Unified Theory of Rogerio Boscovich
(300 Anniversary of the Croatian Scholar)

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Abstract. Rogerio Boscovich was a Croatian scientist which ideas aheaded his time. He created a hypothetical picture of a physical world, worthy of admiration. He uttered amazing ideas about the structure of matter and the properties of the world from atoms to space, and imagined atoms as physical items. According to Boscovich, "*only one law of forces*" acts in nature. The force modifies its character according to the distance between the particles and solids. His hypotheses have confirmed by the modern physics. Rogerio Boscovich was a versatile scientist. He worked in mathematics, astronomy, optics and meteorology. He was a member of many European academies, performed diplomatic missions and interested in poetry, music, archeology, and medicine.

Keywords: Rogerio Boscovich

His idea about point-like particles with "zero radius", which create "fields of force" is fundamental for the contemporary physics [1].

Professor Ivan Lalov determines 18 century as "a *comparatively quiet century*" and specifies that "*in ideological plan it is untraced – there are no new ideas – neither new discovery*" [2].

The authors of the book, cited as a motto of this paper have another opinion [1]. According to Lederman and Terucy, the Croatian scholar Rogerio Boscovich wrote "*a remarkable for the eighteenth century thought*", that "*matter consists of particles without size*". This astonishing idea "*was really crazy*" for eighteenth century. But in the end of 20th century physics discovered "*the atoms of Boscovich*". In that reason, they call him "*pioneer of atomism*" and "*Dalmatian prophet*" [1].

The present report is devoted to the remarkable scholar – Rogerio Josepho Boscovich, who was born before 300 years in Dubrovnik* (18 May 1711). Growing up in a Jesuitic family he studied in Jesuitic College in his native town, and after that – in Collegium Romanum (Jesuitic seminary) in Rome. All scientific heritage of Boscovich, his research and intellectual activity suggest one spiritually rich and highly erudite person.

Jesuitic education before three centuries is interested for us because we do not stop reforms in education. In the Collegium Boscovich studied theology, Latin and Greek languages; and "*seven free arts*": grammar, rhetoric, dialectics, arithmetic, geometry, astronomy and theory of music. In the upper grades, he studied "*erudition*" including geography, history, archeology and natural philosophy; and in the last three years – philosophy, mathematics and physics.

Rogerio Boscovich graduated in 1733. He began to teach in Jesuit secondary school after that. He was ordained for a priest and headed the department of mathematics in Collegium Romanum in 1744. At that time, he already has around 20 published papers mainly in astronomy and mathematics.

Versatile Scientist

The results of Boscovich research are 50 years creative work and 90 published articles and monographs. The review of his papers shows that he is an universal scientist. His first publications are in astronomy: "*On the sun-spots*" (1736), and "*On the passage of Mercury*

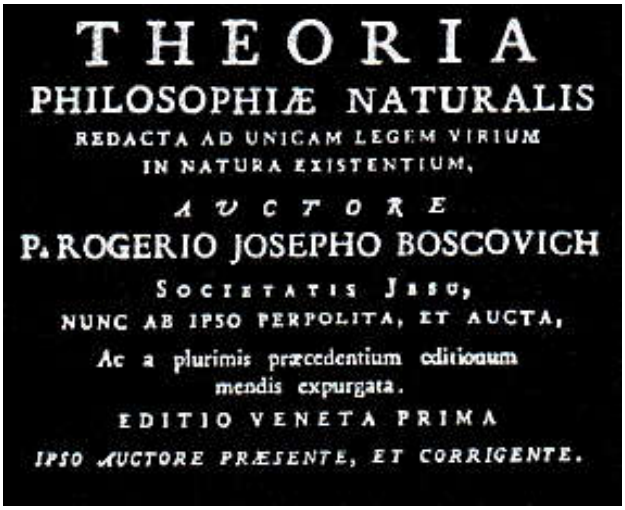
before the Sun" (1737). Later on, he investigated solar and moon eclipses, comets, annual star aberration, planet motion etc. Boscovich was the author of the idea about modern astronomical observatory near to Milan, which he had realized.

Boscovich examined many applied aspect of optics including theory of emission, and diffusion of light. He constructed new devices and improved the quality of some optical instruments: lenses, prism, and telescopes. A variety of telescope full with water was his original idea. He aimed to use it for studying an influence of the Earth motion in the light diffusion. Close to these occasions were his investigations in geophysics and meteorology: the northern lights, high and low tides, the figure of the Earth and its changes etc.

Rogerio Boscovich has significant contributions in mathematics too. He publishes the work "*The construction of trigonometric spheres*" in 1737. He developed the essence and the application of infinitely large and infinitely small quantities, based on the universal mathematics, etc.

Boscovich combined pure scientific researches with applied activities and attained renown and authority. He measured the arc of the meridian between Rome and Rimini and corrected the map of the Pope region because of the granting request of the Pope Benedict XIV. He restored the cathedral "*St. Peter*" in Rome, the Emperor Library in Vienna, the Cathedral in Milan and the Church "*St. Genoveva*" in Paris. He had enviable engineers capabilities elaborating projects for draining swamps, regulating river streams, building bridges, sea ports, and etc.

Common Forces Law in Nature


THEORIA
PHILOSOPHIÆ NATURALIS
REDACTA AD UNICAM LEGEM VIRIUM
IN NATURA EXISTENTIUM,
AUCTORE
P. ROGERIO JOSEPHO BOSCOVICH
SOCIETATIS JESU,
NUNC AB IPSO PERPOLITA, ET AUCTA,
Ac a plurimis præcedentium editionum
mendis expurgata.
EDITIO VENETA PRIMA
IPSO AUCTORE PRÆSENTE, ET CORRIGENTE.

Boscovich had an original ideas for structure of matter and forces ruling the world in the least and largest scales. He generalized his ideas in capital book, published in Vienna in 1757: "T*heory of natural philosophy reduced to common law of forces in Nature*".

Newton introduced force in physics as a term. However, long time after that there are essential differences in its understanding. On one hand, the force was not a basis term. D'Alembert, for instance, treated it completely negative, calling it "*dark metaphysical term*". A number of famous physicists as N. Carnot, G. Kirchhoff, H. Hertz sustained similar view even in the 19th century. In his fundamental book "*Principles of mechanics*", Hertz built mechanics without forces (1891).

Rogerio Boscovich developed an opposite idea. (May be in that reason D'Alembert hated him.) Boscovich gave fundamental significance of the force, considering it as a substance existing with matter and even lies in its basis.

Boscovich tried to explain structure of matter by his ideas of forces. He examined not only the world around us but also the properties of micro world and megaworld inaccessible

for our senses. Boscovich creates an entire picture of the world. The kernel of his theory was a universal law for interactions between particles of the matter.

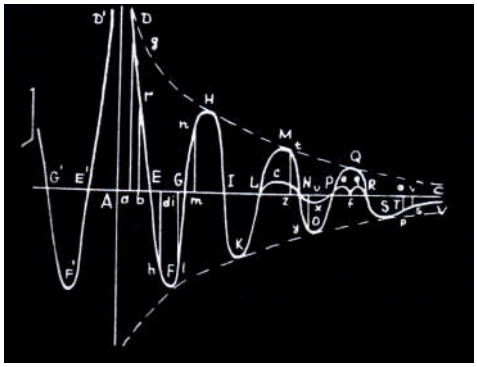
Atoms of Boscovich

The genuine conjecture of Democritus for smallest indivisible particle in Nature was expressed in the IV century B.C., but ideas about atoms were primitive for more than two millennia. To explain the interactions between atoms Lomonosov who lived at the same time as Boscovich, used little hooks, wedges and different unevenness.

Atoms are points, not mathematical, but real points according to Boscovich. They have mass without volume and structure. This hypothesis is peculiar geometrization of matter. It is similar to a certain degree to contemporary models of the theory of elementary particles. Boscovich believed that atoms are simple indivisible, dimensionless and impenetrable points. They are a source of forces between them [3].

Further, the scientist explains how to form a hierarchy in the structure of matter. The concepts of Boskovic have a quite actual sound with respect to well known today hierarchy in the structure of matter. Structureless quarks form the fundamental building blocks (protons and neutrons). Later, nucleus with electrons build atoms, molecules, etc. Scientists foresaw even reducing of the energy of association between particles from simpler to more complex structures.

Boscovich Views about forces



The views of Boscovich about the forces are well illustrated by the picture in left. It is come from his book. The continuous curve corresponds to forces acting between two primary elements located at the some distance. Forces have qualitative presentation by two asymptotic rays – of repulsion (the dotted line DHMQ) and of attraction (FKOS). The forces of repulsion act on short distances between points like particles. These forces do not permit the particles to come into full contact (no one had previously rejected a such possibility). The force diminishes to zero (p. E) and turn into a force of attraction when the distance increasing. diminishing after point F again the force reaches to O and again turns into repulsion. The forces permanently change their destination and sign. Equilibrium points are the cross points to abscissa. Boscovich called them points of adhesion and non-adhesion. The universal force turns into Newton's gravitation law after several large oscillations.

A similar behavior of the forces between known today particles in the nuclear and subnuclear physics easily could be seen. The interaction between two protons on a nuclear distance is a good illustration of the forces of Boscovich. If $r < 0.4\,fm$, forces of repulsion (described by potential of the "*nuclear repulsion*") act between them; if $r \approx (1-10)\,fm$, nuclear forces of attraction act, and if $r > 10\,fm$, the forces are again repulsive (Coulomb's ones).

Boscovich tried to explain physical phenomena and properties of the matter: impenetrability, dimensions, weight, cohesion, hardness, density, capillary and optical

phenomena, and chemical actions by his unified Law of forces. When the bodies are in observable distances, the forces are exceptional gravitational.

The changes of the direction in which the forces act qualitatively explain different aggregate states as well as the transitions between them (melting, evaporation, chemical reactions). According to Boscovich, the solid and liquid bodies are form when the forces have transmuted from repulsion into attraction. If the distance between atoms continie to increase, the forces transform again into repulsion and the liquid start to evaporate. Various forms of crystals, gas expansion, absorption and other phenomena find their explanation in the same way.

Development of Physics in the 19th Century

Ideas of Boscovich had a considerable influence on the development of physics in 19th century contrary to some opinions. William Hamilton started creation of a system, in which optics and dynamics have common principles during the third decade of the same century. He used the ideas of Boscovich to reach his purpose in programme articles "*On a General method in dynamics*" (1834 – 1835). Hamilton considered the work of the Croatian scientist as an alteration of the mechanics that changed it in more dynamical theory reducing all connections and actions between bodies in attraction and repulsion of the points [4].

Well know fact is that Hamilton's ideas of optical and mechanical analogy has served as a basis of the hypothesis of a de Broglie wave-corpuscular dualism in microparticles a hundred years later.

The german physicist Gustav Fechner (19.04.1801 – 18.11.1887) is popular as a creator of psychophysics. His book "*Theory of atoms*" published in 1855 contains ideas for the forces that are the same as expressed by Boscovich 100 years earlier.

Ideas of atomic theory created by Dutch Professor Christophorus Buys Ballot (10.10.1817 – 03.02.1890) in the middle of the 19 century completely match with them [5]. The new element in this theory is the ancient atomism to be used for explanation of the new phenomena in physics: electricity, magnetism, heat and emission.

The ideas of Boscovich undergone serious development in the theory of Michael Faraday (22.09.1791 – 25.08.1867) [6]. The concepts of Faraday for the force lines of the electromagnetic field, for the atom as a center of a force, and his understanding that a force is a characteristic of matter were similar to the ideas of Croatian scientist. Ideas of Boscovich grew up into an idea for a physical field transmitted by Faraday. His field was not mechanical comprehension as an auxiliary notion, but as kind of matter. Great Russian chemist Dmitri Mendeleev gave high appreciation to Boscovich. He gave a short exposition of the atomic doctrine of Boscovch in his monograph "*Foundations of chemistry*" remarking, that Boscovich "*has considered as a founder of contemporary concept of matter everywhere at present*".

Boscovich Ideas in the 20th Century

The influence of Boscovich was felt in several atomic models proposed in the first decade of the 20th century after the discovering of the electron. Famous scientist William Thomson (Lord Kelvin) created one of them in 1902. His attitude to the ideas of Boscovich suffered interesting evolution. Thomson proclaimed that the theory of Boscovich is an old-

fashioned one in 1884. He wrote that it is an "*infinitely unbelievable*" theory in 1893. He recognized it "*as a guide*" in his work in 1900, and declared that his own "*view is pure Boscovism*" in 1905.

Another popular English physicist J. J. Thomson built the first atomic model as "*a number of mutually repelling particles held together by a central power*" in 1897. He explained the stability of electrons in atom by the forces of Boscovich. Several years later (1903), he improved his model by moving electrons in concentric orbits inside the sphere with a positive charge. The model was popular as "*pudding with raisins*". Later, Rutherford proposed the nuclear model of the atom. The idea about stable electron orbits has conserved in it (as well as in the theory of Bohr). Some authors are even disposed to accept the Bohr model as a direct successor of the ideas of Boscovich [7]. Such evaluation is far-fetched in my opinion, but it is indirectly supported by W. Heisenberg (1958).

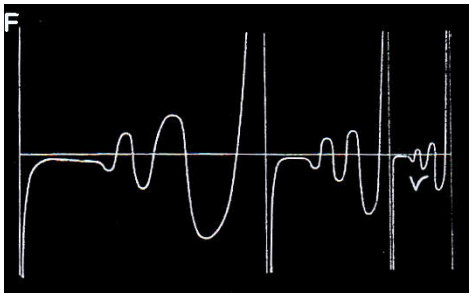
"*The spirit*" of Boscovich has presented in the new achievements of elementary particles physics. L. Lederman and D. Teresi gave "*accelerated theory*" of the Standard model in the last part of their book. Totally ten models from the "*water of Thales*" up to the quark idea are included in it. By their peculiar manner to give the achievements with some humor, authors appreciated models in six degree. They gave "*six*"in their *"arrangement"* only to the idea of Democritus about existence of atoms and to the nuclear model of Rutherford. The model of Boscovich was appreciated as "*very good* 5^{+}". By comparison, "*the standard model*" of Newton received assessment "*four*" [1].

The Space, Time, Universe and its Geometry

We must relate the ideas of space, time, Universe and its geometry to "*mental pushups*" of Boscovich. He criticized the Newtonian absolute space and time and its independence from matter. Boscovich accepted, that space and time are form or condition for existence of matter. According to him, space and time are inseparable and inexhaustible. Everything in the world is moving. There are no absolute rest or motion. Each movement relatively changed space and time of the material points.

The hypothesis of Boscovich of space and time relations is inextricably related to his assumption for point atoms of matter and the forces acting between them. The effect of this hypothesis fit together his theory with general relativity.

As we have mentioned above, the forces of Boscovich turned into gravitational forces at observable distances. According to him, this conclusion is valid only for accessible distance up to observed stars. He admited possibility the curve of forces to undergo the same oscillations and to cross abscissa many times at considerable large distances (shown on the picture in left). From here it follows, that our world is only one of the multitude possible worlds, existing in the infinite space.



Considering the principles of a commonly accepted geometry, Boscovich remarked that it is applicable to our world. He supposed that other worlds exist, and it is possible they have "*own*" space, "*own*" time, and "*own*" geometry as well. He was first who said the idea for

gradual contraction and expansion of the Universe [8]. These ideas remind again about some contemporary cosmological hypotheses.

There is something more interesting. Boscovich mentioned in his "*Theory of natural philosophy*" one omniscient "*spirit*". Knowing all forces and initial positions it is able to learn past and future [7]. A half-century later French scientist P. Laplace formulated the principle of the classical determinism in a similar manner. His absolute faith in the laws of classical mechanics has embodied in the so called Laplace's demon, who can predict everything. Existence of "Boskovic' demon", hypothetical intelligent creature that can instantly enclose all forces moving the Nature, follows logically to be recognize. As we see, in his book "*Theory of natural philosophy*" Croatian scientist tries to explain whole world from atom to Cosmos. It is peculiar theory for everything, created by one only person.

A Scientist – Malcontent

We can reasonably announce Boskovic for scientist – rebel summarizing his contribution in conceptual plan. According to F. Dyson, progressive science is always a kind of revolution against old views [9]. In this sense, Boscovich is one of the most prominent rebels of his time, perhaps, of all time. Progressive thought of Boskovic determines collisions in his life. Psychological and religious barriers overcomed by him determined the drama in his life and work. Like any dissenting person he created to himself enemies among the religious and scientific communities.

French King Louis XVI proposed him a relevant post in his navy due to which Boscovich worked in Paris almost 10 years. Spirit of Voltaire and d'Alembert which did not accept his ideas predominated there at that time. Because of religious and scientific disagreements with them sojourn of Boscovich in Paris was not very pleasant for him. His priorities in some astronomical discoveries were rejected and his manuscripts were not published. The experiments with a telescope filled with water did not receive support, etc. These failures forced the Croatian scientist to left the French capital. He returned to Italy and took up to publish his own labours. His health was already quite destroied. Boscovich died in Milan on 13th February 1787. He was buried in the church St. Maria Podone.

Truly Encyclopedical Personality

Despite accompanied him inconveniences, Boscovich had reputation of multi talented encyclopedist. Besides contributions in science and especially in physics, he has poetic revelation and achievements in archeology, ancient history, literature, music, and even in medicine.

Boscovich had great erudition and experience with different cultures. He was ambassador of Dubrovnik and executed diplomatic missions in Rome, Paris, London, Warsaw, Milan, and Venice for 26 years. He traveled and visited many counries, including Bulgarian soil (under Ottoman rule then). He wrote exclusive valuable travel notes about the Bulgarian villages and towns.

Above all abilities, of course, it was his achievements as a scientist, author of hundreds original writings and hypotheses about the structure of matter and world. His merits in science were appreciated by the European academies and scientific societies. He was a

regular or honorary member of academies in Rome**, London, Paris, Saint-Petersburg, Florence, Bologna, Harlem, Lyon.

Adhering the canon of Jesuits strictly, Boscovich always dressed as a catholic priest taking meals one time per day. He was exclusively intelligent, noble and communicative man. His contemporaries described him as a witty elegant man, welcome visitor of the celebrated European homes. Combining the qualities of Jesuit and noble man, scientist and poet, diplomat and engineer, he had unbelievable creative fantasy.

Consequently in that relatively peaceful for physics 18 century, Croatian scientist Rogerio Boscovich exposed the ideas that influenced development of science during the following centuries. The Institute for Natural Sciences and Technologies in Zagreb and the Astronomical Society in Belgrade are bearing his name now. It is a pride for us to have such remarkable scientist on the Balkan as Rogerio Boscovich.

Translated by A. Karastoyanov

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