A Life in Physics

Dirac. A Scientific Biography. HELGE KRAGH. Cambridge University Press, New York, 1990. x, 389 pp., illus. $44.50.

There is little doubt that Paul Dirac was one of the greatest theoretical physicists of all time. He wrote his first paper in 1924 and his last in 1984, producing altogether 190 publications, of which 89 were pure research papers of penetrating originality, written in a spare, almost ascetic style. In addition, Dirac was reputed to be introspective, taciturn, difficult to approach, shy, and private to the point of indifference and rudeness. To write a biography of such a person is a monumental task, requiring an inordinate amount of time and great courage. The physics profession owes Kragh a debt for producing a serious, well documented, informative biography of Dirac.

The book consists of 14 somewhat overlapping chapters, of which four are purely biographical and eight deal primarily with Dirac's spectacular scientific success. Also treated are his less successful efforts, not to say failures, and his approach to physics and life (which to him were nearly the same).

The first two scientific chapters deal with Dirac's initial contributions to quantum mechanics and with the Dirac equation. It is remarkable that the first of these chapters, which treats Dirac's introduction of Poisson brackets and his transformation theory, is the less incisive. It is little more than a reasonably well written summary, without much discussion or analysis, of some of Dirac's 1925–1926 papers, and manifests some carelessness. It is hard to believe that the mathematics of wave mechanics (complex analysis and differential equations) was little known in Cambridge in 1926; Oppenheimer's first initial did not stand for John; Schweber is misquoted; and Goudsmit is omitted from an enumeration of Dutch theoretical physicists (as of 1926). Altogether the discussion of Dirac's brilliant early work is adequate but not especially deep. By contrast, the chapter on the Dirac equation is well written and gives interesting insights into the process whereby Dirac arrived at his extraordinary results. The reactions to Dirac's equation are carefully recorded and discussed.

Three further chapters discuss the hole theory, the positron theory, and the quantization of the electromagnetic field. The scientific description is very good, if at times a bit abbreviated and incomplete. The fluctuating attitudes and the different approaches of the originators of quantum field theory, Dirac, Pauli, Heisenberg, and Bohr, are recorded in great detail. Dirac introduced creation and annihilation operators but did not like Jordan-Wigner quantization. Dirac also did not like the Heisenberg-Pauli formulation of quantum electrodynamics, but they in turn did not like either Dirac's formulation or his positron theory. Dirac paid no attention to the anti-Dirac paper by Pauli and Weisshopf. All this is noted but not analyzed. Kragh quotes Pais to the effect that the vacuum polarization in 1935 was Dirac's last contribution to physics. Though he adds that "this point may be debated," he does not do so. But it is clear from his account that after 1935 Dirac gradually moved out of the mainstream of physics. His criticism of quantum electrodynamics became more strident, his search for alternative formulations more extreme and even desperate. He became more and more insistent that the road to progress was via mathematical beauty. This is discussed carefully and completely in the last chapter. Dirac's various efforts met with very limited success, as Kragh shows in the chapter on the classical theory of the electron and the excellent chapter on cosmology.

In the chapters that are primarily biographical, Kragh provides an enormous amount of detail, much of which is new and interesting. Throughout the book there are many true and many apocryphal stories about Dirac, many of which have been part of the Dirac folklore for some time. Together they give an interesting, if not revealing, picture of Dirac. The biography is certainly an important, highly professional contribution to the history of quantum theory. A noteworthy feature of it, whether virtue or defect, is its lack of passion. Here is one of the world's greatest scientists, involved in an extraordinary intellectual endeavor, engaged in a truly titanic struggle with his peers, but none of this comes through in the detached style of the author. In the same vein, the intense dislike Dirac had for his father is politely mentioned, but its impact on his emotional life is only hinted at, and certainly not discussed or analyzed.

In the late '60s, before moving to Florida, Dirac spent a semester at the State University of New York at Stony Brook. This reviewer had the pleasure and privilege of taking long walks with him all through the semester. It is certainly true that Dirac was quiet and taciturn, but he liked to communicate; he just needed to be asked, and when he was he responded enthusiastically. He was extremely sensitive to natural beauty and ugliness and often commented on the deplorable physical state of the Stony Brook campus. His view of the world was idiosyncratic, intensely personal, and unreasonably rational. But he was a deeply compassionate human being with a dry and whimsical sense of humor, with concerns, hopes, fears, and ambitions. This person I missed in this biography; perhaps it was not the intention to have him there, but I missed him nevertheless.

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Pleistocene South Americans

Monte Verde. A Late Pleistocene Settlement in Chile. Vol. 1, Palaeoenvironment and Site Context. TOM D. DILLEHAY. Smithsonian Institution Press, Washington, DC, 1989. xxiv, 306 pp., illus. $49.95. Smithsonian Series in Archaeological Inquiry.

This book is no mere background report on an archeological site. It provides an outstanding example of thoroughly integrated multidisciplinary research and an important lesson in epistemology. Even without a detailed consideration of artifacts and cultural features, it presents convincing evidence of 12,000-to-13,000-year-old human occupation in southern Chile.

Any claim for human settlement of such antiquity, especially so far south of Alaska, the presumed point of entry for the first New World colonists, is likely to provoke skepticism. Widespread human occupation of North America is well documented beginning around 11,500 years ago, but the archeological record for earlier time periods is spotty and debatable. Claims for earlier archeological evidence have so often been found to be flawed that explicit and stringent criteria are sometimes recommended: a human skeleton or an assemblage of definite artifacts in undisturbed geological deposits associated with fossils of known age (that is, extinct mammals) or with material suitable for isotopic dating. Preliminary reports on Monte Verde (such as the account in *Scientific American* of October 1984) did not reveal clear conformity with such standards. The majority of the stone artifacts (90%) were said to be pebbles picked up from a