and Ultimate Causes. Therein he states: "The semiconductive antiferromagnetic phase is *irrelevant* for discussing the ground state of the superconducting phase. Actually both phases are separated by a *first order phase transition*." In the same section, Phillips emphasizes that the electron–phonon interaction is some 20 times stronger than the electron–magnon and electron–exciton couplings based on central-field considerations. After these perspectives, the last section (13) on Selective Phonon Condensation follows naturally. As already alluded to, Phillips prefers to use a fictive phonon model rather than the anharmonic double-well potentials used in ferroelectrics to deal with the large-amplitude anharmonic displacements as indicated by diffraction experiments. However he also discusses the anharmonic models: Both models stem from nearly equal oxygen p–copper 3d energies. This chapter, which also includes some numerical estimates, is a highlight of the book and, as stated, to most theoreticians relatively novel. Indeed, in view of the more recent developments, it contains quite some foresight.

There follows a series of short chapters, 5 to 10, on the isotope effect, lattice vibrations, optical spectra, tunneling and relaxation studies by ultrasound and nmr as well as one on materials morphology. Space does not permit us to dwell on them, but the author makes quite a number of interesting points worth reading, this despite that, since his *oeuvre*, more detailed, substantial data have been reported. Two remarks may be in place: To the taste of the undersigned, the author introduces too late in the book the observed strongly anisotropic coherence lengths, especially the extremely short one of approximately 2 Å perpendicular to the CuO_2 planes. This property is quite crucial for these cuprates, underlying both basic and application properties. Also, and related to the science–culture remarks made earlier, the electron-loss spectroscopy results of the Karlsruhe group, known since fall 1987 and unique worldwide, should have been included in the description. These experiments gave clear evidence for the presence of oxygen holes and the p-type character of carriers.

The book ends with three really useful appendices on Macroscopic Parametric Relations, Microscopic Theory and Crystal Chemistry. Villars' theory appears in the last of these, allowing one to systematize the superconductors in terms of valence electrons, electronegativity and differences in spectroscopic radii.

With his remarks, the undersigned hopes to have interested both newcomers to the high-T_c field as well as accomplished experimentalists and theoreticians in Phillips's book and maybe to have helped the author in one way or another to make some changes if he considers preparing a second edition.

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From Paradox to Reality: Our Basic Concepts of the Physical World

Fritz Rohrlich
Cambridge U. P., New York, 1989 [1987]. 227 pp. $14.95 pb
ISBN 0-521-37605-X

Fritz Rohrlich is a distinguished theoretical physicist well known both for his work in quantum field theory and for his textbooks on quantum electrodynamics (with Josef Jauch) and classical electrodynamics. He has now undertaken the important task of communicating to nonscience students and to an educated lay audience an appreciation of the nature of science and of scientific theories through an examination of the conceptual revolutions brought about by the watersheds of thought in 20th-century physics: relativity (both special and general) and quantum mechanics.

In the preface, Rohrlich tells us that this book grew out of a course, Concepts in Contemporary Physics, for nonscience students, that he has given at Syracuse University. Mathematics, used only sparingly in this book, is rarely essential for following his discussion and, when employed, is confined to elementary high-school algebra. The book is divided into three main sections, covering the nature and construction of scientific knowledge, relativity and quantum theory. Rohrlich emphasizes that this text is *not* a popularization of relativity and quantum theory, but an examination of the nature of the scientific enterprise and of related issues in the philosophy of science as illustrated by the development of these two modern theories. For that reason, this review will focus on the discussion of the nature of the scientific enterprise as presented by Rohrlich, rather than on the details of the physics.

To provide a conceptual back-

ground to the theories he will discuss later, Rohrlich sketches a position on the limitations of human knowledge, warning (in the best tradition of Francis Bacon) of the dangers of extrapolation from the domain of everyday experience and of the prejudices that can be engendered by our expectations about how nature will behave. This position is related to the use of approximations (conceptual rather than numerical) and various "levels of reality" in representing the phenomena of the world. In other words, for different purposes (for example, astronomy or geology or building construction), the *same* physical object (for example, the Earth) can be usefully and accurately represented or modeled in different, even incompatible ways. This gives us many different views of nature, all of which are "true" and the sum total of which constitutes our knowledge of nature. For example, the author uses geometrical optics to illustrate the essential role of mathematics in the formulation of models and theories in modern physics.

Rohrlich discusses the heuristic value of mathematics in exploring nature, and he assures the reader of the great importance of the *beauty* of a theory as a guide to or criterion for correctness. However, this can have an elitist air to it since we are told that such beauty and simplicity "can usually . . . be appreciated only by the expert." This does raise the possible difficulty that the process of becoming an "expert" may help define the requisite good taste necessary to perceive such correctness. Rohrlich might have addressed this issue for the critical reader. And while Dirac is cited as an example of one whose sense of mathematical beauty guided him to a successful theory, it is not pointed out that this same skill also led him to apparent dead ends later in life.

Rohrlich emphatically—and quite correctly, in my opinion—informs the reader that it is a mistake to speak of *the* scientific method. Scientific discoveries have in fact been made in many ways: There is no algorithm for such discoveries (an important point to be made for students).

The objectivity of science is, according to Rohrlich, insured by self-correction through a series of checks and balances. While this is not supposed to guarantee the absolute validity of the knowledge science gives us, it can, one hopes, convince us "of its correctness with overwhelmingly high probability." However, the author provides no measure by which to judge this probability.

The picture of science that Rohrlich presents very closely reflects his own work in the philosophy of science, especially as embodied in the article "Established Theories," coauthored with Larry Hardin (*Philosophy of Science* **50**, 603, 1983). In this schema—which supports a realist, as opposed to a merely instrumentalist, view of science—key warrants for correctness are *horizontal* consistency (between theories in different fields) and *vertical* consistency (between theories of different levels in the same field). Intuition tells us that if a theory works and if it fits together well with other successful theories, then surely it must be correct. That seems reasonable enough, but philosophers of science have traditionally had great difficulty either making this notion precise or providing a convincing argument to support it.

For Rohrlich, explanation in science consists of reducing the unfamiliar phenomenon or law to terms already understood. The implication is that this becomes possible with the maturity of a discipline. In this view a law is explained by its deduction from a theory. While it is consistent to take such a stance on what it means to explain, one can still wonder whether such explanation necessarily produces a sense of understanding about phenomena or laws. Here, too, unification of phenomena or laws under ever more encompassing theories is equated with deeper understanding. That is, it appears as though formal explanation and understanding are being equated.

It is not obvious that this need be so. Rohrlich uses several examples from the history of science (gravitation, electromagnetic theory, weak and strong interactions, quantum electrodynamics, grand unified theories) to illustrate this type of explanation. Although these points are well enough made for anyone familiar with these theories, one can reasonably ask whether the uninitiated reader, for whom the book is written, even with the aid of the glossary of technical terms at the end of the book, will really be able to understand these examples without first having some background on where these theories came from and what they mean.

Nevertheless, Rohrlich's discursive presentation of topics related to relativity and quantum theory is generally clear, certainly accurate and easy to read. His view of epistemology and ontology is conducive to a realistic interpretation of scientific theories and is, I would guess, one that most scientists will feel comfortable with.

Despite the impossibility of doing

all things in so short a book, Rohrlich has produced a text that can help redress a serious problem in the present educational system in the US. It is a response to the science illiteracy that is rampant even among so-called educated Americans. His goal is a worthy one, and this vehicle could be effective in many courses for non-science students. It is true that we must educate the students we actually get. Still, what is sad—and this is *no* detraction from Rohrlich's book—is that we must now assume (and demand) so little from *college* students! In a way, such an undemanding approach sidesteps the basic malaise. We must demand more of students, not cater to their weaknesses in mathematics and science.

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Rochester Roundabout: The Story of High Energy Physics

John Polkinghorne
Freeman, New York, 1989. 204 pp. $24.95 hc ISBN 0-7167-2080-9

John Polkinghorne, ordained priest of the Church of England and sometime Cambridge academic, has written a short, informal memoir of 30 years of Rochester Conferences. These initially small, annual gatherings, the brainchild of Robert E. Marshak, began in late 1950 in Rochester, New York, five years before Polkinghorne received his PhD in theoretical physics under Abdus Salam. By the time the author's account ends (effectively in 1980 when he ceased full-time involvement in particle physics to pursue a career as a man of the cloth), the meetings had evolved with the field of high-energy physics into large, formal, biennial international conferences with up to 1000 participants.

Polkinghorne's account, laced with a dozen and a half apt photographs, permits the veterans to indulge in a nostalgia trip, delighting in shared memories of people and controversies, pouting at ignored or slighted topics, or feeling superior at identifying the unidentified in photographs (Jack Leitner with Murray Gell-Mann on page 105). On the down side, one might wish that the author had suppressed the irrelevancies and cuteness, and had been more careful about names, technical facts and some of his generalities.

Inevitably, as is freely acknowledged by the author, the subjects in which he was personally involved or