  
Fontenelle, Bernard le Bovier de  
Huygens, Christiaan  
Leibniz, Gottfried Wilhelm  
Malebranche, Nicolas  
Maupertuis  
Mechanical Philosophy: an Introduction  
Newton and Descartes  
Newtonianism on the Continent  
Rohault, Jacques

## References

Aiton EJ (1972) *The vortex theory of planetary motions*. Mc Donald, London, American Elsevier, New York

Bernoulli J (1742) *Essai d’une nouvelle physique céleste*. In: Johannes Bernoulli, *Opera Omnia*, tomus tertius. Bousquet, Lausanne & Genève

- Borghero C (2011) Les cartésiens face à Newton. Philosophie, science et religion dans la première moitié du XVIIIe siècle. Brepols, Turnhout
- Bouguer P (1734) Entretiens sur la cause de l'inclinaison des orbites des planètes. Jombert, Paris
- Bouguer P (1748) Entretiens sur la cause de l'inclinaison des orbites des planètes, Seconde Edition, Dans laquelle on a saisi l'occasion d'examiner quelle est l'étendue du Méchanisme ou des loix de Physique. Ant. Jombert, Paris.
- Brunet P (1931) L'introduction des théories de Newton en France au XVIIIe siècle, vol. I avant 1738. Albert Blanchard, Paris
- Clairaut A (1743) Théorie de la Figure de la Terre, Tirée des Principes de l'Hydrostatique. David fils, Paris
- Crepel P and Schmit C (eds) (2017) Autour de Descartes et Newton – Le paysage scientifique lyonnais dans le premier XVIIIe siècle. Hermann, Paris
- D'Alembert J (1743) Traité de dynamique. David l'ainé, Paris
- Descartes R (1637) Discours de la méthode pour bien conduire la raison, et chercher la vérité dans les sciences, plus la dioptrique, les météores et la géométrie qui sont des essais de cette méthode. Maire, Leyden
- Descartes R (1644) Principia philosophiae. Ludovicus Elzevirius, Amsterdam
- Descartes R (1647) Les principes de la philosophie. Henry Legras, Paris
- Descartes R (1664) Le Monde de Mr Descartes ou traité de la lumière. Théodore Girard, Paris
- Fontenelle N (1752) Théorie des tourbillons cartésiens, avec des réflexions sur l'attraction. Hyppolite-Louis Guérin, Paris
- Gamaches ES (1740) Astronomie physique ou principes généraux de la nature appliqués au mécanisme astronomique & comparés aux Principes de la philosophie de M. Newton. Jombert, Paris
- Guerlac H (1981) Newton on the continent. Cornell University Press, Ithaca/London
- Huygens C (1690) Traité de la lumière, où sont expliquées les causes de ce qui luy arrive dans la réflexion et la réfraction et particulièrement dans l'étrange réfraction du cristal d'Islande. Avec un Discours de la cause de la pesanteur. Pierre Van der Aa, Leyde
- Leibniz G (1689) Tentamen de motuum coelestium causis. In: Acta Eruditorum, Leipzig, pp 82-96
- Malebranche N (1712) De la recherché de la vérité. Michel David, Paris
- Maupertuis PLM (1732) Discours sur les différentes figures des astres, Imprimerie royale, Paris
- Molières JP (1733-1739) Leçons de Physique, Veuve Brocas, 4 vol., Musier, Joseph Billot, Paris
- Newton I (1713) Philosophiae Naturalis Principia Mathematica, 2nd edn. Cambridge



Palmerino CR (2006) Bodies in water like planets in the skies: uses and abuses of analogical reasoning in the study of planetary motion. In: Bucciandini M, Camerota M, Roux S (eds) *Mechanics and cosmology*, Olschki, Florence, pp 145-168

Rohault J (1671) *Traité de physique*, 2 vol., Veuve de Charles Savreux, Paris

Schuster J (2013) *Descartes–Agonistes: Physico–mathematics, method and corpuscular–mechanism, 1619-1633*. Springer, Dordrecht, pp 453-524

Shank JB (2008) *The Newton wars and the beginning of the French enlightenment*. University of Chicago Press, Chicago

Villemot P (1707) *Nouveau système ou nouvelle explication du mouvement des planètes*. Declaustre, Lyon