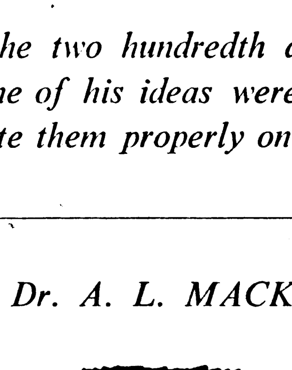
Roger Boscovich: a 20th century mind in the 18th century

This year has brought the two hundredth anniversary of publication of his chief work. Some of his ideas were so advanced that it has been possible to appreciate them properly only in the past few decades

by Dr. A. L. MACKAY

ON the rising ground behind the city of Zagreb in Yugoslavia, just where the trees begin, one can see a modern glass and concrete building in which research in physics and chemistry is carried on by the energetic post-war generation of Yugoslavs. A notice board announces that this is the Boscovich Institute and in the garden in front there is a bronze statue, by Yugoslavia's most celebrated sculptor Mestrovic, of a figure wearing priest's robes and deep in thought with his elbow on a globe. The inscription reads "Rugjer Josip Boskovic, 1711-87."



Most younger scientists have never met the name of Boscovich and only a few of the older school remember having heard of Boscovichian atoms. Yet, 60 years ago, and for 150 years before that, Boscovich had been widely known as a natural philosopher and astronomer. Serious estimates by some historians of science put Boscovich among the dozen greatest physicists, the equal of Newton, Leibnitz, Euler and Franklin. Certainly he was the greatest scientist of Yugoslav origin.

Boscovich's principal work, his *Theory of Natural Philosophy*, was published 200 years ago last month. Unfortunately Branimir Truhelka, who had begun a definitive biography of Boscovich and was editing the collected works, died prematurely, but his sister has just published a short life from her brother's notes.

What did Boscovich do, how did he come to be forgotten and how should his work be estimated today?

Born on 18 May, 1711, the son of a Serbian trader, in Dubrovnik, the then independent state of Ragusa (whose merchant adventurers gave us the word "argosy"), Boscovich went to Rome at the age of 14 to study mathematics, astronomy and theology at the Collegium Romanum. It was at this college that Matteo Ricci had in 1571-77 learnt the astronomy with which he tried to convert all China for the Jesuits.

In 1728 Boscovich finished his novitiate and became a Jesuit and in 1740 he succeeded his teacher Borgondio as professor of mathematics. From his first dissertation on sunspots, in 1736, until he left Rome in 1760, he published about 50 papers on astronomy, optics, mathematics, geodesy and the philosophy of science. He became the principal adviser on technical matters to the Holy See. He set up an observatory, advised on the draining of the Pontine marshes, saw to the repair of St. Peter's when the dome cracked, went on diplomatic missions, visited the site of Troy, made archæological studies in Italy and measured the length of the 2° of latitude along the meridian between Rome and Rimini.

As this is now the International Geophysical Year Boscovich should be especially remembered for the latter task. He worked particularly for the production of accurate maps and surveying and was active in three directions, the invention of instruments (he invented a circular eyepiece micrometer), the theory of instruments and observations and, most important, the international organisation of scientific enterprises.

He agitated for the accurate measurement of the length of a degree of latitude in various places and to this end approached the Royal Society, Maria Teresa and other authorities and intended to go to Brazil himself, but was persuaded to work in the Papal States instead.

The Royal Society later urged him to go to Pennsylvania but an arc there was measured by Mason and Dixon (of the line). The Royal Society then wished to send Boscovich to California to observe the transit of Venus in 1761, but he eventually went to Constantinople for the same purpose, although he arrived too late and became ill for some months.

The principal Academies of Science in Europe competed to make Boscovich a member, and in 1760 he visited England for several months, where he was made a Fellow

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of the Royal Society on 26 June. He dedicated a long Latin poem "On the defects of the Sun and Moon" to the Royal Society and this was printed in London by Andrew Millar. His supporters called it "Newton in the mouth of Virgil" but others said it was "uninstructive to an astronomer and unintelligible to anyone else."

Boscovich met many of the leading figures of the day besides scientists. He disputed with Dr. Johnson. Boswell reports: "In a Latin conversation with the Père Boscovich at the house of Mrs. Cholmondely, I heard him (Dr. Johnson) maintain the superiority of Sir Isaac Newton over all foreign philosophers with a dignity and eloquence that s[illegible]ised that learned foreigner." Boscovich was in Cambridge on Guy Fawkes night 1760 and was very displeased by the anti-Catholic nature of the festivities.

After working temporarily in Pavia and Milan there was a dispute with Lagrange, and trouble with the Austrian government, and on top of that the Jesuit Order was disbanded. Following this, in 1773 Boscovich obtained the Directorship of the "Optique Marine" in Paris and became a French citizen. He continued to write prolifically on astronomy and optics, making bitter enemies (D'Alembert and Laplace) and equally enthusiastic friends (Lalande), but in 1785 he retired to Bassano in Italy to see his works through the printers; but his health was broken and he died two years later in Milan at the age of 75. He is buried in the cemetery of Santa Maria Podone in Milan.

All the works mentioned were of solid, lasting value and contributed greatly to the science of the day, establishing Boscovich as a leading figure, but it is his general *Theory of Natural Philosophy*, published in Vienna in 1758, which is of greatest importance.

Important papers by L. L. Whyte have recently explained how Boscovich's theory was 200 years ahead of its time and could not be properly appreciated until modern ideas on relativity and quantum theory had replaced the billiard-balls and elastic jellies of the last century.

Boscovich's explantion is unusually clear and he says that it "does not go beyond the capacity . . . of classes even far below the level of mediocrity." But he claims to "have advanced, in his kind of investigation, much further than Newton himself even thought open to his desires." Basically, Newton said in his *Optics*, that "to derive from the phenomena of Nature two or three general principles, and then to explain how the properties and actions of all corporate things follow from those principles, this would indeed be a mighty advance in philosophy, even if the causes of those principles had not at the time been discovered."

Boscovich claimed to have done better than this by postulating one single law of forces. Boscovich did not consider masses and forces—his description was purely kinematic and related to the mutual accelerations of particles. His atoms were rather like what are now called nucleons (protons or neutrons) and the mass of any particle of matter was simply the number of these atoms in it.

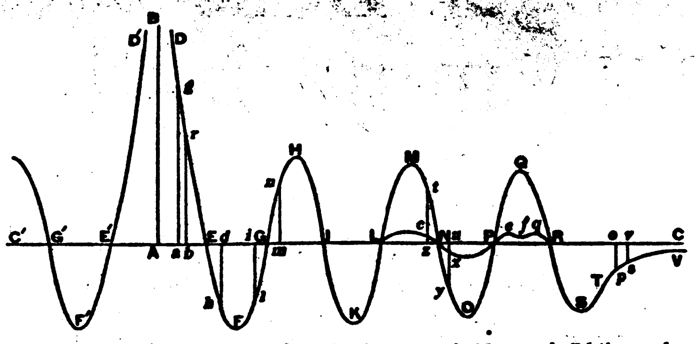

Diagram from Boscovich's "Theory of Natural Philosophy reduced to a single law of forces" showing the type of interaction between point atoms. There is a very large repulsion for close approach and an approximation to the inverse square law at large distances with several stable interatomic distances in between.

Two atoms had a mutual acceleration given by the curve in the figure shown here (which comes from Boscovich's book). "A" represents the centre of one atom and the ordinates show the acceleration of another atom with respect to the first at different distances. For very close approach the atoms experience a very strong repulsion so that matter cannot have an infinite density although the atoms occupy no space.

The law of continuity prohibiting the occurrence of infinite accelerations is one of the foundations of the theory. At large distances the curve approximates to the inverse square law of Newtonian gravitation, but at intermediate distances there are a number of stable interatomic distances (at F, K, O and S) which make the system remarkably like the quantum view of the atom held today.

From this model the basic properties of matter—density, volume, mass, mechanical strength, thermal properties (attributed to agitation of the particles) and gravitation are explained. Optical properties (due to the very rapid motion of particles) are also accounted for in terms of Newton's showers of particles with alternate fits of reflexion and transmission. These follow plausibly from the wave packet nature of the Boscovichian atoms.

Unfortunately Boscovich seems to have had few disciples to publicise his work. His thought was last influential when Maxwell and Kelvin were formulating their ideas of the atom before atoms and electrons were experimentally demonstrated (see "Atom" by Maxwell in the 9th Edition of the Encyclopedia Britannica), but since the rise of experimental nuclear physics older theories constructed on very slender evidence have been of hardly more than historical interest.

The death of Boscovich's biographer is a double loss because Boscovich's life would provide a microcosm of European science at its most active period and because his work and thought are of importance in themselves.