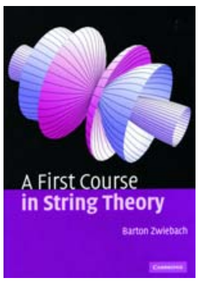
A Most Appetizing First Course

A First Course in String Theory

Barton Zwiebach
Cambridge U. Press, New York, 2004. $65.00 (558 pp.).
ISBN 0-521-83143-1

Reviewed by Marcelo Gleiser

String theory is one of those topics that invoke both awe and controversy.



The awe comes from its elegant mathematical formulation, the symmetries explicitly used, and the promise of a well-behaved quantum theory of gravity that also unifies all fundamental interactions of nature—the final theory that seekers of the hidden unity-in-all-that-is aim to find. One is reminded of the remark Einstein made when he was confronted with the possibility that general relativity—in this case, the calculation of the precession of Mercury's perihelion—might be wrong: "The result could not be otherwise than correct. . . . I did not for one second doubt that it would agree with observation." Indeed, general relativity did not have to wait long for its telltale if then somewhat arguable confirmation—the 1919 observations of the sun's bending of starlight during a total solar eclipse.

The controversy over string theory comes from the paucity of experimental evidence supporting the theory and its twin cornerstones: supersymmetry and extra spatial dimensions. String theorists have struggled to come up with testable predictions that could vindicate their ideas. Periods of great excitement have been followed by quiet disappointment. The current dilemma relates to the theory's energy landscape and the search for a selective principle that will single out the one vacuum from a ridiculously large number of possibilities. Strings are not alone in generating such vast landscapes of choices: Protein folding shares somewhat similar challenges. The advantage for biophysicists is that proteins are known to exist and their properties can be studied in the lab.

I was a graduate student in England during the mid-1980s when Michael Green and John Schwarz reenergized the whole field by showing that supersymmetry tamed the infinities of the theory; as a bonus, they predicted the dimensionality of spacetime to be 10. My graduate thesis explored byproducts of their result, the cosmology of a 10-dimensional spacetime and the so-called spontaneous compactification problem, or how three spatial dimensions became large while the other six remained small, possibly as small as 10^{-33} cm. I also remember how hard it was as a young student to make sense of everything; the material was technically difficult, and the lack of accessible review papers and books on the subject was appalling. How wonderful Barton Zwiebach's *A First Course in String Theory* would have been during my graduate years! (Of course, it would have been much slimmer, but still—.)

Zwiebach, a respected researcher in the field and a much beloved teacher at MIT, is truly faithful to his goal of making string theory accessible to advanced undergraduates. I can see his book being adopted at Dartmouth for a joint graduate and advanced undergraduate course. The author is honest about the promises and serious challenges the theory still faces, a trait for which he should be commended. String theory is not all roses, and students learn that from the start. Zwiebach presents the topics with the clarity and contagious enthusiasm of an outstanding expositor and pedagogue who knows what sorts of difficulties students face when tackling theories in higher dimensions: comprehending the quantization of point particles and strings; calculating in the light-cone gauge; understanding D-branes, Dp-branes, and the T-duality of closed and open strings; figuring out how strings interact or how 11D M-theory relates to 10D string theories, and so forth.

The text develops intuition before formalism, usually through simplified and illustrative examples, such as quantum mechanics with a compact dimension or analogies with musical strings and their vibrational modes. In keeping with the doctrine that you only learn by doing, the exercise problems are an integral part of the text. Solutions are provided for instructors via a specified website; however, a supplemental volume would have been more convenient. Zwiebach avoids the temptation of including topics that would weigh the book down and make many students rush it back to the shelf and quit the course. He presents suggestions for further reading once the topics are mastered by students. I suggest starting with Zwiebach's book and then moving on to Joseph Polchinski's two-volume *String Theory* (Cambridge U. Press, 1998).

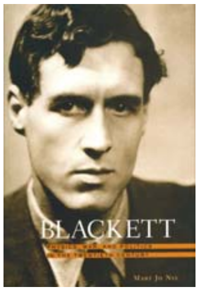
Even if string theory doesn't pan out as a theory of all interactions, it will remain a key chapter in the history of physics, contributing deeply to our understanding of field theories. We will all have to wait and see. I, for one, stand in awe of string theory's elegance but am painfully aware that Nature doesn't always share our longing for harmony.

Marcelo Gleiser *is the Appleton Professor of Natural Philosophy and a professor of physics and astronomy at Dartmouth College in Hanover, New Hampshire. He journeys occasionally into higher dimensions, although he still finds plenty of excitement in just four.*

Blackett: Physics, War, and Politics in the Twentieth Century

Mary Jo Nye
Harvard U. Press, Cambridge, MA, 2004. $39.95 (255 pp.).
ISBN 0-674-01548-7

Patrick M. S. Blackett (1897–1974) was among a generation of outstanding British physicists, five of whom won Nobel prizes in physics in the 1940s and early 1950s. Blackett won his in 1948 for improving the Wilson cloud chamber and for the discoveries he made with the improved device in the 1930s. In 1947 he announced, and then retracted, a new universal law uniting gravity with magnetism. He developed new magnetometers that would be important in establishing the geological theory of continental drift and was a key figure in British wartime operational research. He was also interested in what were considered to be old-fashioned problems, such as the measurement of specific heats.



In *Blackett: Physics, War, and Politics in the Twentieth Century*, Mary Jo Nye, a well-known historian of science, has produced for a general readership a splendid biography of this remarkably multifaceted man. Of particular note are her discussions on Blackett's new universal law of nature and her analysis of Blackett's looks, leadership style, presence, friendships, and connections.

Blackett was an example of a scientist recruited from the English elite. He started his career in the Royal Navy, going through the reformed Edwardian naval education system, designed to create an officer corps knowledgeable in science and engineering. He served at sea during World War I. Afterward, he was sent to the University of Cambridge, where many other young naval officers went to complete their education. He resigned from the navy in 1919 and stayed at the Cavendish Laboratory until the early 1930s. Thereafter, he held chairs and headed departments at Birkbeck College, London, from 1933 to 1937; the University of Manchester from 1937 to 1953; and Imperial College London from 1953 to 1963.

Blackett was a commanding patrician figure. His demeanor is often traced back to his naval experience. For some, he recalled the radical intelligentsia of the 1920s, yet he was also the "archbishop of science," as the obituary in the *Times* (London) described him. His life was full of such seeming contrasts. In the 1960s he was the president of the Royal Society and, simultaneously, an adviser to the Ministry of Technology. Although a lifelong socialist, he advocated a greater role for business in research and development. Despite being one of Britain's leading nuclear physicists, he did not work on the British bomb project during World War II; he did not go to the Los Alamos laboratory, nor to Harwell, Woolwich, or Aldermaston laboratory. He opposed Britain's development of an atomic bomb, and his *Fear, War, and the Bomb: The Military and Political Consequences of Atomic Energy* (Whittlesey House, 1949) was the public expression of his objections to a key policy of state. However, Blackett was not the only politically committed, prominent British physicist of the period: Along with C. P. Snow, he was among the most influential scientific intellectuals of the postwar years.

Blackett's voice was a distinctive one among scientists of the left on the subject of war. He was one of the very few socialists who concerned themselves with military strategy. Blackett, who was certainly a premature antifascist, was to call himself a "premature military realist." As Nye correctly notes, Blackett risked a great deal by taking unpopular stances on defense matters. He was indeed skeptical—certainly ambivalent—about claims by scientists and others for the transformative role of science and technology in war. In his mind, operational research, rather than R&D, was often a better way to make more effective weapons. Another example of his realism was his analysis of the role of science and technology for developing nations. He argued the need for poor countries to adopt old technology rather than new science.

Blackett was an original thinker on issues involving science and public policy; he was driven not just by a commitment to science but also by a particular political commitment—to socialism. Nye's biography is, as many are, in deep sympathy with its attractive subject. The author adds considerably to Bernard Lovell's memoir *P. M. S. Blackett: A Biographical Memoir* (Royal Society, 1976) and a fascinating recent collection of essays, *Patrick Blackett: Sailor, Scientist, and Socialist* (Frank Cass, 2002), edited by Peter Hore. Yet Blackett's distinctive and critical ideas about science, war, and politics, particularly in Britain, still remain to be critically explored. One is left wondering what less-sympathetic biographers would have to say about him.

David Edgerton
Imperial College London
England

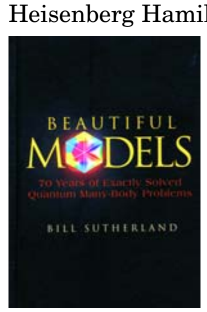
Beautiful Models: 70 Years of Exactly Solved Quantum Many-Body Problems

Bill Sutherland
World Scientific, River Edge, NJ, 2004. $78.00, $38.00 paper (381 pp.). ISBN 981-238-859-1, ISBN 981-238-897-4 paper

In any field of physics, the discovery of an exact solution often brings about deep insights and fundamentally new concepts and methods. For example, the Schwarzschild solution of Einstein's equations revealed the existence of black holes, and the Onsager solution of the two-dimensional Ising model proved the importance of fluctuations close to the critical point. Yet many theorists—rather than viewing exact solutions as important tools in their kit—consider them too unwieldy and difficult to obtain. This attitude is quite surprising since the alternative, the use of approximate methods, is not necessarily easier. History shows that several of the many-body models that were exactly solved were also studied by other methods that in many instances were more complicated and usually uncontrollable.

Beautiful Models: 70 Years of Exactly Solved Quantum Many-Body Problems by Bill Sutherland is a beautifully written book that aims to unveil some of the mystery behind the exact solutions and allow any advanced student access to this vast and fertile field. Having made his own fundamental contributions, Sutherland has developed a deep understanding of the subject and the ability to explain the main ideas in clear physical terms. Although the book involves a good amount of sophisticated mathematics, the author leads the reader with a sure hand through the forest of details.

In the first two chapters of the book, Sutherland outlines the ideas underlying the solvability of many-body quantum Hamiltonians. He emphasizes the nondiffractive nature of the scattering of the particles in the system and relates the phenomenon to the presence of conserved quantities. Subsequently, in chapter 3, he details the construction of the eigenstates. These eigenstates typically take a simple form (the Bethe Ansatz), a consequence of the constraints imposed on the dynamics by the conserved quantities.



The solution of the one-dimensional Heisenberg Hamiltonian is presented in great detail in chapter 6. It is the model in which Hans Bethe, in 1931, first introduced the Bethe Ansatz, which in turn led to a characterization of the ground state and excitations and—many years later, through the fundamental contributions of C. N. Yang, C. P. Yang, Minoru Takahashi, and Michel Gaudin—to the full determination of thermodynamics.

My favorite part of the book, chapters 8 through 10, deals with