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IMPACT OF PHYSICS ON SOCIETY IN THE PERIOD OF RISORGIMENTO

In the history of civilization no greater influence of science on man's activity is known to have arisen than that exerted in the nineteenth century. The rise of technology in the twentieth century which so enormously transformed the life of human society is a mere industrial consequence of applied science, a product of that pure science which experienced its climatic and formative upheaval in the preceding century. That influence, however, which in the realm of ideas can be described as an impact, could not be measured by instantaneous external effects, as observed in political agitations. Man's expanding world of ideas plants seeds of silent but enduring germination. Europe of the nineteenth century and Italy in particular, offers a striking example in which the atmosphere of revolutionary ferment, leading toward liberative unification of insecure small states, is almost directly inspired by the new world of scientific discoveries. Indeed, the personal welfare of most scientists was immediately involved by political forces, which the stream of their fresh, scientific ideas once set in motion.

Before focussing our attention on the principal object of our symposium — seeking to relate scientific events with Risorgimento — it is impossible to separate this course in one region from the general tide overtaking the entire Europe. The spirit of the century was signalized by the triumphant rise of mathematical physics as a distinct consequence of the Galilean-Newtonian revolution. The outstanding product of this trend of ideas was the glittering intellectual meteor that flashed on the sky of the Western World, P.S. Laplace. His « L'origine du système du monde » and « Mécanique céleste » from the very beginning became a symbol as well as a symptom of the new era pregnant with explosive ideas, encouraging the most daring visions stemming originally from Galilean science. Behind the gossamer of genial mathematical equa-

tions there sprung up a startling new picture of a predictable, knowable and deterministic school of thought. All that was needed were facts in terms of « space », « time », and « matter »; then nothing, no mystery could not be solved. It was an electrifying vista enhancing bold imaginations that did not stop at any fantasy. This development reached its triumphant fruition in the mathematical discovery of Neptune in the middle of the century and initiated the famous field of the astronomy of the invisible as marked previously by the theoretical prediction of the duplicity of Sirius. There is an entire series of phenomenal discoveries both in astronomy and physics, marking the symptoms of the age, which emphasized the magnitude of the tide of advancing Galilean science current throughout the Continent. Our concern, however, turns to some less known aspects of the wave in scientific activity as they occurred in Italy, the original homeland of the Galilean revolution.

First of all, the host city of the Symposium on the History of Science, Turin, prompts us to consider the distinguished contributions to nineteenth century science by Amedeo Avogadro, professor of advanced physics at the University of Turin. Avogadro, who spent most of his life in Turin, in the very first decade of the century made a very revealing discovery on the property of gases which, in the course of time, culminated in what is now one of the most fundamental constants of modern atomic physics, the Avogadro number. Avogadro's contemporaries, particularly those in position to understand, failed to realize the significance and the novelty of the ideas of the retiring Conte di Quaregna who forsook practice of law to devote himself to the study of mathematics and physics. Most chemists in Avogadro's time were not yet thinking in terms of Dalton's atoms, much less in terms of Avogadro's refinement implying the existence of two kinds of « ultimate » particles. If the sesquicentennial of Avogadro's discovery was duly honored by the commemorative postage stamp the Italian government issued in 1956, the centenary of Risorgimento should provide the opportunity to reconsider the difficult and rather pathetic position of Avogadro in his lifetime. The unfathomable consequences of Avogadro's constant entailed in our studies of the mysteries of the structure of matter and the universe, the microcosmos and the macrocosmos, should be measured by an appropriate evaluation of Avogadro's life of devotion and selfless sacrifice to the cause of man's growing knowledge and consequently of his liberation.

In the time of Avogadro, Daltonian atomism for almost an entire century was fast becoming a fortress of an accomplished picture of the secure structure of matter. Dalton's atomic theory of one ultimate particle of elements, in its fundamental aspect, could not be reconciled

with the then current Gay-Lussac's law regarding the relationships that exist between the volumes of gases in reactions involving two or more gases. Gay-Lussac believed that his statement was supported by a sufficient amount of observations to ascertain the universal acceptance of his law to all gaseous reactions. Could an interpretation be placed on Gay-Lussac's law in order to make it reconcilable with Dalton's atomic hypothesis? This genial feat was actually accomplished by Avogadro when he combined Dalton's theory and Gay-Lussac's law into a simple integral relationship between the number of atoms, in the case of elemental gases or vapors, in equal volumes of different gases at the same temperature and pressure. He published his results 1811 in a paper (1) which requires careful reading and study due to Avogadro's complex, formative state of thought processes. As an essential novelty, Avogadro presents the reconciliation between Dalton's theory and Gay-Lussac's law in the proposition of the kinds of « ultimate » particles of elements, the physical molecules and chemical atoms, whereas Dalton recognized only one ultimate atom.

Dalton's paper (2) was published in 1808 and Avogadro announced his ideas in 1811. We have stated that only chemists could be concerned in this subject but they remained indifferent to Avogadro's idea of two kinds of ultimate particles. So Avogadro's publication was past by practically unnoticed. All accounts indicate that Avogadro was mild and humble of manner, a contrast to the usual flamboyant character of his people. Amiable as was his nature, Avogadro had the worldly disadvantage of not being aggressive. Thus, during his lifetime he was little known and appreciated within his native Italy and even less so in other lands. In 1822, during the revolutionary upheaval, he even lost his modest position although he was reinstated in 1835. Recognition of Avogadro's genial discovery did not occur during his lifetime. It happened under dramatic circumstances in 1860, four years after Avogadro had passed away.

That year, 1860, the first International Chemical Congress gathered in Karlsruhe, Germany. The congress in itself was a great cultural occasion and nearly every important chemist in the world was in attendance. As many problems remained unsettled and unsolved, Angelo Pavesi of the University of Pavia, toward the end of the sessions distributed the copies of a pamphlet (3) on the course of chemical philo-

(1) Amedeo Avogadro, « *Essai d'une manière de déterminer les masses relatives des molécules élémnetaires des corps, et les proportions selon lesquelles elles entrent dans les combinaisons* ». Journal de Physique, LXXIII (1811).

(2) John Dalton, *A New System of Chemical Philosophy*, London, 1808.

(3) Stanislao Cannizzaro, « *Sunto di un corso di filosofia chimica* » Nuovo Cimento, 1858.

sophy. In this publication his friend, the great Italian chemist, Stanislao Cannizzaro, former student of the University of Pisa's great teacher, Piria, comes to an ardent and illuminating defence of the nearly forgotten discovery of Avogadro. Lothar Meyer, who also attended the congress in Karlsruhe, makes a touching reference to Cannizzaro's pamphlet, copy of which he received from Pavesi. The exquisite clarity of Cannizzaro's text acted as a spark in unsettled deliberations of the learned assembly and Lothar Meyer comments: (4) « The scales seemed to fall from my eyes. Doubts disappeared and a feeling of quiet certainty took their place. If some years later I was myself able to contribute something toward clearing the situation and calming heated spirits, no small part of credit is due to this pamphlet of Cannizzaro ».

Besides his extensive scientific activity, Stanislao Cannizzaro keenly followed the destiny of Risorgimento and while still young, enthusiastically threw in his lot with the revolutionary forces. This for a short time brought Cannizzaro into French exile and it was actually in Paris, in 1851, that together with Cloez he published his first paper. After occupying distinguished positions at the University of Genoa and in his beloved native Sicily, Cannizzaro was invited to the University of Rome to lead its Chemical Institute. There he was made Senator of the Italian Kingdom, indicating his continued interest in public life. Although Cannizzaro wrote about one hundred scientific papers, his fame is principally derived from the above mentioned pamphlet which he commenced with the statement: « the progress of science made in these last years has confirmed the hypothesis of Avogadro... ». The statement is scientifically modest and therein lies its strength.

Although in the realm of chemistry Avogadro's hypotheses were firmly established, above all by Cannizzaro, the most revealing and fascinating corroboration of Avogadro's doctrine was accomplished by Faraday in physics in his pioneering experiments and subsequent laws of electrolysis. When, in 1834, Faraday already writes (5) « the equivalent weights of bodies are simply those quantities of them which contain equal quantities of electricity », not only was he defining the quantity of electricity now known as one faraday (96,500 coulombs), but one wonders whether he was aware or did he know of the existence of Avogadro's publication in a French Journal de physique as of 1811. Here, two genial minds in their quest for the mystery of microphysical laws nearly meet in the same region, deep in the nineteenth century, while paving the way for the foundation of modern atomic physics.

(4) Moore's A History of Chemistry, New York, 1939.

(5) SILVANUS P. THOMPSON: Michael Faraday, His Life and Work, London, 1898.

When Helmholtz in 1881 described Faraday's laws of electrolysis as a most important indication of the atomic structure of electricity, apparently he still was unaware of the famous correlation between the unit of one faraday and Avogadro number for their ratio yields another most fundamental constant of modern physics — the charge of electron. Thus, it was indeed a most revealing and revolutionary contribution in man's search for the nature of the microcosmos that the humble and retiring wizard of Turin, Avogadro, offered in his selfless service, which was bound to produce a transforming impact on the life of man and his culture in the centuries to come with man's increasing realization of the philosophical significance of Avogadro's initial discovery.

It is impossible to separate from Turin and the course of Risorgimento the life of the great astronomer, Giovanni Virginio Schiaparelli, who in his time was the center of attention of the entire cultural world. Schiaparelli, who not only studied in Turin but also started to teach in the same city, in a more phenomenal way than Avogadro was involved in the swift currents of the century. While young Schiaparelli studied abroad with the famous Encke at Berlin and with Struve at Pulkovo Observatory in St. Petersburg, the unification of the Italian Kingdom took place. One of the first acts of the new Government was to appoint an assistant astronomer at Brera Observatory in Milan. Schiaparelli was chosen for this post. Returning from Pulkovo Observatory in July, 1860, he took up his new duties that brought discoveries which in their day produced an echo around the entire civilized world. The internationalized designation « canali » associated with the enigmatic planet Mars still resounds clearly from the lips of the fascinated public. The term originated with Schiaparelli's sensational observations at Brera Observatory. However, with the advancing technique of astronomical photography combined with modern telescopic giants, the once sensational « canali » that have never been recorded on the photographic plate may have lost out in their drawing curiosity, yet the animated imagination Martian « canals » once stirred up in the minds of millions of humanity had its inestimable value in the history of man's growing ideas.

Schiaparelli's fame, however, is not based on his Martian observations alone. While with Brera Observatory's refractor he thought to have recognized some regular features on the surface of our neighboring planet Mars by 1880, Schiaparelli was already well known by a major discovery in the field of meteoritics. When F. Zoellner (6) reported to the Academy of Science in Vienna on December 12, 1872, he refers

(6) F. Zoelner « *Ueber den Zusammenhang von Sternschnuppen und Kometen* » Sitzungsberichte der k. k. Akademie in Wien an 12. Dezember 1872.

to a history making discovery of Schiaparelli, in 1866, which announced the affinity of orbits of some small comets with periodically returning meteoric showers. Zoellner evidently refers to Schiaparelli's letter to his colleague, Father Secchi (7), in which Schiaparelli offered the first report on the evidence of a connection between meteors and a comet, namely Perseids and Tuttle's comet, that annually provides a substantial meteor shower on or around August 12. The date of Zoellner's communication is significant since it follows shortly after the most spectacular meteor shower of the century that occurred on November 27, 1872 and was the aftermath of the disintegrated Biela's comet that was last seen in 1852. The majestic display, in which some 100,000 meteors fell in one single hour from the region of Andromeda constellation instead of returning as a comet, was indeed a most impressive vindication and verification of Schiaparelli's announcement making it truly a history making event. It was this feat alone that brought Schiaparelli the highest honor in astronomy, the Gold Medal of the Royal Astronomical Society of London for 1872. Thus, during thirty-eight years of Schiaparelli's fruitful directorship, Brera Observatory was the center of scientific activity, watched eagerly by the enlightened century. In the rededicated unified Italian Kingdom it added its lion share of light and culture to the liberative forces of Risorgimento.

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(7) G. V. SCHIAPARELLI « *Intorno al corso ed origine probabile delle stelle meteoriche* ». Lettere al P. A. Secchi. Bullettino meteorologico dell'osservatorio del collegio romano, Vol. V, 1866.