the general science journal

Commentary on Boscovich in Encyclopaedia Britannica, fourth edition vol. IV, 1810

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I discuss with various people about Boscovich and his theory, but there does not seem an adequate source to refer to dealing with it; so I provide one here. With the supposed revolutions in physics due to Einstein, much of the physics before Einstein gets forgotten; and Boscovich is far too important to be allowed to be forgotten.

I have split the Britannica article into the following headings:

1. Early History

2. The subjects studied by Boscovich leading to his unified theory

3. Boscovich's contributions to science

4. Further works of Boscovich

5. Introduction to Boscovich's theory

6. Boscovich's System of Natural Philosophy

7. Boscovich's curve

8. Analytic deduction of Boscovich's theory

9. Conclusion

1. Early History

The article begins with a history of Roger Boscovich:

BOSCOVICH, ROGER JOSEPH, the founder of an original and sublime theory of natural philosophy, deserves to be particularly noticed in a work of this nature; but we have to regret that the materials from which our biographical memoir must be compiled, are insufficient to satisfy the curiosity concerning the literary habits, and the characteristic features of this very illustrious man.

His rank, indeed, as a philosopher, we are enabled to appreciate by perusing some of the immortal works which he has bequeathed us; but, for a knowledge of his moral character, disposition, and temporal concerns, we can only have recourse to the elegies of his friends. These are certainly entitled to much of our confidence; and when the names of M. de la Lande, M. Sabroni, Stay, and Zamagna are mentioned, we may be thought fastidious, in implying the least difficulty of their testimony. It is our respect for the public and for truth, and it is our knowledge of the nature of elegies [*], which have made us so.

[*] elegy – lament for the dead

We have, therefore, endeavoured, rather to relate the incidents in the life of Boscovich, than to give the transcript of friendly effusion; and yet perhaps it maybe discovered, that our portrait is luminous with eulogium [*], while its outlines are poorly defined.

[*] eulogium – plural of eulogy – speeches or writings in praise of a person.

Boscovich was born on the 11th of May 1711, at Ragusa, a sea port on the coast of the Adriatic, and capital of a small republic of the same name, under the protection of the Turks and the Venetians. We know so little of his parents, that we can only conjecture at their circumstances and capacity, from the education which they gave to their son being liberal and judicious.

It does not appear that our author gave any tokens of superior genius, till he was sent to learn grammar and philosophy in the schools of the Jesuits [*], who were at that time the principal teachers in Ragula, and throughout Italy.

[*] nickname for the Society of Jesus priesthood part of the Catholic Church. Numerous conspiracies surround the Jesuits.

Amongst them, his docility and obedience could not pass unnoticed, but were sufficient to mark him as a likely subject for future eminence, and consequently to procure to him particular attention. In his 15th year, after he had gone through the ordinary course of education, and when it was necessary to determine his further pursuits, application was made to admit him into the order;[*]

[*] i.e. for him to become a Jesuit priest.

and for the reasons we have mentioned, was readily complied with. This was agreeable to his own inclination, and proved the source of that distinction in learning to which he afterwards attained.

The Jesuits, it is well known, had much interest and authority to promote in the city of Rome; whither it was customary in them to send those members whom they knew to be qualified for that purpose, and those youths of whom they had great expectations, for more instruction. As Boscovich was sent there in the year 1725, we may reasonably imagine he had profited much by his teachers, and was signalized for his abilities. This zeal in the cultivation of youth, which the Jesuits ever preserved, and which perhaps tended more to the preservation of their power than all their religious artifices, was attended with consequences the most beneficial to humanity; and when we recollect how many and how great the geniuses were which it discovered, and fostered and brought to maturity, we are almost induced to believe that it counterbalanced all the ill effects of their order.

Me: Slight criticism of the Jesuits by saying “counterbalanced all the ill effects of their order.”

Britannica: Had this education been confined to some limited sphere; had it embraced the prattling doctrines of casuistry [*] and the unwieldy mass of cloistered theology alone; unfortunate and melancholy for the world would have been this zeal: no refuge for the venial penitent, no security against boisterous sectarism would have remained; an unmanly lethargy would have debased the

mind, and the moral and the intellectual world would have sunk to a dread chaos of confusion.

> [*] casuistry – reasoning that is misleading or oversubtle.
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> Me: The author of this Britannica article might be revealing a prejudice against the Catholic Church's priesthood, by calling their thinking "casuistry", and saying they debase the mind.

Britannica: But the Jesuits knew well the benignant influence of literature, and the salutary elevation of science they saw that wealth, and power, and honour, followed philosophy ; and that philosophy had driven famine, wretchedness, and vice, from their habitations. We dare not say that the interest and aggrandizement of their order were secondary considerations, but we will avow it as our opinion, that the short reign of the Jesuits, and the objects at which they aimed, and above all the means which they employed, were more instructive, promised better, and effected more to humanity, than all the accumulated humility and sanctity of all the religious societies of the Roman church. We have been led into this digression by the coincidence of certain considerations operating at the time on our minds. Boscovich was of the order of Jesuits; that order is no more; [*] its destruction took place in his life-time; gratitude for the delight and the instruction we have received from him and many others of the order; the present disposition among" mankind to detract from its merits, to magnify its imperfections, and to confound it with the fanatical and enthusiastic groups of every persuasion which have disgraced the name and the dignity of religion.

> Me: The order of Jesuits was disbanded in Boscovich's lifetime, but later reformed. The author of this Britannica article is writing without knowing that in his future – the Jesuits were reformed.

Britannica: But to return; our author [i.e. Boscovich] on his arrival in Rome, entered the novice ship of the order, where his Studies were a new aspect, but were still pursued with diligence. Christian morality, the rules and constitutions of the order, claimed his attention for two years; after which he was instructed in rhetoric, and became well versed in general literature, in a particular manner in Latin poetry, which at that time was very much cultivated.

From the noviciate he was sent to the Roman College to study mathematics and physics. It was in these sciences that his elevated genius and uncommon abilities shone forth to[o] conspicuously, and procured to him the admiration of his superiors. In three years time he was able to give private lessons on mathematics ; and was then exempted from a law, by which the noviciates were bound to teach Latin and the belles lettres [*] for five years before they commenced the Study of theology.

[*]belles lettres – literature regarded as fine art.

This exemption was in consequence of his great predilection to the mathematics, of which he was soon afterwards made public professor. It would appear to us, that the science of theology, as it was then inculcated [*],

[*] inculcate – to strongly teach by repeated statement.

had little attraction for the mind of Boscovich ; for it is not likely that a mind intimately acquainted with truth, and accustomed to find her ever plain and undisguised, could relish the retiring obscurities of sophistry, [*]

[*] sophistry – clever but invalid arguments.

Me: The author of this Britannica article reveals again a possible prejudice against the Catholic priesthood by calling their thinking sophistry.

Britannica: or the flimsy decorations of a mystical religion ; nor can we wonder, that during the four years in which he was constrained to the study, he should become more familiar with Leibnitz, Maclaurin, and Newton, than with Loyola, and Laynez, and Aqua viva.[*]

[*] aqua viva – water of long life (elixir of life).

Me: A thing to note is that the heliocentric theory was banned in Catholic countries when Father Boscovich was studying Newton.

From wikipedia: In 1664, Pope Alexander VII published his *Index Librorum Prohibitorum Alexandri VII Pontificis Maximi jussu editus* (Index of Prohibited Books, published by order of Alexander VII, P.M.) which included all previous condemnations of heliocentric books. An annotated copy of Philosophiae Naturalis Principia

Mathematica by Isaac Newton was published in 1742 by Fathers le Seur and Jacquier of the Franciscan Minims, two Catholic mathematicians with a preface stating that the author's work assumed heliocentrism and could not be explained without the theory. In 1758 the Catholic Church dropped the general prohibition of books advocating heliocentrism from the *Index of Forbidden Books*. Pope Pius VII approved a decree in 1822 by the Sacred Congregation of the Inquisition to allow the printing of heliocentric books in Rome. [2]

> Me: Note – heliocentrism was banned and the priests le Seur and Jacquier were able to read Newton's book – decide it was based on heliocentrism and publish a book on it. Priests or certain priests in Catholic countries had privileges that allowed them to read banned books; it was only the general populace not allowed to read banned books. And since these priests published a book on Newton it must have been only intended for other priests (and other elite allowed to read banned books). So when Father Boscovich was studying Newton it was known that Newton was based on heliocentrism; and as a priest was allowed privilege to read forbidden books such as Newton. Note also that the ban on heliocentrism was lifted in 1758 the same year as Boscovich published his book "Theory of Natural Philosophy" based on Newton's work, offering a unified theory of Newtonian physics.

2. The subjects studied by Boscovich leading to his unified theory

Britannica: For the professorship of mathematics he {Boscovich] was eminently qualified, as, besides a thorough knowledge of all the modern productions in the science, he had acquired a pristine severity of demonstration by studying the works of the ancient geometricians; and he conjoined withal an obliging accommodation of his own powers to the deficiencies of his pupils. It was for their benefit he at this time composed elementary treatises on arithmetic, algebra, geometry, and trigonometry.

But notwithstanding the arduous duties of his situation which he invariably fulfilled, he found time to instruct and enlighten more than boys; for about this period, he entertained some of those original notions Boscovich, which were destined to grow up- into system, and one day

to astonish the whole world of science. These, as they grew, were strengthened by solid arguments in the public disputations, by anticipating obstacles, overcoming and removing them, and by mighty efforts in extending and applying them to the most remote and discretive actions of the universe. The animating Spirit of discovery and invention led him to consider every portion of physical science; and indeed so versatile and so vigorous was his mind, we would be at a loss to specify one portion, which, within a few years, it did not comprehend, elucidate, and advance. In confirmation of this we beg to present our readers with an enumeration of the principal subjects to which he turned his attention, and concerning which he published dissertations whilst he continued in the professorship.

- The transit of Mercury over the sun
- the spots in the sun
- the aurora borealis
- the construction of Spheric trigonometry
- the figure of the earth
- a new telescope to determine celestial objects
- the ancient arguments for the rotundity of the earth
- oscillating circles
- on infinites and infinitely little quantities
- the motion of bodies in unresisting spaces
- the aberration of the fixed Stars
- the inequalities in terrestrial gravity
- on astronomy
- on the limits of certainty in astronomical observations
- on the solid of greatest attraction
- the cycloid
- the logistic curve lines
- the vires vivce
- the comets
- light
- tides
- the rainbow
- the calculation of fractions
- the centre of gravity
- the moon's atmosphere
- the law of continuity
- lenses and dioptrical telescopes
- the objective micrometer
- The divisibility of matter.

Some of these are short, but all of them contain curious and valuable matter. It is only by perusing them we are able to discover the gradual progress of his mind; and to understand the manner in which he arrived at the theory of natural philosophy, which alone will render his name immortal.

About this time a taste for philosophical poetry was much prevalent amongst the learned, and some of our author's acquaintances had laboured in it with success. Of these we may mention Father Noceti who wrote on the rainbow and the aurora borealis, and the justly celebrated Benedict Stay, whose poems on the philosophy of Descartes, and on the more modern philosophy, are excellent examples of fine Latin composition and scientific investigation. Boscovich published their works with annotations and supplements, in which a splendid fund of information and learning is displayed.

By such undertakings, the same of our author was widely diffused, and he became an object of general admiration. The learned societies of many countries in Europe conferred on him unsolicited honours, and several foreign princes invited him to their courts. His opinions on various subjects of civil architecture, topography, and hydrodynamics, were asked and entertained by Pope Benedict XIV. John V. of Portugal, and others. These necessarily required his presence in different states, where he never failed to increase his reputation, and often terminated disputes which might otherwise have gone on to open warfare. He was employed to correct the maps of the papal dominions, and to measure a degree of the meridian passing through them. In this he was assisted by an English Jesuit, Christopher Maire. An account of their expedition was printed at Rome and Paris, and is interspersed with some curious anecdotes, concerning the opinions which the peasants of the Apennines formed of them, and the operations which they had to perform ; but it is valuable on account of the accurate detail which is given of their observations.

In the year 1757, he was sent to Vienna by the republic of Lucca, to reconcile some differences concerning the draining of a lake, in which the grand duke of Tuscany the emperor Francis 1, and that republic, were concerned. It was after he had succeeded in the object of his visit to that city, that he published there his Theoria Philisophia Naturalis in 1758; and that he gained the esteem of the empress queen.

Another occasion for his mediating powers soon presented itself, and which more nearly interested him, as his native city of Ragusa required them. It had been suspected by the British government, that some ships of war were fitted out at that port for the service of the French, thereby infringing the neutrality. Such a suspicion having no just foundation, alarmed the senate of Ragusa, and required speedy removal, as the consequences of it might be extremely prejudicial to their commerce. Boscovich, who had often been successful in similar circumstances for other powers, appeared to them the most proper person for this purpose, and was accordingly instructed with it. He repaired to London, and here also effected the object of his mission with honour to himself. He visited the Royal Society, which received him with distinguishing marks of respect, and which he soon afterwards complimented with an excellent Latin poem on the solar and lunar eclipses. This was in the year 1760, when Dr Johnson was in London. Mr Murphy speaks of an interview which took place between our author and Johnson; but in order to magnify the unruly powers of the tremendous companion, he rather unhandsomely tells us of the easy cant [*] with which a priest might travel through Italy and France.

> [*] cant- the characteristic or secret language of a particular group.
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> Me: The word “cant” is peculiar and should not be confused with “can’t”.

Britannica: We are unwilling to mention what effects on some minds may have been produced by the formidable society of a Johnson - but if they are a contempt of elegant simplicity and ingenuous ease, and an affected devotion to repulsive pomp and authoritative ostentation, be our lot far from his influence, amid the peace and liberty of social life.

Boscovich was invited by the Royal Society to be of the party of their members sent to America, to observe the transit of Venus over the sun's disk, which happened in the year 1762. The nature of his embassy, and the necessity of returning home, however, prevented his acceptance of the invitation. Soon after his return, and when his embassy was fulfilled, he was appointed by the senate of Milan to the mathematical chair in the University of Pavia, and to superintend the observatory of the royal college of Brera. He continued in this situation for six years, when he was made professor of

astronomy and optics in the Palatine schools of Milan by the empress queen; who also requested him to continue his attention to the observatory.

This he expected to be the most agreeable part of his life. 'Admired by the learned ; beloved by his friends ; having an adequate income, and a constitution sound and vigorous; he promised to himself happy, because useful days, in the tranquil cultivation of the sciences; but a cloud long impeding now burst over his head, and these bright days never came.

The mysterious regulation in the political constitution of the Jesuits, though it had attracted the keen curiosity of the world, had, for very substantial reasons never been explored; nay, such was the influence of the order over the minds of the most enlightened statesmen, that this impenetrable mystery was held sacred by the civil power in many countries, as if no danger could exist in what was not understood. But the rapid progress of science, and the gradual decay of superstition, required some evidence of security, and some proof that it was ever necessary to conceal good intentions, and to cover virtuous principles with any other garb than what truth could bestow. These it is well known, the Jesuits either could not, or were unwilling to give; and they, therefore, justly increased the suspicion of men.

> Me: This is referring to the conspiracies surrounding the Jesuits. The Jesuits were involved in political intrigue.
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> Although the film “Elizabeth: the Golden Age” is fiction distorting historical facts, it does highlight some of the activities that the Jesuits got involved in, such as involvement in attempted assassination of Queen Elizabeth. From wikipedia:

“Jesuits in London conspire with [King] Philip to assassinate [Queen] Elizabeth and replace her with Mary, in what Philip calls "The English Enterprise," and which is known to history as the Babington Plot. Walsingham discovers the plot. From her imprisonment Mary sends secret correspondence to the Jesuits, who recruit Anthony Babington (Eddie Redmayne) to assassinate Elizabeth.” [3]

> Me: To have priests involved in political assassinations is quite amazing. But the Jesuit priests had their mission of promoting Catholicism and they would stop at nothing. If they saw the

> removal of a head of State as furthering their aim then they would consider removing that head.

Britannica: The most trivial circumstances would augment this suspicion, and the least deviation from rectitude in any of the order would serve to justify it: these were not wanting, and soon became invincible; the interest of the Jesuits rapidly declined for many years, and at last, in 1773, their order was totally abolished.

> Me: The Jesuit order was suppressed in 1773, except in Prussia and Russia, and was restored in 1814. A thing to note is this Britannica article is 1810 and unaware of the restoration of the Jesuits that will come 4 years later.

From wikipedia: The Suppression of the Jesuits in Portugal, France, the Two Sicilies, Parma and the Spanish Empire by 1767 was troubling to the Society's defender, Pope Clement XIII. A decree signed under secular pressure by Pope Clement XIV in July 1773 suppressed the Order. The suppression was carried out in all countries except Prussia and Russia, where Catherine the Great had forbidden the papal decree to be executed. Because millions of Catholics (including many Jesuits) lived in the Polish western provinces of the Russian Empire, the Society was able to maintain its existence and carry on its work all through the period of suppression. Subsequently, Pope Pius VI would grant formal permission for the continuation of the Society in Russia and Poland. Based on that permission, Stanislaus Czerniewicz was elected superior of the Society in 1782. Pope Pius VII during his captivity in France, had resolved to restore the Jesuits universally; and after his return to Rome he did so with little delay: on 7 August 1814, by the bull *Sollicitudo omnium ecclesiarum*, he reversed the suppression of the Order and therewith, the then Superior in Russia, Thaddeus Brzozowski, who had been elected in 1805, acquired universal jurisdiction. [4]

Britannica: No exemption from the edict for its downfall [of the Jesuits] could be procured: all who held offices were dismissed; and Boscovich sought refuge in the city of Paris. Thither indeed he was invited by the minister, (we believe Turgot) by whose means he was made one of the directors of optics for the sea service, and received a pension: but it does not seem that his situation was agreeable to him; for it is well known that the peculiar

nature of his circumstances was the sole cause of his long residence in Paris.

> Me: A strange thing to note here is – that earlier Boscovich was working for the English and now he is working for the French.
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> Quote from earlier: “It had been suspected by the British government, that some ships of war were fitted out at that port for the service of the French, thereby infringing the neutrality.” – Boscovich worked for the British ‘then.’ It’s very strange how he is able to work both sides – since French and British were often enemies at war.

Britannica: Whether his dislike arose from the envy of some of the French,

> Me: Maybe many of the French distrusted him because he had worked for the British? Anyway, Britannica seeks to find other possibilities

Britannica: ….his own irritability of temper, or the incongruity of the prevailing manners with his own, we cannot determine: but it is reasonable to imagine, that the ruin of his order, and the subsidence of his own importance, would leave some indelible mark in his mind; and perhaps when he contemplated the apparent levity and the real scepticism of the age, he might be brought to fear that the degradation or the downfall of the world was concomitant. Sentiments very opposite to those of the French, would thence naturally arise; morosity and discontent would invade him, and he wished to revisit the scenes of his youth.

Be all this, however, as it may, certain it is, he applied for leave of absence for two years, after he had resided in Paris for ten years : this he easily procured, and accordingly set out for Basiano in the republic of Venice. At this place he published in five vol[ume]s, quarto, a collection of the works which he had finished in Paris. This forms a body of optical and astronomical knowledge, well worthy the attention of the philosophical and mechanical cultivators of the sciences. It may be worth mentioning, that by proceeding on the principles contained in one of the dissertations in this collection, an amiable philosopher of our own country (Dr. Robison)

> Me: Robison is very interesting, he got involved in conspiracies.

From wikipedia: John Robison FRSE (4 February 1739 – 30 January 1805) was a Scottish physicist and mathematician. He was a professor of philosophy at the University of Edinburgh. A member of the Edinburgh Philosophical Society when it received its royal warrant, he was appointed as the first General Secretary to the Royal Society of Edinburgh (1783–98). Robison invented the siren and also worked with James Watt on an early steam car. Following the French Revolution, Robison became disenchanted with elements of the Enlightenment. He authored *Proofs of a Conspiracy* in 1797—a polemic accusing Freemasonry of being infiltrated by Weishaupt's Order of the Illuminati. [5]

> Me: Robison would probably be better remembered as an important physicist if he had not got involved in conspiracy theories. But from the hardcore conspiracy theorists group he is one of the main sources of information on the Illuminati conspiracy.
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> Its interesting how these series of conspiracies run through this history connecting with the physics of Boscovich. He studied forbidden physics; his book on the physics was immediately published after the Ban was lifted. He was a member of a priesthood – notorious for getting involved with conspiracies such as assassinations. A British physicist interested in his work was also talking about conspiracies.
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> From what is the mainstream version of history as told to the general public (actual more like propaganda than actual history), they prefer to not mention conspiracies. If we followed physics to Einstein we find more conspiracies; but I won't go there in this article. I just want to highlight how much can get hidden – if a physics theory such as Boscovich can be hidden by not mentioning it; well that is complemented by the history of conspiracies surrounding it which also don't want to be mentioned.

Britannica: . . believed it possible to ascertain the motions of the earth, though the observer would be confined in a cellar; in prosecuting the subject, however, he found that an error into which Boscovich had fallen, concerning the aberration of light, undermined

the principles on which he had erected such a wonderful but legitimate problem. The candid and very interesting acknowledgement of the error, and his extreme disappointment in the discovery of it, which the doctor made in the 3d vol. of the Edinburgh Transitions, is at once an evidence of his own liberality, and an undefeasible testimony to Boscovich's genius. –

> Me: The article does not go into enough details on this issue. There is an experiment referred to as "Airy's failure" – Airy performed an experiment proposed by Boscovich, [6] which might be connected. But that makes a better subject for another article.

3. Boscovich's contributions to science

> Me: The Britannica article continues with Boscovich's discoveries:

We beg to recommend to our readers the perusal of the works which we have now mentioned; they would tend to form the mind to the true mode of investigating the phenomena of nature, and will satisfactorily shew that this mode is always rewarded by discovery. The following is a pretty just account of their contents:

- A new instrument for determining the refracting and diverging forces of diaphanous bodies
- a demonstration of the falsehood of the Newtonian analogy between light and sound
- the algebraic formulae regarding the focuses of lenses
- and their applications for calculating the sphericity of those which are to be used in achromatical telescopes
- the corrections to be made in ocular lenses, and the error of the sphericity of certain glasses
- the causes which hinder the exact union of the solar rays by means of the great burning glasses, and the determination of the loss arising from it

- the method of determining the different velocities of light passing through different mediums by means of two dioptrical telescopes, one common, the other of a new kind, containing water between the objective glass and the place of the image
- a new kind of objective micrometers
- the defects and inutility of a dioptrical telescope proposed and made at Paris, which gives two images of the same object, the one direct, the other inverse, with two contrary motions of moveable objects
- masses floating in the atmosphere, as hail of an extraordinary size, seen on the sun with the telescope, and resembling spots
- the astronomical refractions, and various methods for determining them
- various methods for determining the orbits of comets and of the new planet, with copious applications of these doctrines to other astronomical subjects, and still more generally to geometry and to the science of calculation
- the errors, the rectifications, and the use of quadrants, of sextants, of astronomical sectors, of the meridian line, of telescopes called the instruments of transits, of the meridian, and of the parallallic machine , the trigonometrical differential formula, which are of so much use in astronomy
- the use of the micrometical rhombus, extended to whatever oblique position
- the error arising from refractions in using the astronomical ring for a sun- dial, and the correction to be made
- the appearing and the disappearing of Saturn's ring
- the methods of determining the rotation of the sun by means of the spots, proposed formerly by the author, and now perfected
- the greatest exactness possible in determining the length of a pendulum oscillating every second of middle time by the comparison of terrestrial and celestial gravity
- a compend of astronomy for the use of the marine, containing the elements of the heavenly motions, and of the astronomical instruments, to be explained to a prince in the course of one month
- a method for determining the altitudes of the poles with the greatest exactness, by means of a gnomon alone, where other instruments are not to be had
- the determination of the illuminated edge of the moon to be observed on the meridian

- a method of using the retrograde return of Venus to the same longitude, for determining the less certain elements of her orbit
- a method for correcting the elements of a comet, of which the longitude of the node is given, and the inclination of the orbit has been found nearly
- another method for the same purpose, and for finding the elliptical orbit, when the parabolic one does not agree with the observations
- a method for correcting the elements of a planet by three observations
- the projection of an orbit inclined in the plane of the ecliptic
- the projection of an orbit inclined in any other plane
- the calculation of the aberration of the stars, arising from the successive propagation of light
- Some beautiful theorems belonging to triangles, which are of great use in astronomy, reduced to more simple demonstrations.

After the publication of these works, our author left Bassano, and went to Rome to visit the companions of his youth. From Rome he proceeded to Milan, where he revised some of his own works, and prepared for publication the two last volumes of Stay's poems.

In such occupations, and amidst friends whom equal misfortune and temporary separation had still more endeared, he had remained happy, and might perhaps have been still further useful to the world ; but his leave of absence was now nearly expired, and his dislike to a residence in Paris was augmented by the contrast which his present abode afforded. He was too delicate to apply for more leave of absence; and though he was sensible of the gratitude which he owed to France, he could not reconcile it with the destruction of his own repose.

About this time also he had several attacks of gout, but he would admit no medical aid. Under these distresses, and others which we have before mentioned, our illustrious author at last sunk ; a melancholy despondency seized on and subjugated his mind, so that for five months he remained perfectly fatuous ; and an imposthume having burst in his breast, terminated his existence on the 13th of February 1787, in the 76th year of his age. The following inscription was composed by Benedict Stay, and engraved on marble by order of the senate of Ragusa, in memory of their useful citizen the illustrious Boscovich.

ROGERIO. NICOLAI. F. BOSCOVICHIO,
Summi. Ingenii. Viro. Philosopho. Et. Mathematico.
Praestantiffimo
Scriptori. Operum. Egregiorum
Res. Physicas. Geométricas. Astronomicas
Plurimis. Inventis Suis. Auctas. Continentium
Celebriorum. Europae. Academiarum, Socio
Qui. In. Soc. Jefu. Cum. Effet. Ac. Romae. Mathefim.
Profteretur
Benedicto. XIV. Mandante
Malto

Me: I pass on the Latin comments.

4. Further works of Boscovich

Britannica: Besides the works which we have mentioned, he wrote several others on various subjects, as:

- on the project of turning the navigation to Rome from Fiumiciro to Maccarese
- a third on two torrents in the territory of Perugia
- a fourth on the bulwarks on the river Ponaro
- a fifth on the river Sidone in the territory of Piacentia
- A sixth on the entrance into the sea of the Adige.
- He wrote other such works on the bulwarks of the Po
- on the harbours of Ancona, of Rimini, of Magna Vacca, and Savona, besides others, almost all which were printed.
- He had likewise received a commission from Clement XIII. To visit the Pomptin lakes, in the draining of which he drew up his opinion in writing, to which he added further elucidations at the desire of Pius VI.

5. Introduction to Boscovich's Theory

Britannica: We have spoken of Boscovich as the founder of a new system of natural philosophy, which has occupied much of the attention of the learned, and which alone will render the name of its author immortal. It becomes us therefore to give such a synopsis of it, as may satisfy the general reader, or induce the student to search for more information in the work from which we ourselves have derived it.

In a subject so abstruse and remote from observation as many of the principles which we have to consider in this theory, much difficulty in investigation is to be expected, and perhaps the metaphorical language which we are constrained to employ, will tend not a little to embarrass and mislead us. We are also aware of the many obstacles which a theory of such magnitude has to encounter in the improved mode of philosophising of the present day; we are aware that at the bare mention of a new theory in natural philosophy, some of our readers will revolt from our page, affect a contempt of our labours, and call to their aid the authority of Bacon.

> Me: I remind you that this article was 1810 and refers to a theory published in 1758.

Its interesting that the article refers to the authority of Bacon; advocate of scientific method. I will remind you who Bacon was-

From wikepdia: Francis Bacon, 1st Viscount Saint Alban, KC (22 January 1561 – 9 April 1626) was an English philosopher, statesman, scientist, lawyer, jurist and author. He served both as Attorney General and Lord Chancellor of England. Although his political career ended in disgrace, he remained extremely influential through his works, especially as philosophical advocate and practitioner of the scientific method and pioneer in the scientific revolution

Bacon has been called the father of empiricism. His works established and popularized inductive methodologies for scientific inquiry, often called the *Baconian method*, or simply the scientific method. His demand for a planned procedure of investigating all things natural marked a new turn in the rhetorical and theoretical framework for science, much of which still surrounds conceptions of proper methodology today. His dedication probably led to his death, bringing him into a rare historical group of scientists who were killed by their own experiments. [7]

> Me: So the article is referring to people who would be opposed to Boscovich's theory and would want to claim Bacon scientific method as reason for opposing it.

Britannica: But we would ask such, from whence does their spirit arise?

> Me: i.e. asking why would these people oppose Boscovich's theory.

Britannica: We have found it in those who never studied a page of Bacon;

> Me: i.e. accusing those who appeal to Bacon as authority to oppose Boscovich's theory as having not studied Bacon; therefore don't know what they are talking about.

Britannica continues: . . and we have known it accompanied by indolence,

> Me: So now accusing those opposed to Boscovich's theory as being lazy (indolence). Not only have those opposed to Boscovich's theory not studied the scientific method (of Bacon) but they were lazy in not studying it.

Britannica continues: . . and by a supine indifference to aught that dignifies and elevates humanity.

> Me: Strong words to condemn those opposed to Boscovich's theory; accuses them of not wanting to help humanity to progress.

Britannica: It is surely no hard matter to condemn a theory, merely because it is a theory; nor is it at all demonstrable that such condemnation requires any great effort of genius or understanding.

Now the spirit of Bacon is a spirit of zeal, and labour, and perseverance, and above all, of investigation. Not then from his writings has this contempt arisen, but from a total ignorance of them; not from his doctrine, but from an imaginary inspiration of his principles.

> Me: i.e. there are people who don't understand science and its method. That seems true then in 1810 – the date of the article and true of today. People have different viewpoints (philosophies, worldviews, and ideologies) and what should be science – people have different opinions. Hence why we see clashes today from Creationism versus Darwinism. From the Darwinism group they don't perceive Creationism as science, and from the other group they don't perceive Darwinism as science.

6. Boscovich's System of Natural Philosophy

Britannica: We have reason to believe that the theory of Boscovich would have received the sanction of the illustrious Bacon; because the foundation on which it is erected is consecrated by irradiation from his works. Be this, however, as it may, we are convinced that such an example of true genius will be acceptable to every friend of humanity, and to every cultivator of science.

> Me: i.e. Boscovich's theory is based on adhering to scientific method. However, with people there are different opinions. I agree that Boscovich's theory is a scientific theory, but there are those who might not agree.

Britannica: That we may do justice to our author in giving a synopsis of his theory, we shall follow the order which he himself has adopted; and shall subjoin some general observations and remarks which have occurred to us in the course of the work.

Boscovich's Theoria Philoshophia Naturalis is divided into three parts, of which the first contains the explication of the theory, its analytic deduction, and its vindication.

The second contains the application of the theory to mechanics, and the third the application of the theory to physics. Of these in order, and first of the explication of the theory.

This theory has something in common with the Leibnitzian and the Newtonian.

With the former it admits that the elements of matter are simple and inextended; but it differs from it, in denying the continued extension of the elements, and in asserting that the elements are perfectly homogeneous.

Like the Newtonian, it allows the existence of mutual powers or forces, which vary according to the distance by certain laws; but it goes further, in that it asserts these powers are both repulsive and attractive, and that when either of these terminates the other begins: but it

differs from the Newtonian in explaining by one principle phenomena to which the latter applies three.

This one principle may be expressed by an algebraic formula, or by one continued geometrical curve and it is the law by which the powers of repulsion and attraction act. As continued extension of bodies is rejected from this theory, it is obvious, that as on the one hand a repulsive power must render it impossible, so on the other an attractive power must give rise to the apparent examples of it, to the phenomena of cohesion: this accordingly is one essential characteristic of the theory.

From these few remarks we may deduce the principles of the theory.

The first elements or atoms of matter are indivisible, in extended, but simple, homogeneous, and finite in number.

> Me: I would call attention to change in meaning of the term “atom.” The term from ancient Greece referred to something unsplittable. But the term “atom” as used nowadays might better be called “atom of a chemical element”. Where this “chemical atom” cannot be split further unless it changes its chemical element. i.e. a “chemical atom” can be split as per A-Bomb etc. But there is the original meaning of the atom as referring to something that cannot be split. So Boscovich refers to the original meaning of the term “atom” and that is not the “chemical atom”, its something smaller.

Britannica: They [Boscovichian atoms] are dispersed in an immense space, in such a manner as that any two or more may be distant from each other any assignable interval. This interval may be indefinitely augmented or diminished, but cannot entirely vanish. Actual contact of the [Boscovichian] atoms is therefore impossible, seeing that the repulsive power which prevents the entire vanishing of the interval, must be sufficient to destroy the greatest velocities by which the [Boscovichian] atoms tend to unite.

The repulsive power must encircle every [Boscovich] atom, must be equal at equal distances from the atoms, and moreover, must increase as the distance from the atoms diminishes.

> Me: Encircle the Boscovichian atom like what we might now call force field.

Britannica: On the contrary, if the distance from the [Boscovichian] atoms increases the repulsive power will diminish, and at last become equal to nothing, or vanish : then, and not till then, an attractive power commences, increases, diminishes.

> Me: If you have not guessed by now the Boscovichian atom is what we would now call a point-particle. So it's a point-particle with a force field around it.

Britannica: But the theory does not stop here; for it supposes, that a repulsive power succeeds to the second or, attractive, increase, diminishes, vanishes; and that, there are several alternations of this kind, till at the lest an attractive power prevails, and though diminishing sensibly, as the squares of the distances increase, extends to the most distant regions of our system.

7. Boscovich's curve

Britannica: Such a process as we have now mentioned may seem complicated and confused ; but the curve line which expresses it is so simple, that we are persuaded, our readers, though unacquainted with geometry, will comprehend it, and hence will be able to understand the theory itself.

We shall now proceed therefore to exhibit this curve, and to shew in what manner it elucidates the principles of the theory.

> Me: The diagram of the curve to be referred to is as follows (I hope the lettering is correct):

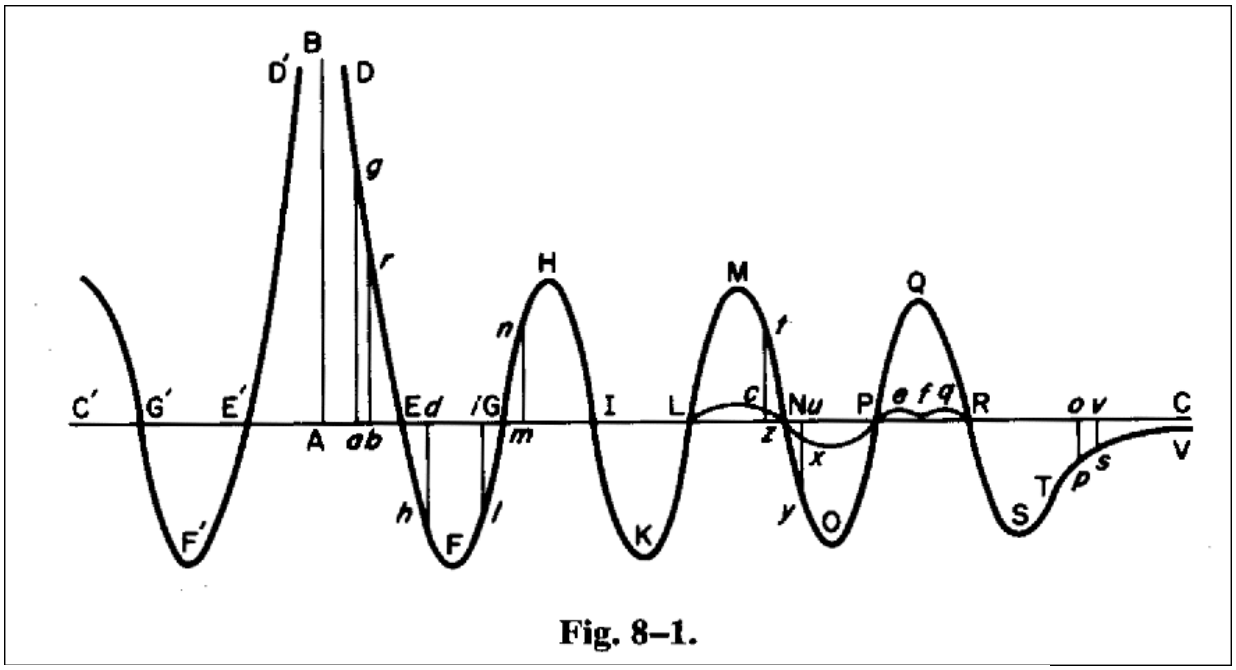

Fig. 8–1.

From: http://dbhs.wvusd.k12.ca.us/webdocs/Chem-History/Boscovich-1763-Fig8-1.GIF

> Me: Ideally I would have liked to have talked about other things before Boscovich's curve; because that seems jumping into the deep-end. Anyway-

Britannica: The axis C'AC has an asymptote of a curve in the point A, viz. the indefinite right line AB; on each side of which are placed two equal and similar branches of a curve, viz. D'E'F'G', &c. and DEFGH1KL MNOPQRSTV; the latter of these having the asymptotical arch ED, though indefinitely produced towards the right line AB, will never touch it; but it accedes to the axis C'AC, and touches it in some point E. From this point it recedes on the opposite side of the axis to some point F, bends again to the axis C'AC, and cuts it in the point G; from this it recedes in a similar manner, on the side of the axis from whence it originated, and arrives at the point H. From the point H it bends to the axis C'AC, and cuts it in the point I, and so on in alternate fits of accession and recession till it has completed the remaining arches IKL,LMN,NOP,PQR, RST; after which it becomes asymptotical, forming the arch TpV, which approaches the axis C'AC on the side opposite that from which it originated, in such a manner as that the

distances from the axis shall be in the reciprocal duplicate ratios of the distances from the asymptote BA.

> Me: Some terms need to be defined:
>
> Asymptote – straight line closely approached but never touched by a curve.
>
> The line C’AC we would normally today call the x-axis, and the line AB the y-axis. A point would be defined as (x,y) where x represents a number for the distance along the x-axis and y represents a number for the distance along the y-axis. The x coordinates are referred to as abscissa, and the y coordinates as ordinate.

Britannica: Now, if we raise and let fall perpendicular on the axis C'AC in the points a, b, d, and c. the segments of the axis so formed, viz. A a, A b, Ad, &.c. are abscises, and will represent the distances between any two [Boscovichian] atoms or points of matter ; and the perpendiculars so constructed, viz. a g, b r, d h, are ordinates, and will represent the intensity of the repulsive or attractive powers, according to their situation with respect to the axis C'AC ; for, if on the same side with the asymptote AB as a g, b r, they represent the former ; and if on the side opposite to the asymptote, as d h, the latter power.

From what we have said, it is manifest, that the ordinate a g may be increased beyond any assignable limit, provided the corresponding abscissa A a be. diminished beyond any assignable limit; seeing that the limb of the curve ED is asymptotical which terminates the ordinate a g, and consequently never touches the right line AB; but that, if the abscissa be increased as to A b, then the ordinate will be diminished to b r; and that by perpetually increasing the abscissa to the point E, the ordinate will be perpetually diminished till at the point E it will totally vanish. Moreover, if we shall increase the abscissa to A d, we shall find that on the opposite side of the axis C'AC, there will appear the ordinate dh, which, by continuing the same increase of the abscissa will increase to the point F, and then will diminish perpetually, as it approaches to the point G, where it will totally vanish. If the abscissa be still increased, an ordinate arises on the opposite side, increases to H, diminishes to I, and vanishes, appears again, increasing to K, diminishing to L, vanishing; and so on through all

the remaining points and situations of the curve, till at length coming to p v and s v, it continues to diminish perpetually, but never again totally vanishes.

Such then is the nature of the curve, and such, it will be admitted, will comply with the description of the repulsive and attractive powers, and the manner in which they alternate, so essential to the theory. The first power or that next the [Boscovichian] atoms is repulsive, and is greatest at the least distances from them; by increasing the distances it diminishes, vanishes; is succeeded by attraction, which increases, diminishes, vanishes; is in like manner succeeded by repulsion; and those two powers alternate repeatedly, when the attraction succeeding, constitutes the general gravity of Sir Isaac Newton, and reaches to the planets, and the far distant comets of the system of the sun.

It is obvious, that the transitions which we have described must occur in the insensible distances, being all comprehended betwixt the [Boscovichian] atoms and the exterior attractive power; but it is also obvious that this law of the forces differs much from the Newtonian gravity, as the curve which expresses the latter is a hyperbola of the third order, lying all on one side of its axis which it never cuts; consequently it does not admit of any transitions, as we have before hinted at. It is of consequence to remember this distinction, for we shall find that on it depends much of our reasoning in the, application of the theory to physics.

Some further explanation of the curve remains to be given in the second part: in the mean time we proceed to take notice of certain geometrical properties essential to it, as answering the conditions of the principles of the theory.

Boscovich, in an after part of the work, demonstrates strictly that the curve is possessed of these properties; but we do not think it necessary to detail his demonstration, as it is only accessible to those who are versed in the high geometry, and as we imagine that a bare statement of the conditions required will satisfy the generality of our readers.

The conditions necessary in the curve are six in number. First, that it be regular, simple, and not an aggregate of arches of different curves. Secondly, that it shall cut the axis C'AC in certain given points only, and at

the two distances AE', AE; AG', AG, &c. which are equal on both sides of the asymptote, the right line AB. Thirdly, That there shall be ordinates to correspond to every abscissa. Fourthly, that there shall be equal ordinates at equal abscises on each side of AB. Fifthly, that the right line AB be an asymptote to the curves on each side of it ; the area BAED asymptotical and therefore indefinite. Sixthly, that the arches which are terminated by any two intersections may be varied in any manner, recede from the axis C'AC to any distance, and accede to whatever arches of whatever curves, cutting, touching, or oscillating them wheresoever and howsoever we please.

If these conditions answered, it must be evident that by this curve we can express in any intensity of any force, in any direction we please, and of consequence, that by one law of the forces, everything in the universe, connected in any manner with motion, may be explained.

8. Analytic deduction of Boscovich's theory

Britannica: We come now to consider the analytic deduction of the theory, in which we shall follow closely the steps of Boscovich.

Boscovich sets out, by examining the nature of the law of continuity, and the principles on which it is founded. In the year 1745 the published a dissertation De Viribus vivís, in which he was led to consider the phenomenon of the collision of bodies, and in consequence, the dilemma into which former philosophers had fallen by their mode of investigating it, and the breach of the law of continuity which some had allowed to extricate themselves from The dilemma.

Maclarin, of whom Boscovich speaks in terms of the highest respect "Summus nostri aevi geómetra et philosophus,"[*]

> [*] Latin translates as: Of our age, the Supreme geometry and the Philosopher

Britannica: . . was the principal advocate for the breach of the law of continuity in the collision of bodies, and spoke with some indignation of those who asserted that this law was universal. He of course, believed in the production of motion by impulse, and in the immediate contact of bodies. Now, Boscovich, as we have before

mentioned, rejects both of these suppositions, and consequently explains the phenomenon in a very different manner from Maclaurin, and endeavours to prove that the law of continuity is universal, and that no instance of a breach of it is ever observable or possible.

Before proceeding to his reasoning on this subject, we shall explain what is meant by the law of continuity, and give one example of it, to which all others are referable.

The law of continuity (says Boscovich) consists in this, that any quantity whilst passing from one magnitude to another, must pass through all the intermediate magnitudes of the same kind: or, according to the law of continuity, all changes in nature are produced by insensible and infinitely small degrees; so that no body can in any case pass from motion to rest, or from rest to motion, without passing through all possible intermediate degrees of motion. Maclaurin's Newton, b. 1. c. 4.

Let there be a right line AB [….] , to which another line CDE is related ; let AB represent the time, and from any points of it, F, H let there be erected the perpendiculars FG, HI, which (ordinates) may represent any quantities continually variable, and will correspond to the moments of time F, H ; but to the intermediate moments K, M, other magnitudes KL, MN, will correspond and if from the point G to the point I there goes a continued and finite part of the line CDE, it is evident that there is no intermediate point of the line AB, as K, to which some ordinate - KL does not correspond ; and conversely that there is no ordinate of magnitude intermediate betwixt FG, HI which does not correspond to some point intermediate betwixt F, H. Now the variable quantity expressed by this variable ordinate, changes according to the law of continuity ; because from the magnitude FG, which it has in the moment of time F, to the magnitude HI, which it has in the moment of time H, passes through all the intermediate magnitudes K.L, corresponding to the intermediate moments K,M, and to every moment a determinate magnitude corresponds.

This then may be sufficient to explain the nature of the law of continuity, about which we may remark there can be no ambiguity ; for the terms which express it are precise, it is a matter of fact, and one example of it is enough to give us an adequate idea of it. We proceed, therefore, to consider on what its universality is founded; and here two questions naturally occur: Have we

discovered the universality of this law by a laborious induction? Or does it necessarily result from the nature of continuity? Boscovich answers both of these questions in the affirmative.

1. It is discovered by induction. Here we beg to transcribe the words of our author, as much more satisfactory than any thing we can give:

> Me: I pass on the Latin.

Britannica: From these and other examples, in which the law of continuity is manifestly held, Boscovich infers, that it is universal; and that in so far as induction supports us, we are at liberty to apply it in the explanation of phenomena. Nay, we are by the same principle compelled to admit it in cases where observation fails us; because to imagine that in such cases this law is broken and some other is adopted, is to transgress one of the fundamental principles of true philosophy: it is to multiply causes unnecessarily; it is to limit the power of the Creator {*] by the imperfection of our own senses; and it will plunge us into difficulties which no effort of human reason will remove.

> [*] thinking here in religious terms, we could substitute word “nature”, i.e. not limit the power of nature.

Britannica: Besides this, it is very easy to conceive that the law is permanent; and as no absurdity, therefore, accompanies the supposition, and no fact can be brought to overthrow it, whereas the contrary is unsupported by any fact, but is plainly repugnant to all, it is surely rational to make use of it, and to hold it as the general principle, till some higher one be discovered on which it depends.

From induction alone, therefore, we may infer the universality of the law: but Boscovich has other arguments which he calls positive, to support and evince [*]it.

> [*] “evince” is - to make evident; to show.

Britannica: This leads us to the second question: Does this universality necessarily arise from the nature of continuity? The limit which joins the precedent and consequent of any thing, is common to both, and is therefore indivisible. Thus, a superficies separating two solids, wants thickness, and is that in which a

transition from the one to the other occurs; a line dividing two parts of a continued superficies wants breadth; a point discriminating two segments of a continued line wants every dimension. So it is with regard to time, for the limit of two conjunct portions is common to both, and indivisible; and, as every change of a variable quantity from one magnitude to another must be made in time, so every change must be influenced by the continuity of time. But to every moment of time, a certain magnitude of the variable quantity corresponds, and the limit of two moments of time is common and indivisible; therefore, the limit of two magnitudes corresponding to these two moments, must be common and indivisible. Moreover, it is impossible for any quantity to have two magnitudes at the same time, and when continually varying, that it shall have the same magnitude at different times; much more impossible, therefore, that in the limit of two moments of time it shall have two magnitudes, the one corresponding to the precedent, and the other to the consequent moment, or shall not have gone through the intermediate magnitudes in the intermediate moments of time. For the same reason, a body cannot have two velocities at the same time, and therefore cannot have two velocities in the limit common to two moments of time; and when continually changing its velocity, cannot have the same velocity in different moments of time, but must go through all the intermediate velocities in the intermediate moments of time. Hence then, in passing from the magnitude 8 to the magnitude 12, the variable quantity passes through the magnitudes 9, 10, 11. In going from the velocity 7 to the velocity 11, a body must go through the velocities 8, 9, 10. The increase of temperature goes on gradually: the mercury in the thermometer rises gradually, going through every intermediate degree from one to another. Now as this reasoning is uninfluenced by any considerations of the hardness, softness, elasticity or other property of bodies ; these, it is evident, do not influence the universality of the law as resulting from the nature of continuity.

From these arguments, therefore, and from induction. Boscovich concludes, that the law of continuity essentially universal, and that a breach of it is metaphysically impossible. The use made of this deduction in explaining the collision of bodies, must at once be understood by our philosophical readers. If in this and all other phenomena, the law of continuity is preserved, there can no actual contact take place amongst bodies; and it is from the universality of the law so established

that Boscovich derives this original principle of his theory.

To apply this then in the collision of bodies, we argue in the following manner. Since the bodies cannot come into immediate contact with the preceding velocities, it is necessary that their respective velocities be changed before contact, that either the velocity of the antecedent body shall be augmented, or that the velocity of the consequent body shall be diminished, or that both of these changes shall occur. Now the cause operating betwixt the bodies, so as to retard the one, and to accelerate the other, must be a power, and must act from the bodies, and must also be sufficient to overcome the greatest velocities with which the bodies tend to unite, and be mutual, because action and reaction are equal. In fine, this is the interior repulsive power according to the definition. This mode of explaining the phenomenon, we may observe, is general, seeing that no hardness, softness, or elasticity of the bodies, has any influence on the general principle from which it is deduced; but these properties will influence the particular cases of the phenomenon, and cause certain modifications, which, however, do not concern us at present.

In this manner we derive evidence for the existence of the interior repulsive power; but for this we have also the light of induction to assist us, as we shall prove in the conclusion of our article.

As the repulsive power may be increased to infinity, by diminishing to infinity the distances betwixt the atoms of matter, it is obvious, that no part of matter can be contiguous to another part; from which it follows, that the primary elements of matter are simple and uncompounded. From similar arguments, and from others deduced from the absurdities involved in the contrary supposition, Boscovich maintains, that they are also inextended and indivisible.

The existence of an attractive power is allowed on all hands; we need not therefore enumerate Boscovich's arguments on the subject. For proofs of the transitions from one power to another, we are referred to the phenomena of effervescence, fermentation, cohesion, &c.; the consideration of which belongs to the third part of our subject.

To prove the homogeneity of the [Boscovichian] atoms, Boscovich makes use of the same reasons which have been employed by other philosophers; and he removes the

objections made to it by Leibnitz, on the principle of the sufficient reason, and the visible diversity of bodies: the former he contends to be false, being founded on that doctrine of necessity which Leibnitz maintained; and with respect to the latter, he describes a beautiful and linking analogy, which we cannot refrain from transcribing.

Me: I pass on the Latin.

It is from these simple principles which we have enumerated that Boscovich deduces analytically the whole of his system; and he now proceeds to remove it or explain away the objections made to it.

It has been objected in the first place to the mutual to the powers, that they are occult qualities, and that they induce action at a distance.

Me: occult meaning hidden from view; concealed.

Britannica: But in reply, so far from being occult they are very manifest, an idea of them can easily be formed, their existence is evinced by a positive argument, and their effects are continually before our eyes; we may add also, that the same objection was made to the Newtonian attraction, and that the same arguments serve to remove it from both. As to the mutual powers inducing action at a distance, much indeed may be said, but it is very questionable if all that can be said will ever clear up the obscurity that perpetually involves this inextricable phenomenon.

We reserve some remarks on the commonly received notions on the subject, for our conclusion; in the mean time, we may affirm, that it is as easy to conceive motion produced by the powers we have spoken of, i. e. at a distance, as produced by immediate impulse. We know, indeed, that till of late, philosophers were accustomed to consider the connexion between impulse and motion so essential, and their notions on the subject so clear and fundamental, that whenever they could reduce any phenomenon to that predicament, they flattered themselves every difficulty vanished, and consequently further investigation was superfluous. But we also know, that till of late, water was held to be a simple body, and that when it could be shewn to arise in any chemical experiment, it was customary in chemists to believe it had previously existed in the subjects of their

experiment. Do we coincide in this belief in the present day?

It has been objected, that the theory itself admits a sudden transition from one power to another ; but a due inspection of the curve, and the explanation of it which we have given, will convince that this is impossible, for that every change is made by passing through every intermediate degree.

The principal objections, as might have been expected, have been made to the rejection of contact, to the inextension of the [Boscovichian] atoms, and to their indivisibility. But it is allowed, that bodies approach so near to each other, as to leave no sensible distance between them; and that the reliance which we experience is made by the repulsive power which gives us the same sensation as actual contact. We can form no idea, it is true, of an inextended indivisible [Boscovichian] atom of matter, because all our ideas of matter are associated with extension and parts; and so difficult is it to break the association, we imagine these are essential to it.

Boscovich directs us to consider the nature of a mathematical point, in which there is involved no notion of extension or parts, and that from this we can form an idea of an inextended atom. The notion of an inextended and simple atom is not peculiar to the theory of Boscovich. Zeno and his followers among the ancients, and the modern Leibnitzians adopted it. But Boscovich, by denying actual contact and continued extension, gets rid of the absurdities which resulted from their opinions.

Some have asserted that the atoms of this theory not differ from spirits, because they have not extension, which is the characteristic of matter. Does then extension constitute matter, and the want of it spirit? We apprehend not. The discrimination of matter and spirit consists in these two circumstances: the former is perceptible by our senses, and is incapable of thought and volition; whereas, the latter does not affect our senses, but can both think and will. But the perceptibility of matter arises from its impenetrability, not from continued extension. Besides this, the [Boscovichian] atoms have repulsive and attractive powers, though they do not therefore resemble spirit. For were we to admit the existence of a kind of being possessed of these active powers, conjoined with inertia, and having at the same time cogitation and volition ; it would neither be matter nor spirit, but a tertium quid,[*] distinguished from the former by cogitation and

volition, and from the latter by inertia, and by powers which induce impenetrability.

> [*] tertium quid = something that cannot be classified into either of two groups considered exhaustive; an intermediate thing or factor.

Britannica: Boscovich treats the other metaphysical objections to his theory in a similar manner; but we think it very unnecessary to dwell longer on them, and shall therefore proceed to the second part of our subject.

We are obliged to be concile in our account of the application of the theory to mechanics, because though very valuable in itself, it can hardly be abridged, and would prove interesting to those only who are versed in mechanical science. There remain, however, some further circumstances of the curve to be considered, which are essential to the fully understanding the theory itself, and the manner in which it is to be applied either to mechanics or to physics. We propose to deliver them in this place in conformity with our author's plan, though they are equally suitable to any of the three parts.

The circumstances we mean are of three kinds. 1st, the arches of the curve, 2dly, the areas comprehended betwixt the axis, and the arches which the ordinates generate by continually flowing. 3dly, the points in which the curve cuts the axis.

1. The arches are either repulsive or attractive, according as they are situated on the same side of the axis with the asymptotic limb ED, or on the side opposite, and terminate the ordinates exhibiting the repulsive or the attractive powers. The arches may bend towards the axis, and turn again from it without touching or cutting it, as in the arch P vf; this bending may be repeated, and may occur on either side of the axis, and it may admit of many varieties in figure and size, so as to express every possible action and mode of action.

2. The areas may be of any magnitude however great or small, or they may be infinite, according as the arches depart more or less from the axis, or become asymptotical with respect to it. The abscises represent the distances betwixt the [Boscovichian] atoms, and the ordinates the present force by which they are acting: the areas which the ordinates run through, express the increment or the

decrement of the squares of the velocities which are generated. From these principles it is easy to see in what manner the doctrine of dynamics may be applied in the theory. And from this very circumstance it is clear that this theory does not interfere with principles in mechanics which are deduced from reasoning abstractedly on space, velocity, and time, and in which the nature and properties of matter have no place. This remark is momentous, because it serves us in forming an adequate opinion of the merits of the theory, and it completely overthrows the scepticism concerning mechanical knowledge into which some have been led by imperfectly understanding the object and the principles of Boscovich. We beg to impress this on the minds of our readers, and to assure them, that though the theory of Boscovich be most satisfactorily established, there will not one fundamental principle in the science of mechanics be overturned. This will no doubt mortify the ignorant sceptic, but it will animate the true student to greater exertions, and it may open to him a field in which glory and same remain yet to be reaped. To return, the asymptotic area included betwixt any asymptote and ordinate may be either infinite, or finite of any magnitude however great or small: or more generally, the area is infinite if the ordinate increases in the simple reciprocal ratio; but if the ratio be less in any degree, the area is finite.

3. The points in which the curve cuts the axis are of two kinds, one where the transition is from repulsion to attraction, the other where it is from attraction to repulsion. Now these are called limits, and though they have something in common with each other, yet do they essentially differ. They have this in common, that if two [Boscovichian] atoms be placed at the distance of any limits from each other, no mutual power is exerted by them; consequently if they are respectively at rest, they continue so. But if they be moved from their respective rest, then an essential difference is observable betwixt these two kinds of limits. In the limit of the first kind, viz. where the transition is from repulsion to attraction, the [Boscovichian] atoms resist further separation, and endeavour to regain their former distance by the attractive power then operating; and they resist nearer approach than the limit, and endeavour to regain their former distance, by the repulsive power then operating. This therefore is called a limit of cohesion, seeing that if an [Boscovichian] atom be any way removed from it, it endeavours to regain it.

But in the limit of the second kind, if the distance betwixt the [Boscovichian] atoms be in the least increased, then will these [Boscovichian] atoms tend from each other more and more, by the repulsive power then operating; and if the distance betwixt them be in the least diminished, then they will tend to each other more and more, by the attractive power then operating. This therefore is called a limit of non cohesion, seeing that if an [Boscovichian] atom be any way removed from, it departs more and more from it. Now the limits of cohesion may be very strong or very weak; for if the curve cuts the axis perpendicularly, it is evident that the ordinates on each side of the limit are the greatest, and therefore the forces which they express the greatest. On the other hand, if the curve cuts the axis in a very small angle, it is also evident that the ordinates on each side of the limit are very small, and therefore the forces which they express very small; and these in any proportion. Of the limits of non-cohesion we may observe that, in a similar manner, according to the angle formed by the curve in cutting the axis at the points representing them, the [Boscovichian] atoms will recede from, or accede to each other with greater or smaller velocity, when their respective distance is changed.

The remarks which we have now made, together with the former explanation of the curve, are sufficient to acquaint our readers with the general principles of the theory, and will serve to exhibit the manner in which it may be applied to mechanics and to physics. Of the former, we have already mentioned, it is difficult to give even an abridgment; we propose then to employ the remainder of this part in enumerating the particular subjects in mechanics to which our author has applied his theory, and in giving our opinion of the degree of success with which his application is attended.

He commences by showing in what manner masses of matter may be formed by the [Boscovichian] atoms, supposing them endowed with the powers of repulsion and attraction ; and first of the combination of two [Boscovichian] atoms, then of three, and so to the most complicated bodies. He proves that the masses so formed will be possessed of different properties, in consequence of the disposition of the powers which in certain cases will always attract, in others always repel, and in others again will do neither, i. e. will be neutral. From these differences will necessarily result peculiarities in the mode of the action of different masses, and these so endless and

diversified, as to include every possible phenomenon in nature. It is easy to conceive that the varieties in figure will readily result from the position of the [Boscovichian] atoms, and the influence of the powers in respect to each other. Thus a pyramid may be formed of four [Boscovichian] atoms, and a cube of eight; these smaller or primary masses may be combined to form secondary, and so on to any order. Regular and irregular bodies will thence be formed; and yet it may be shown that the most irregular and complicated may be reduced to the primary or original forms, from whence they were constructed. The crystallization of salts, for example, may in this manner be accounted for, and the reduction of them into the primitive forms be explained on the principles of the theory. These phenomena imply composition and equilibrium of forces, which firstly belong to mechanics ; our author therefore proceeds to consider these and other subjects connected with them : as the centre of gravity ; the equality of action and reaction ; the collision of bodies ; the centré of equilibrium ; the centre of oscillation ; the centre of percussion. In all of these we may observe his law of the forces is strictly applicable; that by it some very difficult problems are solved, and some intrícate phenomena explained, with an accuracy and precision highly creditable to Boscovich, and strongly presumptive of the value of his theory. The formulae which his investigations afford are certainly curious and interesting to the speculative, and may be useful to the practical mechanic. He adds a few remarks on the pressure and velocity of fluids, which are equally clear, and in our opinion satisfactory.

We have already anticipated some of the principles which more properly belong to this part, in which we consider his application of the theory to physics. This necessarily comprehends all the general properties of matter, some of which have already engaged our attention when treating of the analytic deduction and vindication of the theory, but still require some particular observations.

The impenetrability of the [Boscovichian] atoms is a necessary consequence of the interior repulsive power increasing as the difference diminishes; but it also arises from the inextension of the [Boscovichian] atoms, and their indivisibility: because as space is infinitely divisible, it is infinitely improbable that any two [Boscovichian] atoms should ever meet in the same part of it, though no repulsive power existed, seeing that they

may move in an infinite number of the parts of space which are unoccupied. So that, independent of any repulsive power, it is infinitely improbable that any compenetration should occur.

Physical extension necessarily arises from the impenetrability of the [Boscovichian] atoms; because by it, no two [Boscovichian] atoms can occupy the same part of space, and are therefore kept without each other; but it is not mathematical or continued extension, seeing that some space must intervene betwixt all the [Boscovichian] atoms. Our senses, it is true, cannot perceive this space on account of its smallness; no more can they perceive the distances betwixt the particles of water or other fluid, and yet from certain phenomena it is demonstrable that such distances exist.

From extension arises figurability, seeing that by the combination of the [Boscovichian] atoms certain forms must be produced: it can be easily shown that, on account of the various limits of cohesion, there may be very different quantities of matter under the same figure; and this involves the consideration of density. The mass of a body is the whole quantity of matter pertaining to it, or the number of [Boscovichian] atoms which compose it. But it may be remarked that our idea of the mass is very vague, arbitrary, and confused, owing to the apparent heterogeneity of bodies.

The inertia of bodies is the consequence of the inertia of the [Boscovichian] atoms and of the mutual powers; and by it we understand the determination to persevere in the same state of rest or uniform motion in a right line, unless forced by something external to change from it.

Mobility, one of the general properties of bodies, being essential to the [Boscovichian] atoms, is so to the masses formed of them. It is a consequence of the mutual powers of the theory. Now all the motion we observe is merely relative, either in respect of the earth, the planetary system, or the system of the fixed stars.

> Me: Note the word “relative”, its dealing with relativity – relative motion.

Britannica: From this perhaps we may derive an argument for the universality of the law of continuity in the case of motion, seeing that the instances where the law appears to be broken, must be explained by the combined influence of moving powers which act continually and

gradually; and that there is not one example of absolute rest in the universe.

> Me: No absolute rest as per relativity.

Britannica: Though continued extension and divisibility be denied to the [Boscovichian] atoms, it is allowed that they may be infinitely compounded; and hence componibility is contrasted with divisibility in the theory.

General gravity, according to the Newtonian principles, is allowed in this theory, as we have before mentioned ; and we may now remark, that the objection urged against it, as tending to produce an aggregate of all the matter in the universe, by drawing the planets, comets, and fixed stars, into one portion of space, may be obviated by supposing that a repulsive power succeeds the attractive after it has reached to the comets of our system ; or that as by the curve, the limb T p s V ceases to be asymptotical, and cuts the axis so as to exhibit an arch of repulsion on the opposite side.

> Me: considers idea that gravity which is attractive between planets and sun, can get repulsive past a certain distance. This might explain some anomalies like the Pioneer space probe anomaly. [8]

Britannica: Of all the general properties of matter, that of cohesion is most simply and beautifully explained by this theory; but as we have already spoken of its limits and their varieties, we need not now enlarge on it. We have to consider certain other properties of bodies, which from not being general have been called secondary. Of these the principal are solidity and fluidity.

Fluidity – Boscovich imagines that the particles fluid bodies are spherical, and that their forces are more directed to their centres than to their surfaces; by which motion is allowed freely when any force is applied to them from without; and that when at rest all the particles are in equilibrium in respect of each other, but that the pressure of incumbent bodies, and containing vessels, always causes some deviation from it. He says there are three kinds of fluids; one in which the particles or masses have no mutual power; one in which they have repulsive power, and the other in which they have attractive power. Of the first we have examples in sand and fine powders; of the second are the elastic fluids, as air; and of the third, are all liquors, as

water, mercury &c. Now these three kinds are produced by the ordinary differences in the primary particles which compose them; and we are able on the principles of the theory to specify the causes of the diversity in the phenomena which they exhibit.

Solidity is the consequence of the irregular figure of the particles and their great deviation from sphericity, by which free motion among them is prevented, and their cohesion better secured. Now the diversity in solids arises from the various degrees of strength in the limits of the cohesion; and the same principles will give rise to a class of bodies intermediate betwixt solids and fluids, viz. the viscous, whose particles attract each other more strongly than the fluids, and not so strongly as the solids.

If we imagine the particles to be so formed as to attract on some sides, and to repel on others, and to attract particles similarly constructed, and to repel others, we may conceive in what manner the regular bodies denominated organised are compounded; and for these the varieties admitted in the limits of cohesion, situation, and combination of [Boscovichian] atoms, will abundantly suffice. Humidity is only relative, seeing that water , e.g. adheres to our fingers , and may be easily spread out on glass, wood &c. whereas it does not affect oleaginous and resinous bodies : now this in consequence of the partial arrangement of the powers in different bodies ; and the varieties in the combination, &c. of the particles.

Of the chemical operations, Boscovich remarks in general, that they all be traced to the same principle, the law of the forces, and the differences in the particles which thence arise; and that were they subjected to the observation of our senses, a general reason for them would be discovered; but for this there are required an intimate knowledge of the texture of all the particles, and a power of geometry and analysis which far exceeds the human mind. He explains some of them in the following manner: And first of solution. The particles of some solids have a less attraction for each other than for the particles of some fluids, and consequently when these are applied to each other, the particles of the former will separate and will combine with those of the latter, so as to form a mixture in which the two bodies are suspended in combination.

But the separation of the particles of the solid can only take place so long as the particles of the fluid are in the sphere of their attraction; and when either of them get beyond it, or when the attraction of the mixture so formed, becomes equivalent to the attraction of the particles of the solid for each other, then no more solution will take place, and the menstruum is said to be saturated. But if into this mixture another solid, whose particles have a greater attraction for the menstruum than those of the former, be thrown, then the menstruum will leave the former solid, or its particles, and adhere or combine with the latter; in which case the former solid in the form of powder will fall to the bottom, or what is called precipitation will occur. In short, he gives pretty nearly the common explanation of the phenomena; and on similar principles he accounts for the mixture of fluids. Now if the particles of two fluids which are mixed together, come into the limits of cohesion, a solid will be thereby generated, of which we have some examples. On the other hand, two solids triturated together may compose a fluid, in consequence of the particles of each departing from the limits of cohesion.

If we consider that the first limb of the curve exhibits impenetrability, the last gravity, and the intersections the various kinds of cohesion, we may form some notion of the manner in which fermentation, evaporation, deflagration, &c. are caused ; for whilst atoms accede to each other with any velocity, they increase the velocity in every attractive arch, but they diminish it in every repulsive arch ; whereas on the contrary, whilst they recede from each other, they increase it in every repulsive arch, and diminish it in every attractive arch, until in the former case they arrive at a repulsive arch, or in the latter an attractive one, which is sufficiently strong to extinguish the whole velocity. When they do so, they are reflected in the same course, and oscillate backwards and forwards. Besides this, if bodies composed of particles which have different properties, in consequence of the different situation and combination of the powers, be mixed together, an agitation among them must necessarily arise in order to attain an equilibrium ; hence oscillations, perturbations of various kinds, will follow, and cause the great diversity of phenomena which are observed. Now all of these take place within the sphere of general gravity, which does not immediately influence the operations. Substances which are dissolved may not only be obtained again by precipitation, but also by evaporation of the menstruum in which they are dissolved. In this latter case the bodies generally

assume some regular forms, denominated crystals. Now this arises from the particles coming gradually into the sphere of the attractive power of each other, and consequently attaining to some limit of cohesion by the menstruum, which formerly kept them asunder, being gradually removed; whereas in the former case, where we obtain them by precipitation, the menstruum is suddenly removed from betwixt the particles, which are consequently left beyond the sphere of attraction of each other, and do not therefore assume any regular form. It will follow from this, that the more slowly evaporation is performed, the more regular will be the crystals which are deposited; and is verified by observation.

We profess not to understand Boscovich's notion of the nature of fire; but lest our readers may require it, we beg to transcribe his own words:

Me: Latin - pass

And he observes in another place, that if fire be excited only by a fermentation of sulphurous substance, where there is none of this substance there is danger of fire.

Boscovich retains the Newtonian opinion concerning light, viz. that it is an effluvium or emission from the sun, propagated with immense celerity, and retained in certain bodies from which it may be extricated by certain means. He holds the atoms of light to be immense, but still finite in number, and endeavours on, the principles of his theory to account for the wonderful properties with which light is endowed. In doing so, he makes extensive use of the repulsive power, the varieties in the limits of cohesion, and we may add, with much plausibility and success. Sir Isaac Newton, in explaining the reflexion of light, found it necessary to admit the existence of a repulsive power, for which, however, he had made no provision in his system. The late experiments in optics by Mr Brougham serve to confirm the supposition of the existence of a repulsive power in regard of light at least. Boscovich refers his reader to his dissertation De Lumine for more information concerning the reflexion, refraction, &c. of light and colours, and for the application of the principles of his theory to them.

He proceeds to explain many of our sensations ; but we must confess there is very little praiseworthy in his remarks concerning them : indeed we can see no reason why they should be introduced at all into a system of natural philosophy, erected on such or any other foundation which

concerns the external world only. In the small example of the ardour of systematic arrangement and application of physical principles to the intellectual world, which Boscovich has given us, we observe a striking coincidence with the doctrine of Hartley; but our opinion of that doctrine is not in the least meliorated by such coincidence. It is a doctrine which affects to teach more than it is given to man to know; a doctrine by which we are induced to depart from the humble but secure path of observation, and to wander in the boundless incomprehensible field of transcendentals, and which, howsoever harmless its consequences may be, as it augments the vanity of man, prevents the employment of his faculties in the inquiry into familiar truths.

Boscovich adopts Franklin's hypothesis of electricity, which he defends on the principles of his theory; but we must refer our readers to the work itself, for his reasoning on electricity and magnetism. We would only remark, that as our knowledge of these curious phenomena is much augmented even since the time of Boscovich, his theory was applied to them with disadvantage; but perhaps these very phenomena afford the best proofs of the truth of some of its principles.

We have now followed Boscovich through the consideration of his theory, and we flatter ourselves that, in so doing, we have given such an exhibition of its peculiar principles as will at lean excite the curiosity of our readers, though it may not gratify it; and indeed, little more could be expressed from us in detailing a system of such magnitude, and affecting to comprehend so much. We have however engaged ourselves to give such observations and remarks as may have been suggested to us in the course of the work. In conformity with this, we beg the retrospection of our readers to those circumstances in the theory which are most peculiar to it, and which serve to fix on it the characteristic feature of originality. Of these the rejection of contact, as it is the most conspicuous, so it requires the most particular attention, as on it rests the greatest part of the reasoning and fabric of the system.

We have seen that Boscovich supports this principle on the universality of the law of continuity, and on the existence of the interior repulsive power. Of the former we have to observe, that the mode of proving it by induction is strictly philosophical, just, and convincing ; but that the metaphysical or positive arguments used

for the same purpose are by no means so. We do not mean to assert that these arguments have no weight, but only that they are not so far removed from a considerable source of error and misconception, as to prevent all suspicion of their accuracy, and to entitle them to an unqualified application to the subject we consider. It is true indeed, that no appeal to observation can directly determine the question, and therefore, it may be said, we must have recourse to some other authority. But, to us at least, it seems as true, that the proof by induction is the only satisfactory one we can have; and that if we are careful to keep in view that precept of philosophy which teaches us not to multiply causes unnecessarily, and to reason from analogy on the simplicity and steady uniformity of nature, there will be no occasion to have recourse to other authority.

We are disposed to believe, that the metaphysical arguments which Boscovich employs may be retorted on the theory itself. Does not the theory seem to admit a breach in the law of continuity, when it denies the continued extension of bodies? Or, as it rejects the divisibility and extension of [Boscovichian] atoms, must we not imagine and believe, on the faith of the law of continuity, that these [Boscovichian] atoms are mere nuclei of repulsive powers? Or shall we admit that the law of continuity depends on some higher principle not yet discovered, a principle in which extension or duration are concerned; that where there is neither extension nor duration, the law does not hold; that consequently, in the: case of the [Boscovichian] atoms and their mode of union, this law suffers a breach; i. e. that the metaphysical arguments do not prove its universality, or that a breach of it is impossible? Such are the mysteries into which we are enveloped, when we wander from that path which is assigned to human reason.

> Me: Boscovichian atoms as nuclei of repulsive powers might be better said as centres of force.

Britannica: As to the existence of the interior repulsive power, it may be observed, that if it be proved or evinced to us, the impossibility of contact must be admitted. Now we are of opinion that a power of repulsion does exist in the nearest vicinity of many bodies; but we pretend not to know the law by which it operates, or even that it increases to infinity on the diminution of the distance. We are satisfied that it occasions many very curious phenomena, some of which have been explained by it; and we sincerely believe that the investigation of

its laws and the extent of its influence will fabricate a crown as unfading as that of Newton. But we are convinced – that were the theory of Boscovich concerning it tacitly consider in, such a crown could never be obtained. Nay we insist further, that though by reasoning it could be determined that such a power does exist, it would be useless to us, till the most laborious induction be practised to discover how far it influences observable phenomena, and how far it may be subjected to human artifice and ingenuity.

The phenomena which give evidence of the existence of a power of repulsion are chiefly optical; but it belongs not to this article to explain them. We may however just mention that we allude to the experiments of the object-glasses of long telescopes, the brilliancy of dew drops while supported on leaves or rolling on the surface of water, in which it is demonstrable that a certain space intervenes betwixt bodies which are apparently in contact, and that this space can be caused by repulsive power alone. Sir Isaac Newton himself virtually admitted the existence of such a power, as appears from the last question of his Optics; indeed it is very certain that the attractive power alone will not produce many of the phenomena of which he speaks.

Concerning the other principles of the theory we have little to remark, seeing that most of them result from those we have now considered. The transitions of the powers are in our opinion to be ascertained only by observation, and this it must be confessed is no easy matter: the phenomena of fermentation, effervescence, &c. to which we are referred for proofs of the existence of these transitions, seem to be easily explained on such a supposition; but it is nevertheless probable that the supposition was prior to the observation of the laws by which these phenomena are regulated. It may be worth while remarking, that if we are able to conceive these transitions as existing, we can also conceive how motion may be produced at a distance, which was held up as an absurdity in the schools. It must be very evident to our readers that the theory of Boscovich supposes this production of motion, and that any other mode is impossible, seeing that contact is so. But we are not therefore to believe that the repulsive or attractive powers are efficient causes ; though they certainly are physical ones, i. e. they are higher principles than the phenomena which succeed them, and may for aught we know depend on some one more general principle which this theory does not comprehend. We do not therefore foresee any dangerous consequences of the supposition of matter

acting on matter at a distance; nor can we believe that these two expressions are equivalent or consecutive, viz. if matter act where it is not, it may act when it is not. The one is a reference to space, the other to time, and betwixt these we know no mean of comparison.

We see then that the theory of Boscovich is intimately connected with the most abstruse metaphysical inquiries and disquisitions that can employ the mind of man; in particular, that which attempts to discover the mode in which our perception of the material world is carried on. For such, we confess, we have not talents of investigation, and indeed we are convinced that no investigation has yet been, or ever will be, successful; but we are also convinced, that if the theory of Boscovich be established, many preposterous dogmas will be overturned: as such we prefer it to any that has hitherto been offered to the world.

> Me: i.e. it was the best theory in 1810 that there was of explaining physics. Today its still the best we have, or rather extension to it by others is the best we have.

Britannica: But it is to be considered as valid, in so far only as induction satisfies us of its principles; that it can be satisfactorily applied to the solution of many phenomena where other theories fail us; that it does not in anywise inform us of the nature, or supersede inquiry into the laws of matter. We are of opinion that it was his very intimate knowledge of these laws, and his diligent inquiry into matters of fact, that led Boscovich to the discovery of the law of continuity and of the forces, and made him see the propriety of erecting some new system in which these might bear a part. The merit of Boscovich consists not in having discovered the cause of motion, or on what it depends. He attempted a more humble strain: he investigated familiar operations, and acquainted himself with vulgar things. No mysterious analogy indeed conducted him either to the harmony or to the beauty of the spheres but then, no stupendous vacuum intercepted his path, and no unruly vortices whirled him from rectitude. That he stopped not where prudence might have directed, and beyond which his guide could go no farther, was the failing of genius elevated by success, the lot of the resplendent few who are dazzled by their own lustre. But it would ill become his followers to attempt continuing to the end on that path which he pointed out; moderate minds mould accompany him as their friend, only so long as they perceive he is directed by a friend which is greater than him: let them remember that

it is his observations alone which are valuable, the simple arrangement of them which they should esteem; it is the plain narrative of the honest traveller which assist them, not the pompous fabric of the self-deluded novelist.

The only theory with which we can properly compare this of Boscovich, is the Newtonian, and in so doing its superiority will appear ; but for very obvious reasons we enter not minutely into the comparison, and will only add that in the Newtonian, we must have recourse to the three principles of gravity, cohesion, and fermentation, for the explanation of phenomena ; and even these are insufficient in the modern chemistry : but we learn from the former that these are only portions of a more general principle, that they result from one fundamental law, and that to this law may be referred as well the formation of a dew drop, as the rolling of the spheres (A).

Britannica Footnote: (A) It may be a satisfaction to our readers to know that Sir Isaac Newton entertained notions very similar to those of Boscovich concerning the causes of motion at the insensible distances, though it is to be regretted that he had made no provision for them in his system. The last question in his optics plainly indicates that he himself was convinced that no law by which an attractive force might be supposed to act would be sufficient for the explanation of certain phenomena which take place in the immediate vicinity of the atoms of matter. “And if all these things are so, then all nature will be very simple, and consistent with itself, effecting all the great notions of the heavenly bodies by the attraction of gravity, which is mutual between all those bodies, and almost all the less motions of its particles by another certain attractive and repulsive force, which is mutual between those particles. Now it seems that these elementary particles not only have in themselves the vis inertiae, and those passive laws of motion which necessarily arise from that force, but that they likewise perpetually receive a motion from certain active principles ; such as gravity, and the cause of fermentation, and of the cohesion of bodies. And I consider these principles, not as occult qualities, which are feigned to flow from the specific forms of things, but as universal laws of nature, by which the things themselves were formed. For that truly such principles exist, the phenomena of nature shew, although what may be their causes has not as yet been explained. To affirm

that every species of things is endued with specific occult qualities, by which they have a certain power, is indeed to say nothing; but to deduce two or three general principles of motion from the phenomena of nature, and then to explain how the properties and action of all corporeal things follow from those principles, this truly would be to have made a great advancement in philosophy, although the causes of those principles, we not as yet known. Wherefore I do not hesitate to maintain the above said principles of motion, seeing they extend widely through all nature." Newton's Optics.

Back from Britannica Footnote:

Some of the admirers of Boscovich may be surprised that we affirm, his theory gives no information of any one efficient cause in nature, and that all the discovery he has made is, that of some events which precede the Newtonian gravity. We have already borne ample testimony to the merits of Boscovich, and we think we are secure from any suspicion that we endeavour to depreciate the value of his theory; such indeed is far from our thoughts, but we must say it is farther from our thoughts to consider it as the ultimatum in natural philosophy, or that it discloses to us the most supreme process in nature. We will venture farther ; for we will maintain, that though all the principles of the theory were established on a firm and invariable foundation, as they are not, it would be impossible for any one to determine what shall be the consequences resulting from them, prior to experience of the regularity and the constancy of the conjunction of events ; and that of consequence the same, nay greater, labour of induction and observation is required in the phenomena of the material world ; greater, because the objects are increased in number by the discovery which Boscovich has made. But this assertion concerns the laws of nature alone, not the laws of human thought, of which, in our opinion, Boscovich has made too free use. He tells us that one consequence of the interior repulsive power is, the impossibility of contact, and that another is the impenetrability of the [Boscovichian] atoms. Now it requires no great exertion of understanding to perceive that he is displaying a law of human thought, for these consequences of which he speaks are parts of the same conception, and that no reasoning a priori is employed to determine their connexion; for we cannot possibly imagine, that contact or penetrability of the [Boscovichian] atoms should occur, if such a repulsive power exists, or that the

impossibility of the former, and impenetrability, could be caused by any thing else than such a power. The most ignorant of the sons of men are as well qualified to understand this as the greatest philosophers who have adorned humanity; and if it be entitled to the name of discovery, it is one in which all mankind have shared; but for having expressed it in words, and incorporated it with others which some kindred genius alone could have made, all are indebted to Boscovich, and must acknowledge that in his hands it has served to fabricate a lasting monument of genius, industry, and sagacity. We are not therefore to consider that these are instances wherein any consequences have been determined a priori; and they do not affect our assertion, that prior to experience of the regularity and the constancy of the conjunction of events, it would be impossible for any one to determine a priori what shall be the consequences resulting from the principles of the theory. To illustrate our meaning in the assertion, we shall suppose that the transitions of the powers have been discovered to exist in the constitution of matter ; and we then ask, if, prior to the knowledge of the phenomena of fermentation, &c. it could have been determined that these phenomena should necessarily result from them : we apprehend it could not, and our reason is, that we cannot find any mode of connexion betwixt any transitions of any forces and these phenomena ; for we can conceive the former to exist without the latter, and this might have been the case, for aught we know to the contrary ; and we think we are authorized in saying, that these transitions are only -rules or methods observed in the production of such phenomena, that they are events prior to fermentation, &c. and remain themselves to be accounted for. We may say the same of the repulsive and attractive powers; and of all the other principles in the theory which are not laws of human thought. Causation is inscrutable, the labours of every age serve only to add to its mystery, seeing that they conduct us nearer to the boundaries of human observation, and discover to us the delusive glare of every weak meteor which promised permanent and enlightening lustre.

We have seen that the general properties of matter may be well explained by the theory; and so far therefore we must admit that the theory is applicable to the objects of investigation, and may be useful to connect together some general principles. There remains to us to make one remark concerning one of these, viz. Newtonian gravity. The supposition that it terminates beyond the comets of

our system, and is succeeded by repulsion, appears to us very unnecessary, not to say unlikely, though highly worthy the accommodating genius of Boscovich. We are of opinion, that the objections urged against Sir Isaac Newton on this subject, may be much better and more simply obviated by a supposition which the modern improvements in astronomy have nearly confirmed, viz. that there are systems of suns and revolving planets, similar to, and reaching to the limits of, our own; and that those are sufficient to counteract the necessary effects of universal gravity of attraction.

If such be the case, inequalities in our systematic motions, relative to others, may arise from the varying situations of the other system; and, if we consider the fixed stars as forming these, we may observe differences in their positions and magnitudes, in consequence of such variations. Our astronomical readers will perceive that we allude to the apparent approach of our sun to the constellation Hercules in the northern hemisphere, the gradual widening of the stars in that quarter of the heavens, and the consequences of it. But without any such confirmation it must be acknowledged, that our supposition is much more probable, and gives a more elevated notion of the great Artificer's skill than that of Boscovich, and we are the more anxious to retain it, that one of the principles in the theory may not be broken, that the transitions of the powers occur in the insensible distances.

We request the attention of our readers to Boscovich's provident supposition on another account. Does it not indicate one of the modes by which his theory was formed? Does it not plainly shew us how far genius will be exerted when observation fails? Does it not satisfactorily demonstrate that part of this splendid theory is the offspring of an imagination heated by systematic love, and animated by a reconciling enthusiasm? Indeed when the imagination is the provider, the reason can be well satisfied ; for what is wanting can be readily supplied, what is displeasing can be easily rejected, what is unshapely can be fashioned to conformity, and all can be decorated and adorned, till at last there arises some fine fabric to please and to delight. But we require more than delusive ornament, and yet we expect not perfection ; we know that every theory of natural philosophy has failed hitherto, not from a deficiency but rather from a luxuriancy in grandeur, which, surpassing, has eclipsed the minute gems that glitter below ; no one has failed in explaining the stupendous structure and the mighty rollings of worlds,

which no eye ever comprehended, and no hand ever approached ; but take it from its godlike work to the mean purposes and the trivial uses of man, and behold the airy phantom shrink from our view. It is in explaining familiar circumstances, or, so to speak, the events of our neighbourhood, that every one has failed; but it is consoling to mankind to know, that in every succeeding one, there is a greater approximation to perfection, a greater extent and more facility of application; and we will acknowledge that this of Boscovich, though not totally invulnerable, certainly leaves the least uncovered.

The observations which we have now made seem to us very proper to introduce those we have to offer on the application of the theory to physics. We are of opinion that Boscovich, in his account of solidity and fluidity, has rather given a description, and related some properties, than proposed an explanation or deduction on the principles of his theory : but in a system of such extent, and promising so much, we require more than this, and it is our opinion that more may be given. Without pretending that we have complete success in our attempt, or wishing to preclude others, we offer the following as at least a probable one. We can imagine, that any number of [Boscovichian] atoms shall come into the limits of cohesion of each other in such a manner as that a mass of some determined form shall be produced ; and that the powers on each side of these limits are so strong, as to withstand considerable divellent force from without.

Now in a mass so constructed every [Boscovichian] atom is retained in its situation by powers of the same kind, acting by the same laws, and which cannot be increased or diminished by any other means than varying the distance betwixt these [Boscovichian] atoms. The powers so influenced are those only which belong to the particular [Boscovichian] atoms whose respective distances are changed; for the powers of the [Boscovichian] atoms whose distances are not changed remain the same; therefore a portion of the mass may be separated, or the whole mass may be moved, without causing any relative motion among the [Boscovichian] atoms; for, in the former case, a few only, in the latter, none, of the limits of cohesion are disturbed. This then is the structure which the atoms of matter would form, did such laws as we have considered exist; and it appears to us that it is the natural structure; for we ourselves cannot conceive how a fluid body should be composed by -such laws, independent of composition of them.

But admitting composition, we would explain fluidity in the following manner : As in a mass, such as we have described, there are spaces betwixt all the [Boscovichian] atoms; it is possible that other [Boscovichian] atoms may be introduced within it, or that in the vacant intervening space the powers of other atoms may operate. Now, it is easy to conceive, that in the former case very various effects will result in consequence of the differences in the proximity of the [Boscovichian] atoms ; for some will quit the limits of cohesion in which they were prior to the introduction of the adventitious [Boscovichian] atoms, and will enter into new ones, and will vibrate from one to another, if there be a constant addition of [Boscovichian] atoms made, or if any of those which have been introduced be removed ; and that in the latter case, in consequence of the composition of forces, very different effects will result, according as the composition is of similar or different powers acting in the same or different directions, and of different intensities : in either case relative motion among the particles will occur, and the mass will yield to the lean extrinsic force ; an equilibrium will sometimes be produced, but it will be destroyed very readily in different ways, as by the addition or subtraction of the adventitious [Boscovichian] atoms, and by the application of forces to the mass.

We might specify some of the particular circumstances which would tend to the production of different fluids did; your limits permit; but as this would be prolix, we shall only mention some of the consequences which may be deduced from the principles we have stated, and granting that they are well founded, we shall consider how far they coincide with the phenomena we observe. Every fluid must be a compound body. This will be pretty generally admitted by modern chemists ; for though they well know that the composition of several fluids is not yet discovered, they will allow that the rational presumption from analogy is, that when our analytical powers are augmented, we shall be able to discover the composition of all of them ; nor is it any objection to the rationality of the presumption that many of the gaseous fluids are simple or elementary, for it must be remembered, that all of them are combined with caloric or the matter of heat. Nay caloric itself, which we hold to be a substance, may, for ought we know to the contrary, be a solid body ; it is indeed almost universally believed to be fluid, and essentially so ; but, for this belief we can find no other reason than that it causes fluidity, and surely that is a very unphilosophical one

; for in a similar manner, and we venture to say, with as much truth, if matter or its atoms be constructed in the way Boscovich describes and if they possess the power of repulsion and attraction, then all matter is fluid, for all the atoms of it will cause fluidity in certain circumstances. We do not deny that when it combines in sufficient quantity with bodies it causes fluidity ; but we beg to remind our readers that there are cases of fluids being generated by the trituration of solids together, and surely they will acknowledge, that what is true in the one case, is at least possible in the other ; but we will even admit, that caloric is the principal cause of fluidity (though we are aware that in admitting it, we depart from true philosophy), and yet we do not perceive, that the lean objection to our supposition will thence arise. May not caloric be composed of the very smallest, or the primary atoms of matter, and consequently be more easily insinuated betwixt the atoms of other bodies which are composed of the aggregates of these primary atoms? Do we not find that it corresponds pretty accurately with the description of these atoms which Boscovich has given? Does it not seem in the least distances to repel its own particles, and at greater distances to be attracted by the particles or atoms of other bodies?

The constant addition of adventitious [Boscovichian] atoms to the interstices in a solid body, as we have before mentioned, will cause vibrations, and will at last, by totally separating the atoms from the limits of cohesion and the sphere of the attractive power, render them susceptible of the influence of surrounding bodies, so that they leave each other, and combine with those which surround them. When caloric is the body added, the most general effect which results from its repeated and constant addition is evaporation. Now the particles of an evaporated fluid will recombine if the superabundant caloric which holds them asunder be withdrawn, provided the bodies with which they unite do not attract them more powerfully than they do each other. But it is possible that such an addition will in certain cases strengthen the combination of a solid, i. e. that fluidity will not always be the consequence of insinuating atoms into the vacant spaces, for it is possible to specify circumstances, in which a body already fluid, may be rendered solid by interposing amongst its particles, the particles of another, fluid.

When the adventitious [Boscovichian] atoms are removed, one of two consequences will occur, either the

[Boscovichian] atoms of a solid which has been rendered fluid by such Insinuation, will be left within their spheres of attraction, and consequently will enter into limits of cohesion, and form a solid again, or they may be left beyond these spheres, so as not to enter into limits of cohesion, but to form a loose uncombined pulverulent substance. It may happen that in the latter case, the particles being separated from each other beyond their spheres of attraction, will enter into combinations with other bodies, of whose influence they are now susceptible. We have instances of both of these in the fusion of metals: sometimes on cooling these form again into solids; others, having their [Boscovichian] atoms too far separated from each other, cannot so unite, but combine with other bodies, (generally oxygen) and form powders which retain no characteristics of metals; and some combine with other metals constituting alloys.

We recommend the prosecution of this subject to the philosophical chemist; and though we encounter the charge of vanity, we cannot help flattering ourselves with having pointed out a mode by which, though nothing should be discovered, yet to resolve some apparently unconnected phenomena into one general principle, and hence to abridge the labour of acquitting the science of chemistry, and to facilitate the application of it to the practical purposes of life. We are of opinion that the facts in chemistry are now so numerous, as to require a generalizing spirit to reduce them into some kind of order, to shew their connexion in the chain of nature, and to derive from them by induction, certain principles which may be employed in the synthetic process. Indeed without such it will soon be found that no ordinary memory can retain what may be useful, but certainly is elegant in the art, and that a great body of evidence is insufficient to enforce conviction, if it be huddled together in chaotic confusion : pillars and porticoes and carved stones may be collected, and may astonish us by their grandeur ; but unless they be methodized, connected, and combined, our astonishment will resemble that which we feel, when we contemplate the preposterous structure of some natural monster, whose limbs are individually elegant, but serve by their elegance to magnify the error of their position. We do not wish to depreciate the merits of modern chemists, but we must confess, they appear to us more scrupulous about ascertaining the few grains of earth in some cockle shell, than anxious to erect a temple to their science, and are themselves too much elevated by the discovery of a semi-metal, to be concerned about the deities which preside. What we have said may be thought mere

declamation, if we do not accompany it with some example of the employment of such a generalizing spirit ; we know not how far it may become – us to do so, but as the consideration of the theory of Boscovich, in which we have been engaged, has naturally led us to those phenomena which seem best qualified to admit of its application, and as therefore, in some sort resulting from, or connected with our subject, we shall attempt to give a small specimen of it.

It is well known to chemists, that although certain individual or single bodies of the saline class be very soluble in water, the compounds formed of them are very insoluble in that fluid, i. e. that though alkalies or acids be singly very soluble in water, the neutral salts formed by them are very insoluble ; and that many varieties in the degrees of solubility are to be met with in the compound bodies or neutral salts, which are contrary to whet we should expect from reasoning on the varieties of these degrees, in the simple or elementary bodies which compose them.

For example, the sulphuric acid is very soluble in water, and so is the vegetable alkali or potash ; but the sulphate of potass, which is a compound of these, is so – difficult of solution, that 16 times its own weight of water, at the temperature of 60°, is required to effect it. The acetite of potass affords another example, though not so remarkable, requiring only about 10 times its own weight of water at the same temperature. Indeed, there are many instances of a compound or neutral salt being less soluble –than either the alkali or the acid which enter into its composition; but in those we have mentioned, the difference is so great –as to have merited much attention, though as far as we know, there has not been assigned a reason for it. Now we apprehend the reason to be, that as both the simple bodies have an attraction for water, or that as there is an attraction betwixt water and these two bodies, the degree of attraction will be equal to the difference only of the separate attractions betwixt water and the bodies individually –, or, in other words, the attraction betwixt water and one of the bodies– will be lessened; by the attraction betwixt water and the other body, so that the difference only of these two will influence. Now, in certain cases, this difference will be equal to nothing, when the attractions are equal; but in every case, it is evident, it will be less than the greater of the attractions, and, of consequence, the solubility of the compound will be less than that of the simple bodies which compose it. Now this consequence is not affected by

the absolute solubility of the simple bodies, but by their solubility in respect to each other, i.e. relative alone ; therefore, the compound of simple bodies, which themselves are highly soluble, may be no more soluble than the compound of simple bodies, which themselves are very little soluble.

The principle is universal. Other consequences will result, which are not only curious, but, in our opinion important ; and we do not in the least hesitate to assert, that the principle may be applied to determine à priori the degrees of solubility of neutral salts, provided we are sufficiently acquainted with the relative solubility of the simple bodies which compose them. One consequence will be, that a compound formed of a very soluble and a very insoluble simple body will be nearly, or quite, as soluble as the former, seeing that the attraction betwixt it and water will be little or not at all diminished by the attraction betwixt the other very insoluble body and water. As a proof of this, we may take the instance of the sulphat of magnesia, which is soluble in its own weight of water at temperature 60: Now in this case, the magnesia is soluble to a very small amount only; but the acid, it is well known, is so to a great degree; even the small solubility of the magnesia, however, does in a certain degree impair the solubility of the compound. The same is true of the nitrat and muriat of magnesia; and, did our limits permit, we might adduce very many examples of the same: we might shew, that the compounds of very soluble acids with the metallic oxide are soluble, if these oxids are not so; but if they are, the solubility of the compound is impaired: and we might also apply the principle to bodies soluble in alcohol and other menstrua, where it will be found to hold. But we leave the prosecution of the subject to our chemical readers, confessing, however, that we have found exceptions to its universality, which as yet we have not been able to reconcile.

Perhaps, a principle still more general, and higher in the order of events, may influence or modify this which we have specified; it may be connected with some of those varieties in the composition of forces, which must take place in, the insensible distances, changing the limits of cohesion, and modifying the position and the action of the atoms of matter. We have ventured far in the exposition we have given; did we persevere, there might be imputed to us temerity. We have attempted to apply Boscovich's theory to several other chemical phenomena, particularly those of elective attraction and disposing affinity; but though our success has been somewhat

flattering, we have not been able hitherto to collect and arrange our principles and results, so as to present them properly to the public. At some future stage of this work, however, such may be in our power, when we hope to convince our readers, that the theory is sufficiently accommodated to that object, and that it will assist us in deducing principles more genera!, than any yet received in chemical science.

9. Conclusion

Britannica: It is now time for us to conclude our account of the theory of Boscovich ; and in so doing, it becomes us to recommend to our readers, that they endeavour to form a just and an adequate opinion of its merits, of the objects which it has in view, and of the means which it employs to accomplish them. Considered in respect to itself only, as the production of a great and an enlightened mind, no labour to comprehend it can be in vain or worthless, and no one can comprehend it without receiving the most elevated pleasure; but there is another inducement for us to effect this purpose, different from any we have yet mentioned: we mean the tendency it will have to modify, and to subvert, many of the leading doctrines in the metaphysics of the day. Nor ought this to alarm any of our readers, for if these doctrines be true and legitimate, they will be paramount to all objections, and the improvements made in every other science will serve to confirm them; but if they are not so, surely the sooner they are subverted the better it will be for science and for us all; at all events, aπ inquiry into them is rational, and it may do good. This, however, we dare not now propose to ourselves, and will therefore recommend our readers to peruse the Essays on Perception, by Professors Reid and Stewart, where they will find sentiments which derive most of their validity from some of the Boscovichian principles. They are sentiments in which we have the honour to agree "with these true philosophers; though it is somewhat mortifying to us to confess, that they have convinced us that the phenomenon of which they treat is inexplicable.

> Me: Probably referring to Thomas Reid (1710–1796) a Scottish philosopher and one of the founders of the “common sense” school of philosophy. [9] And Dugald Stewart (November 22, 1753 – June 11, 1828) [10]. Both part of the Scottish Englightenment of the 18th Century.[11]

Britannica: It is indeed very mortifying to humanity to be convinced, that for many, very many centuries, our forefathers have been unceasingly attempting to explain phenomena intellectual and material by a nullity, on principles which do not exist; but it would be still more mortifying to find, that though there is ground for such convictions, men calling themselves philosophers should persevere steadfastedly in the same invaluable course of error and absurdity. In our own days, a light, clear and authoritative, has arisen to direct and to animate us in the search after truth; it is our own faults if we shut our eyes against its splendour, and suffer the interior man to be dark and unenlightened. Of this light the theory of Boscovich forms a part: it has succeeded and surpassed that of Newton; it will be the parent of a greater than either; it professes to conduct us to the interior veil of the temple of nature; but it has failed in this very sublime attempt, failed,[*] however, only after it has conducted us beyond Descartes, Leibnitz, and Newton.

> Me: The article does not give sufficient reason for why it thinks Boscovich's theory has failed; the theory is good enough as far as I am concerned; and anyway gets extended upon by those others (I deal with in my writings) who work on unified field theory. And the article says it has surpassed Newton and will be parent of a greater theory; so it is part of the tradition of unified field theory development.

References

[1] Boscovich in Encyclopaedia Britannica, fourth edition vol. IV, 1810, p 41 -59.

> Me: Some references below are wikipedia; wikipedia gives usually a fair summary for introduction to a subject, but it is not "fixed" and gets updated; and usually tries to block conspiratorial side. I only want to give an introduction, and if the conspiratorial side of this subject is being blocked and still some of it manages to get through the blocking then so much the better.

[2] http://en.wikipedia.org/wiki/Heliocentrism 2011-01-29

[3] http://en.wikipedia.org/wiki/Elizabeth:_The_Golden_Age

2011-01-29

[4] http://en.wikipedia.org/wiki/Jesuits

2011-01-29

[5] http://en.wikipedia.org/wiki/John_Robison_%28physicist%29 2011-01-29

[6] See for instance: AIRY'S FAILURE RECONSIDERED Walter van der Kamp http://www.geocentricity.com/ba1/no066/vdkamp.html and http://ldolphin.org/geocentricity/Kamp2.pdf - which probably gives a non-mainstream view. - It would really take deeper analysis of these papers by me than I have given here.

[7] http://en.wikipedia.org/wiki/Francis_Bacon 2011-01-29

[8] http://www.space.com/448-problem-gravity-mission-probe-strange-puzzle.html

[9] http://plato.stanford.edu/entries/reid/

[10] http://en.wikipedia.org/wiki/Dugald_Stewart 2011-01-30

[11] http://plato.stanford.edu/entries/scottish-18th/

My comments: c.RJAnderton2011-01-30