ÉTUDES BIOGRAPHIQUES

HELGE KRAGH: *Dirac. A Scientific Biography*. Cambridge: Cambridge University Press, 1990. 389 pp.

This book is indeed a 'scientific biography' of one of the founders of quantum mechanics, Paul Adrien Maurice Dirac (1902-1984), Nobel prizewinner of 1933 and one of the major figures in 20th-century physics. Chapter 2, for instance, deals with the discovery of quantum mechanics, reporting on Dirac's approach in the context of the exciting years 1925/1926 and the many priority races which Dirac did not by any means always win. In chapter 3, Kragh then covers Dirac's work on relativity and spinning electrons, leading to his famous electron theory, the interpretation of which was at first so troublesome (cf. chapter 5): How are the negative energy states to be understood? Which interpretation should be adopted for the 'Dirac sea'? Is the anti-electron identical with the proton, and if yes, why is there this large mass difference? Clear historical analysis based on a fair account of the published sources as well as on many hitherto unpublished letters, some of which are quoted in extenso (as, e.g., Dirac's letters to Bohr, Nov. 26, and Dec. 9, 1929, discussing "a simple way of avoiding the difficulty of electrons having negative kinetic energy", from the Archive of the History of Quantum Mechanics; cf. 90-91, 92-93), retraces the gradual process of Dirac's and his contemporaries' understanding of all these questions. Elsewhere, Kragh also makes use of Dirac's correspondence with Heisenberg, Pauli, Schrödinger, Gamow as well as of excerpts from the correspondence of Heisenberg, Bohr, Pauli etc., with others insofar as it is relevant for an understanding of Dirac's physics and of the way in which his activities were perceived by his contemporaries.

In later chapters, Kragh deals with Dirac's lifelong effort to cope with quanta and fields, introducing the reader to Dirac's characteristic style and the structure of his papers (cf. p. 132), as well as to Dirac's subsequent drift away from the "so-called quantum electrodynamics" of the late thirties and later (chapter 8). The few photographs are very carefully chosen: one of them, for instance, shows Dirac in discussion with Richard P. Feynman in 1962, depicting Dirac passively leaning against a post, away from an enthusiastically gesticulating Feynman, who was possibly trying to convince Dirac, who throughout his life remained hostile toward standard quantum electrodynamics. It is a virtue of the book that its author does not just restrict himself to a report on the successes in Dirac's oeuvre, but also treats with equal attention Dirac's activities which turned out to be failures (like his cosmological speculations, cf. chapter 11), or which were not appreciated for very long and are still controversial (like his work on magnetic monopoles: cf. chapter 10).

Another strong point of this biography is that it centers around, but does not confine itself to recapitulating Dirac's contributions to physics. The author tries to find out whether there are any "significant meta-principles guiding his physics" (p. 261) and where they could have come from. This is far from obvious, since, unlike other great physicists of this century, like Einstein, Heisenberg, or Schrödinger, who in print expressed the importance of philosophical considerations for their work, Dirac virtually never wrote papers or gave talks which openly addressed this point. Therefore, in the last two chapters, Kragh endeavors to reconstruct Dirac's *implicit* philosophy of science from his contributions to physics. He singles out four interrelated themata (in Holton's sense) which served as heuristic guidelines in Dirac's work, namely: 1) instrumentalism and the observability doctrine; 2) the unity of nature; 3) the principle of plenitude; 4) the principle of mathematical beauty.

Kragh claims that none of these should be correlated to external factors like the *Zeitgeist* of the cultural and social world around Dirac, but that "the roots of Dirac's implicit philosophy should be looked for internally, in physics itself". But why is it, that (1) has been heralded by most of the representatives of the Kopenhagen interpretation of quantum mechanics, most notably Heisenberg? Insofar as Kragh acknowledges the correctness of important studies by Favrhold, Paul Forman, Jagdish Mehra, and Helmut Rechenberg, etc., who have all shown the multitude of varied influences from outside physics on the founders of quantum mechanics, and insofar a Dirac seems to take over the attitudes of Heisenberg, Jordan, and others at least on the rhetoric level and adapts himself to the climate of instrumentalism in the 20s and early 30s, Dirac can no longer be understood from a purely internal point of view.

This is even more true for (4) as the most important of Dirac's themata, "a sort of super-thema to which Dirac was deeply committed and which dominated much of his intellectual life" (p. 261). Mathematical beauty was equally the guiding principle for Einstein from the 30s onwards, as it was for Schrödinger, Weyl, and Wigner. Perhaps the fact that Dirac heard lectures by the idealistic, almost platonic philosopher Charlie Dunbar Broad about philosophical aspects of relativity theory during his study years at Bristol University in 1920/1921 (cf. p. 6) is more revealing in this respect than Kragh wants to make us believe, because of his dislike for rooting Dirac's views in philosophical influences (p. 261). Dirac's striking, sometimes breath-taking reliance on mathematical beauty and simplicity as criteria for the correctness of a physical theory (if need be against all empirical evidence) must have come from somewhere, although this motive might very well have taken a life of its own in the mature Dirac, and it deserves to be compared more closely against the deep reliance on the preestablished harmony between physics and mathematics common among the Göttingen mathematicians and physicists between 1870 and 1930.

In this context, it is highly interesting to relate Dirac's activities with those of Hermann Weyl, who often worked on similar topics: for instance, he also derived the commutation relations in quantum mechanics in the fall of 1925 (cf. p. 20); from 1928 on, he worked on spinor analysis as suggested by the algebraic properties of Dirac matrices. It was Weyl's suggestion to interpret the other two components of Dirac quantities as due to the proton, which suggestion was adopted by Dirac in his famous paper on the theory of electrons and protons (cf. p. 90); and it was again Weyl who showed in the second edition of his book on *Gruppentheorie und Quantenmechanik* that Dirac's electron theory implied the equality of the mass of electron and hole, thereby destroying any hope of saving the standard interpretation of the anti-electron as proton and forcing Dirac to the experimental prediction of an anti-particle to the electron in 1931 (cf. p. 102 ff.), which then led to the discovery of the positron.

Due to these many paralleling inquiries, Hermann Weyl seems to have been both an admirable and a threatening figure for Dirac. Astonishingly, he disliked the abstract group-theoretical approach to quantum mechanics favored by Weyl (cf. p. 43) and later by Wigner (cf. p. 152), although it would have fit so nicely with his 'super-thema' of mathematical beauty; and in an interview with an American journalist, Dirac frankly admitted that he did not understand Weyl (see pp. 72-73 for the full text of this very amusing interview, p. 73 not listed under Weyl in the name index, which is unfortunately far from complete).

On the other hand, Dirac strongly recommended Weyl's mathematical approach of 1931 and later (cf. the important quotes on pp. 103 and 239 f.!), and with their general, thoroughly mathematical approach to physics, no one was more similar to Dirac than Weyl (cf. p. 287). The puzzle remains: why did Dirac only realize this in his later years?

By relating Dirac's work and motives more systematically with some of his most important colleagues, most notably with Pascual Jordan (cf. p. 233), Erwin Schrödinger (cf. 255,

261f), and Hermann Weyl, Helge Kragh could possibly have achieved somewhat more vividness in his portrayal of Dirac, the more so, since Dirac was so notoriously shy and taciturn, so that a biography of Dirac inevitably has to be a *scientific* biography, focussing on his work. In chapter 12, Kragh collects most of the known anecdotes about Dirac's character and his behavior, revealing that the "purest soul" was in fact a socially weak, sometimes unbearable person, lacking genuine interest in his colleagues and students, a "lost experience" for many of his contemporaries who had the chance, rather than the pleasure, to meet this character, uninterested in politics, the arts or culture, and who was basically a "fanatic of rationalism" (as Heisenberg once called him, cf. p. 256).

Precisely this extreme one-sidedness of Dirac's personality calls for a psychoanalytic treatment of Dirac's case, but as with most figures in the history of science, the historians lack details about Dirac's early childhood and private life. Chapter 1 mentions Dirac's authoritarian father, Charles, who imposed an atmosphere of "cold, silence and isolation" (p. 2) on the whole family, as well as some further details about Paul's upbringing and early education; later, chapters 4 and 7 mention Dirac's travels and other occurrences in his life, including his marriage to the sister of Eugene Paul Wigner, Margit Wigner Balasz (cf. 152-155). We would have liked to learn more, esp. on the relation between Dirac and his wife, but I suspect that Kragh simply could not find out anything else.

Since the author of this scientific biography has published an excellent *Introduction to the Historiography of Science* (Cambridge University Press, 1987), it is not surprising that he tries as many facets of today's methods in history of science as can usefully be applied to his subject. The book thus ends with an appendix entitled 'Dirac bibliometrics', in which he gives statistics on Dirac's publications and his own citations, a table of Dirac's references to selected physicists, and a table of references to Dirac's papers, distinguishing citations by others from self-citations. These statistical analyses support Kragh's claim also made on different grounds in the preceding chapters that Dirac worked to a large extent in isolation from mainstream physics.

This scientific biography can warmly be recommended to anyone interested in Dirac's scientific work – it serves equally well as a guide to understand the diachronic unfolding of themes in Dirac's work, as it is a good introduction to particular problems on which Dirac worked, because it includes information on the synchronic context, and because of its many useful references to more specialized studies which deal with these topics in greater depth.

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