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Introduction

Since Galileo claimed that nature speaks in a mathematical language and that its words are circles, triangles, and other geometrical figures, the problem of the relationship between mathematical formalism and physical concepts has not ceased to interest physicists and epistemologists.

In the nineteenth century, physical models were successfully used by Maxwell and William Thomson to reach highly elaborated conclusions on the nature of the electromagnetic ether. In more recent times, after the Bohr–Einstein debate on the possibility of a realistic interpretation of quantum mechanics, the priority of mathematical equations, as tools for the representation of the microphysical world, has been more or less tacitly accepted by physicists. P.A.M. Dirac, one of the fathers of modern theorethical physics, challenged modern materialists with his almost platonic statement: if equations work well in mathematics that means that they are an expression of a physical truth. However, strange as it may seem, the usage of macroscopic physical models as formal or structural analogs for the interpretations of microphysical entities (nuclei, spins, etc.), still continues to be practised by physicists, even at the level of the more sophisticated theories.

Thus, it is evident that there are many reasons as to why historians of physics should attempt to illustrate and to better focus the problem. This is in fact the program of the National Congress on History of Physics held in Rome in the fall 1984, and contained in the works published in the proceedings. The historiographical method of the so-called cases-in-history seemed to the organizers as the most suited approach on this circumstance.

The history of the institutions, in which physics is cultivated and physicists find their material and intellettual support, is relevant for such approach. In fact, the history of the formation of the professional figures of the experimental and theoretical physicist in the nineteenth century German scientific faculties — presented by Armin Hermann — lies at the bottom of that change of context which produced the acceptance and the development of theoretical physics as an autonomous discipline. As Hermann shows, the emergence in this background of an Einstein as a professional physicist acquires new perspectives.

In the nineteenth century, this rise of theoretical-physics to the status of a professional discipline was prepared by a rich outburst of critical dialogs, on the theoretical and meta-theoretical level, a propos of the nature and significance of mathematical theorization in physics and its relationship to physical concepts.

According to Giulio Giorello, this relationship presented complex problems earlier in time even to the founders on the infinitesimal calculus, Barrow, Newton, Leibnitz, Mac Laurin, etc. One serious problem was presented, for instance, by the formulation of a conception of velocity (and its rate of change) which could be mathematizable. Giorello's thesis is aimed to demonstrate that physical notions were often used to resolve doubts about mathematical puzzles rather than viceversa, as it is often asserted.

In fact, mathematics in the physics field has different kinds of usage, as Ivor Grattan-Guinness puts it. His views are exemplified by his original study of the French community (1800-1830), in a period during which the seeds were laid down for much of the later developments of mathematical-physics. A large spectrum of different roles of mathematics in physical theories, is examined with great insite, ranging from the influence of " Langrange's algebraic ideology " to " Euler's geometrical tradition ".

Enrico Bellone is convinced that the major difficulty in building up physics — and in writing its history — does not concern the different beliefs of scientists about the physical existence of entities such as " particula ", " molecules ", " centre de force ", etc., but the difficulty resides in establishing relations between names and descriptions — the true core of physical theories. Models have the function of allowing the passage from one type of description — i.e. molecules as spherical particles — to the other — molecules as center of force — playing thus a stabilizing effect in the development of theories.

The debate between modellists and mathematicists has however warmed up the discussions and the writings of philosophers and philosophically-minded scientists. One important case, emblematically represented by the diverging opinions of Campbell and Duhem, is illustrated by John Worrall. He compares the different reactions of the two above mentioned scholars vis a vis with an interesting case in history: i.e. the Fresnel's wave-theory of light and he concludes: if it is true that the aim of physics is to exploit the predictive power of mathematical theories (pace Duhem) and not to invent models in order to explain the unknown by the known (contra Campbell), it is however also true that particular models are often a prerequisite to the discovery of mathematical theories. The two contrasting views of Duhem and Campbell are thus considered by Worrall extreme and abstract positions. The examination of the historical case teaches us that the two apposite positions never present themselves in isolation in the concrete process of research, but interact with each other in order to reach the optimum mediation.

In more than one occasion Maxwell theorised this function of models, proposing as a true aim of the enquirer the difficult balance between the danger of mathematization and the excess of a naive faith in the truthfulness of physical hypotheses. His own usage of a theory of dimensions in order to prove the equality between the velocity of light and that of his electromagnetic waves, is, perhaps, an example of the fruitfulness of his balanced method.

The pre-history of the concept of distant simultaneity, an impressive sequence of problems and conceptions running back to ancient Greek, classical antiquity and middle-ages, shows how ordinary language is capable of dealing with complex problems in the initial stages of the physical inquiry. Neither Newton nor Leibnitz succeeded however to give these problems the precise formulation which they received in modern mathematical physics and in the theory of relativity. This is one of the many comments suggested by the highly scholar stand of Max Jammer's work, "Distant Simultaneity...". The thematic content of this work gains light and depth through the vastness of interests manifested by the author. He guides the reader across the cultural background, toward the understanding of the more technical parts of the paper, i.e. the modern theoretical and experimental problematic of distant simultaneity.

If mathematization of physics is not philosophically neutral — as one should conclude from what has been remarked above — it is neither ideologically indifferent, as Marcello Cini seems to imply in his paper. Cini illustrates throught his work the role of the leading scientists in establishing the "rules of the game" and thus control the changes of physical theories (with respect to John von Neumann and his widely accepted formalization of quantum mechanics).

We are convinced that the problem of the relation between mathematical models and physical theories is adeguatedly illustrated in the following pages. We hope that this book will represent a valid help in our programm of bringing the discussion a step further.

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