The Background of Modern Physics

Physics

F. K. Richtmyer, in *Introduction to Modern Physics* (McGraw-Hill):

The term "modern physics," taken literally, means, of course, the *sum total* of knowledge included under the head of present-day physics. But by "modern physics," many writers and speakers frequently mean that part of present-day physics which has been developed during the past twenty-five or thirty years; in contradistinction to "classical physics," by which is meant the sum total of physics as it was known in, say, 1890. The justification for the latter use of the term is to be found partly in the fact that advances since 1890 have been very great indeed and partly in the fact that some of these advances have brought into question, or are in direct contradiction to, many of the theories which, in 1890, were thought to be firmly and finally established. For example, few, if any, physicists in 1890 questioned the wave theory of light. Its triumph over the old corpuscular theory was thought to be final and complete, particularly after the brilliant experiments of Hertz, in 1887, which demonstrated, beyond doubt, the fundamental soundness of Maxwell's Electromagnetic Theory of Light.

And yet, by an irony of fate which makes the story of modern physics full of the most interesting and dramatic situations, these very experiments of Hertz brought to light a new phenomenon—the photoelectric effect—which, together with a series of discoveries coming in rapid succession in the single decade, 1887-1897, was the beginning of the development of the now famous quantum theory. This theory is, in many of its aspects, diametrically opposed to the wave theory of light. Indeed, the reconciliation of these two theories, each based on incontrovertible experimental evidence, may be said to be one of the two great problems of modern physics; the other problem being that of the structure of matter.

It shall be the purpose of the following pages to give a brief outline of the origin, development, and, in so far as may be possible in this rapidly developing subject, the present status of these two problems.

But a history of the United States cannot begin abruptly with July 4, 1776. In like manner, if we understand the full meaning of the growth of physics since, say, 1890, we must have clearly in mind at least the main events in the development of the subject up to that time. Accordingly, we shall begin our study by a brief account of the history of physics up to a half-century ago.

In presenting this brief historical survey, however, the author has in mind another purpose, toward which he hopes the reader will be, ultimately at least, sympathetic. Modern scientists have with few exceptions, grossly neglected to cultivate the history of their respective sciences. How many physicists can answer the questions: When was the law of the conservation of energy first enunciated? Who was Count Rumford? Did the concept of universal gravitation spring full-grown from the head of that genius Newton? Indeed, when did Newton live?

Just as any good American should know the essential outline of the history of his country, so any good physicist should know the principal facts in the history of physics. For in that history, in the lives of those men whose labors have given us our subject, and in the part which physics has played in moulding human thought and in contributing to modern civilization, the student will find a story which is as full of human interest and inspiration as is any subject of the curriculum.

What can be more inspiring than the life of Michael Faraday and his whole-souled devotion to his work? Which have had a greater effect on present-day civilization: the victories of Napoleon or the electrons of J. J. Thomson. Was Roentgen when he discovered X-rays seeking a new tool to help surgeons set broken bones?

The physicist owes it to his science to possess such a knowledge of the history of physics as gives *him* a correct perspective of the development and present-day importance of the subject and, in turn, enables him to acquaint his lay contemporaries with these essential facts. If there *is* apathy on the part of the public toward physics, the physicist himself is largely at fault, since he is so absorbed in the interest of the present that he forgets the importance of the past. He would find it much easier to justify to a popular audience the latest experiments on, say, the magnetic spectrum of electrons emitted from targets radiated by X-rays, if he prefaced his remarks by an account of the relation of Faraday's work to the modern dynamo.

It is hoped, therefore, that the student of these pages who proposes to follow physics as a profession, as well as the student whose interest is largely cultural, will extend the following all too brief historical sketch by independent study, particularly of biography.

In order to make it easier to keep the essential facts in mind, we may, somewhat arbitrarily, divide the history of physics into four periods.

The First Period extends from the earliest times up to about 1550 A. D., which date marks, approximately, the beginning of the experimental method. During this long era, there was, of course, substantial advance in the accumulation of the *facts* of physics as a result of the observation of natural phenomena, particularly by the Greeks, whose authority was almost unquestioned for many centuries. But the development of physical *theories* was rendered impossible, partly by the speculative, metaphysical nature of the reasoning employed, but more particularly by the almost complete absence of experiment to test the correctness of such theories as were proposed. The main characteristic of this period, therefore, is *the absence of experiment.*

The Second Period extends from 1550 to 1800 A. D. While numerous basic advances were made during this period—by such men as Gilbert, Galileo, Newton, Huyghens, Boyle, Benjamin Franklin—its most important characteristic is *the development and the firm establishment of the experimental method* as a means of scientific inquiry, as is well illustrated by Galileo's famous experiment (about 1590) of dropping two bodies of unequal weight from the leaning tower of Pisa, thereby proving *by experiment* the incorrectness of the assertion of Aristotle that the heavier body would fall more rapidly—an assertion which had been believed implicitly for nearly two thousand years.

It took two centuries after Galileo's experiment to overcome prejudice, dogma, and religious intolerance and to bring universal recognition, even among scientific men, to the basic principle that . . . *science can advance only so far as theories, themselves based upon experiment, are accepted or rejected according as they either agree with*

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or are contrary to other experiments devised to check the theory.

The Third Period, 1800-1890, is characterized by the development of what is now called "classical physics." The experiments of Count Rumford (about 1798) led ultimately to our present kinetic theory of heat. The observations of Thomas Young (1802) and his proposal of the principle of interference (of two beams of light) resulted ultimately in the triumph of Huyghen's Wave Theory of Light over the corpuscular theory, as supported by Newton. And the researches of Faraday gave Maxwell the material for the crowning achievement of this period, namely, the electromagnetic theory.

So profound were there, and many other, developments, that, by 1880, not a few physicists of note believed that all the important laws of physics had been discovered and that, henceforth, research would be concerned with clearing up minor problems and, particularly, with improvements of methods of measurement so as "to investigate the next decimal place." They could not have foreseen that the world of physics was on the eve of a series of epoch-making discoveries, destined, on the one hand, to stimulate research as never before and, on the other, to usher in an era of the application of physics to industry on a scale previously unknown.

The Fourth Period dates quite definitely from the discovery of the photoelectric effect, in 1887. In rapid succession, followed the discovery of X-rays, in 1895; of radioactivity, in 1896; of the electron, in 1897; and the beginning of the quantum theory, in 1900.

So varied and extensive have been the developments in both pure and applied physics from that time to the present that it is difficult to characterize this period by a single appellation. Hence, perhaps one may use the pleonasm "modern physics." Only the historian of a century hence can properly evaluate the growth of physics during the first part of the twentieth century. We, of the present, are too close to it to grasp its full significance.

Science News-Letter, February 9, 1929

Five cities in the United States are officially credited with more than a million population: New York, Chicago, Philadelphia, Detroit and Cleveland.

Life Not Limited

Medicine

DR. EUGENE LYMAN FISK, at the meeting of the American Association for the Advancement of Science:

"I believe I am safe in saying that the average point of view, especially among medical men, is contrary to the thesis of this paper. Even among those who admit offhand that the life cycles of living organisms are not fixed, there is a subconscious conviction that in a practical sense this is so and that it is more or less futile to attempt to interfere with the course of nature or the plans of the deity, depending on the religious or philosophical views of the individual. . . .

"Inasmuch as the body is not an inanimate machine but a physiological mechanism covering waste, maintenance and repair, the fixation of a limit to its existence by other than natural causes more or less under scientific control implies supernatural agencies acting in an arbitrary way.

"Has it been decreed somewhere, somehow, by somebody that the tissues of the human body, or of any other living organism, shall become lifeless within a certain length of time? With those who hold such a view purely as a matter of religious conviction I have no quarrel, but as a scientific proposition it is untenable.

"At once we see the implied and essential fundamentalism of such a view which actually is quite as crude in its aspect as the concept that all existing organisms are descended from those that came out of the Ark. Whether we use the term 'nature' or 'creator,' there is involved in such a concept the inevitable thesis that life cycles of living organisms have been fixed by edict and not through evolution or reaction to conditions in the universe. . . .

"I am able to say, from a fairly broad experience in this field, that one of the greatest obstacles to prolonging human life lies in the acceptance, at least tacitly and subconsciously, of the thesis that such effort is more or less futile, that the years of man are three-score-and-ten, and that it is more important for him to study ways and means of having a good time during that period than in attempting the impossible in endeavoring to work against nature—whatever that may mean—in attempting any emphatic prolongation of the human life cycle."

Science News-Letter, February 9, 1929

New universities have been established at Jerusalem and Saloniki.

Boston public schools have teachers designated as safety counsellors, who promote interest in safety, in addition to other duties.