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Book review

Leo Corry, David Hilbert and the axiomatization of physics (1998–1918), Springer, Netherlands, ISBN 1-4020-2777-X, 2004 (513 pp., Euro 160, US$ 179, £111, Hardcover).

In his 1900 famous list of mathematical problems, D. Hilbert formulated Problem 6, "Mathematical Treatment of the Axioms of Physics":

> The investigations on the foundations of geometry suggest the problem: To treat in the same manner, by means of axioms, those physical sciences in which mathematics plays an important part; in the first rank are the theory of probabilities and mechanics.

This problem stands apart from the other ones in that it is formulated as a general suggestion or a vague research program crossing into neighboring areas rather than as a definite mathematical question.[1] Even though Hilbert gives somewhat more extended comments on his Problem 6, still the meaning of this question remains sufficiently vague and subject to interpretations.[2]

This problem becomes better understood if one, together with Leo Corry, takes a deeper look into Hilbert's involvement with physics over the years. In fact, the idea of applying axiomatic method, originally formulated in the foundations of geometry, to physical theories repeatedly appears in Hilbert's works following 1900. He even presented some of his most significant contributions to physics (e.g., his work on GTR) as an application of axiomatic method which he obviously was very proud of.

The main message of the book is that physics played in Hilbert's research and in his general views a much larger role than is commonly recognized. Apart from his publications, much new evidence was found in Hilbert's *Nachlass*, such as his lecture notes of 1905 Axiomatization of Physical Theories where Hilbert treated topics from mechanics, thermodynamics, probability calculus, kinetic theory of gases, insurance mathematics, electrodynamics, and even psychophysics in a certain 'proto-axiomatic' style. Influences of Hilbert's views on the physics related research in Göttingen can also be traced through private correspondence with many people, which Leo Corry makes extended use of.

[1] At present both probability theory and mechanics are so well-grounded in mathematics that it comes as a bit of surprise to a modern reader that Hilbert could consider the theory of probabilities as a 'physical science' in the first place. It can be argued that Hilbert's idea of axiomatically treating the theory of probabilities was finally realized with the appearance in 1933 of the famous book by Andrei Kolmogorov Grundbegriffe der Wahrscheinlichkeitsrechnung.

[2] One, probably wrong, interpretation of this problem sometimes encountered in popular literature is to identify it with the problem of 'Theory Of Everything' in the modern sense of the word.

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For some logically minded readers the book under review could be an eye-opener, because it demonstrates the fallacy of what can be called a *Hilbert-myth*. According to this popular misconception, Hilbert's philosophy of mathematics was the so-called formalism which amounted to a perception of mathematics as an empty game of symbols representing logical conclusions from arbitrarily chosen axioms. Although Hilbert essentially did use this kind of game in his program of securing the foundations of mathematics (the so-called Hilbert's Program destroyed by Gödel's incompleteness theorems), there is no evidence that he perceived actual, or even ideal, mathematical activity in this simplistic way. In fact, in a course taught in 1919 he explained:

> Mathematics is in no sense like a game, in which certain tasks are determined by arbitrarily established rules. Rather, it is a conceptual system guided by internal necessity, that can only be so, and never otherwise.

Hilbert's axiomatic analysis meant something entirely different from such a game. It had to do with establishing higher standards of mathematical rigor in some already established but problematic mathematical and physical theories. In other words, axiomatic method meant an a posteriori logical analysis of the existing body of knowledge rather than playing a game by some a priori fixed rules.

Despite the fact that the idea of clarifying the mathematics underlying physical theories and putting the latter on a rigorous basis does have a lot of appeal to a mathematical mind[3] it is obviously much less of a concern for working physicists who are driven by entirely different motivations (such as, e.g., learning new facts rather than logically reorganizing the established facts). This could be one of the reasons why Hilbert's attitudes and his work in physics in general were perceived with sufficient scepticism even by his own students such as H. Weyl, notwithstanding his remarkable contributions to solutions of some particular problems in mathematical physics.

The book under review is written in a non-biased way; the author tried to give a balanced picture rather than an apology of the work of his main hero. It is written in a lively but at the same time in a very careful academic style. It combines in an agreeable way some analysis of Hilbert's writings with the surrounding biographical and scientific background. Particularly, the background on geometry and on the foundations of mathematics is necessarily rather extended.

Throughout the book the reader is confronted with many interesting and not very well known facts. I found some stories incorporated in the book particularly interesting. The first one is on Hilbert's justification (1912) of Kirchhoff's law in radiation theory and its subsequent criticisms by Planck and Pringsheim.

The second one is the great and intricate story of Hilbert's involvement with general theory of relativity culminating in the publication of his Grundlagen der Physik paper (1916) and of his interaction with Einstein, Mie, Weyl and others.

The second story is the one of a major scientific discovery and, therefore, attracts attention irrespective of its particular relation to Hilbert's axiomatization program. In contrast, the first story concerns a problem that was overshadowed by later developments in radiation theory and, therefore, remained largely neglected by physicists. Yet, it illustrates the issues around the axiomatization method and its applicability to Physics very vividly.

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[3]Much work in modern mathematical physics could be seen as just this kind of activity.

Hilbert's initial claims that the current proofs of Kirchhoff's law, such as those due to Planck and Prigsheim, were unsatisfactory provoked, fairly uncompromising discussions with those two leading physicists. In the course of the discussion, Hilbert laid bare some assumptions upon which these proofs were based and, quite in the spirit of his method, demonstrated that in either case these assumptions were not sufficient for a rigorous proof. Interestingly, Planck was able to quickly convince Hilbert that the latter overlooked an important aspect of his proof, and therefore Hilbert's axioms did not adequately represented Planck's original assumptions. On the other hand, Pringsheim, unlike Planck, did not seem to fully understand Hilbert's axiomatic methodology. He attacked Hilbert's proof on the grounds that it, as he claimed, implicitly assumed Kirchhoff's law in one of the axioms and he also plainly rejected the general idea of using axiomatic method in Physics. Hilbert never agreed with Pringsheim's criticisms, but it forced him to develop his axioms of radiation in much greater detail than he previously did for any physical theory.

I think Leo Corry's book is a significant contribution to Hilbert studies and will be a major reference source on Hilbert's activity in Physics in the future. I enjoyed reading the book and can recommend it to everyone.

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