Ruđer Bošković (1711-1787) Scientist and Humanist

This year marks the three-hundredth anniversary of the birth of one of the greatest Croatian minds, a scientists and humanists, Ruđer Bošković[1]. The year 2011 was therefore named *The Year of Ruđer Bošković* in Croatia. Ruđer Bošković (Ruggiero Joanes Boscovich)[2] was born on may 18th 1711 in Dubrovnik and was the second youngest of the nine children in the family. After attending elementary school in the Jesuit Collegium of Dubrovnik in 1725 he enrolled in the famous Roman Collegium, one of the most prestigious Jesuit higher education establishments of that time. His main subjects were theology, philosophy and literature, and in 1731 continued his studies of mathematics and physics in Rome. He was active in Rome, Pavia, Milan, London, Venice, Vienna, Constantinople, Versailles, Paris etc. He was a welcome guest in other European cities, never forgetting his homeland and his home town Dubrovnik. He constantly kept in contact with his family, especially his younger sister Anica who had potential in literature. Their letters of correspondence are today seen as valuable documents of those times. The scientific opus of Ruđer Bošković is in the fields of mathematics, mechanics, astronomy, optics, geosciences, civil engineering and archaeology. He lectured in chairs of mathematics at universities in Rome, Pavia and Milan. His versatility was evident in several scientific disciplines and fields. Pursuing the mathematical problems of infinitesimally small values, logarithms of numbers, he gave several trigonometry theorems, explored the notion of continuity in geometry and nature and laid down the basics of fractal structures. He wrote eight works in the field of astronomy outlining his observations and insights into the Solar system and Universe. His research concerns the shape of Earth's globe, the phenomena of sunspots and the appearance of comets and determining their trajectories, he's interested in the surface of the Moon, he writes of light (*De Lumine*, 1748), the passage of Venus across the Sun… In the field of optics, Bošković posits that the speed of light is a constant. In his dealings with lenses he contributed to the improvement of astronomical instruments. His considerations on the nature of light can today be interpreted as the beginnings of the theory of luminescence and the principles of laser operation. Appling his scientific findings, he established and built the Brera observatory in Milan. He made a major contribution in the field of geosciences regarding the shape of Earth's globe. It deals with the distribution of mass on the globe and brings it into connection with its irregular shape. His observations were confirmed a hundred years later by Johan Benedict Listing (1873) as he dubbed the geometrical shape of the Earth's globe a geoid. Bošković collaborated with Christopher Maie in measuring the meridian arch between Rome and Rimini and used it as a basis for making a very accurate, for its time, geographical map of the Papal State. Pope Benedict XIV commissioned him for the reconstruction of the apse and dome of St Peter's Basilica in Rome. He worked on the problems of drying out wetlands. He engaged in archaeology and exploring the ruins of Troy, expressed his doubts that the site in Asia Minor was actually Troy (*Relazione delle rovine di Troia*, 1784), which was later proven correct.

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[1] Dadić, Žarko; *Ruđer Bošković*, Školska knjiga Zagreb, 1998.

[2] Dadić, Žarko; *Egzatne znanosti u Hrvata u doba prosvjetiteljstva*, Matica Hrvatska, 2004.

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During his lifetime he had associated and debated with people of significance for the history of science, and was held in high regard by some of them: Alexis Claude Clairaut, Michael Faraday, D'Alambert…

Among his most prized works is the theory of forces and the structure of matter The theory of natural philosophy reduced to the one law of forces that exist in nature (*Philosophiae naturalis theoria redacta ad unicam legem virium in natura existentium*, 1758)[3]. The work is separated in three volumes with appendices. The first volume is dedicated to Bošković's fundamental understanding of matter and forces acting in the nature. The second volume analyzes the governance of forces and attempts to find examples in different branches of physics. The third volume contains examples in physics and chemistry and, derived on previously postulated principles, definitions for impenetrability, extension, mass, density, divisibility and other basic physical properties, chemical properties, properties of light, sound, heat, electricity and magnetism. He presents his understanding of space and time in the appendices. This work delves in the foundations of the world and its acting forces. Before his time, in the 17th century, scientists and philosophers were occupied with the knowledge of the existence of atoms. Physicists and philosophers of that time were taking the first steps in atom theory as one of the principal secrets of nature. Robert Boyle (1627 – 1691), an English chemist, was trying to find a link between specific types of atoms he envisioned as having a distinct shape and specific characteristics for each particular substance. Sir Isaac Newton (1642 – 1727), an English scientist, accepts the theory of the existence of atoms, but raises the question of their origins. In any case, Newton applies his generalized law of gravity on macroscopic and microscopic phenomena in nature. History connects R. Boyle and I. Newton with the scientific achievements of somewhat younger Ruđer Bošković who uses Newton's theory of gravity to build his own theory of molecular physics, a notion that was very advanced for its time. Of course, Bošković's opinions and world view, as in his predecessor Newton, don't exclude in their idea of the complexity of the world, the existence of God. We can say that his discoveries are pioneer efforts in the theory of atomic physics that was outlined at the beginning of the 20th century by Niels Bohr (in 1913) and the theory of relativity defined by Albert Einstein (in 1916)[4].

Heat engines form the core of engineering craft. The Scottish inventor James Watt started the first steam engine in 1765. The transformation of thermal energy inside a heat engine is defined by the first and second law of thermodynamics. Fundamental achievements in understanding the basics of thermodynamics were noted during the 18th and 19th century. A plethora of thermodynamic appears in this period, each contributing in their own domain to the discoveries of laws of physics in the field of thermodynamics. Most of them are recognized by the titles of the laws that were named after them. Before Ruđer Bošković, two more precursors of thermodynamics were active along with R. Boyle in the 17th century: the French mathematician Blaise Pascal (1623-1662) and French philosopher and physicist Edme Mariotte (1620 – 1691). Boyle and Mariotte gave the link between pressure and gas density, one of the first laws in gas thermodynamics. Even though he's seldom mentioned in the field of thermodynamics, the Jesuit Ruđer Bošković can be said to have contributed to the subsequent development of fundamental thermodynamics with his thoughts on atoms, heat and radiation. This is supported by the fact that the English physicist William Thomson, better known as Lord Kelvin (1824 – 1907) after whom the thermodynamic unit of absolute temperature was named, wrote five papers[5] on the bases of his discoveries.

Ruđer Bošković was first and foremost a cleric, but the area of his scientific research widely exceeds the confines of catholic theological thought of that time. Ruđer Bošković was a mathematician, physicist, astronomer, structural engineer, hydrodynamist and, it can be said, a thermodynamist. This issue of the *Journal Strojarstvo* is dedicated to Ruđer Bošković with a recommendation for an even more detailed study of his work both in his home country and abroad, in order to raise him as an equal to those world renowned personages who he debated with about his discoveries, who he associated with and with whom he belongs.

Prof. D.Sc. Bernard FRANKOVIĆ

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[3] Marković, Željko; *Almanah-Bošković*, Školska knjiga Zagreb, 1950.

[4] Blanuša, Danilo; *Almanah-Bošković*, Školska knjiga Zagreb, 1950.

[5] W. Thomson; *On Boscovich's Theory*, Nature XL (1889), pp 545 – 547.
W. Thomson; *On the Moduls of Elasticity in an Elastic Solid According to Boscovich's Theory*, Proceedings of Royal Society of Edinburgh, 189
W. Thomson; *On the Elasticity of a Crystal According to Boscovich*, Philosophical Magazine and Journal of Science XXXVI (1893), pp 414 - 430
W. Thomson; *On Atomic Configurations in Moleculas of Gases According to Boscovich*, Nature LV (1897), p 238
W. Thomson; *Contact Electicity and Electrolysis According to Boscovich*, Nature LVI (1897), p. 238