"Clarity at the price of . . . a partial view"

Superposition and Interaction: Coherence in Physics

R. Schlegel
314 pp. U. Chicago P., 1980. $22.50

Reviewed by Katherine S. Arima

In *Superposition and Interaction: Coherence in Physics*, Richard Schlegel presents ideas that he has been developing with remarkable consistency for about 30 years concerning physical theory, such as the clock paradox of relativity and statistical interpretation in quantum physics. Again he examines the philosophical implications: the completeness, for instance, of scientific explanation and the role of subjectivism. These are worthy topics, of course, that have long challenged scientists and philosophers of science. However, their very familiarity raises basic critical points. Is there anything new in Schlegel's book? How does Schlegel's achievement stand up to work by others? What motivates yet another study of these subjects?

Schlegel claims "three novel ideas." First, by the "interaction hypothesis," he extends the well-known interaction between observer and physical system required by the Copenhagen interpretation of quantum theory to the formalism of special relativity: Observations of Lorentz transformations involve physical interactions in which the objects are themselves transformed instead of involving the usual transformation of measuring rods and clocks. Second, Schlegel modifies the notion of superposition of states for quantum systems and postulates a "restricted superposition hypothesis," whereby the only allowed states are related by Lorentz transformations on velocity, spatial translation and rotation, space but not time inversion, and charge conjugation. Third, he proposes that superposition applies also to relativistic systems insofar as any object system is defined by the superposition of all possible, Lorentz-transformed, inertial systems. Thus the Lorentz transformations act as a "unifying principle," giving both the transformed states of relativity and the transitions between different quantum substates.

Whether or not these ideas are new, they are not arresting scientifically or philosophically, in Schlegel's exposition. No conclusive experimental evidence supports his interaction hypothesis; his interpretations do not contribute significantly to the explanatory or predictive power of science. If Schlegel's views do not especially alter the content of theory, they cannot, in his terms, much affect epistemology, for Schlegel considers knowledge in physics largely as what is embedded in the principles and concepts of physical theory.

Evidently Schlegel wants to resolve the outstanding problem of twentieth-century physics, the conflict between quantum and relativity theories. The company he keeps—beginning with Niels Bohr and Albert Einstein—is naturally illustrious. By comparison, in his method Schlegel is neither as scientifically rigorous as similarly motivated physicists in A. Held's *General Relativity and Gravitation* nor as philosophically exacting as the contributors to C. A. Hooker's *Contemporary Research in the Foundations and Philosophy of Quantum Theory*. Furthermore, although mindful of historical illustration, Schlegel's orientation is not historical, such as is Thomas S. Kuhn's *Black-Body Theory and the Quantum Discontinuity* 1894–1912. What Schlegel has stated about the way of science equally applies to his eclectic approach in "Progress and Completeness in Science" in *Centennial Review* (1978): "simplicity and clarity at the price of... a partial view."

Schlegel's perseverance suggests other motivation. Fideism surfaces when he writes "We are seeking a unity which must in some sense exist; for nature is one and theories concerned with a common domain should therefore be altogether consistent." He describes mystic experience. The last section of the book, a conversation among two scientists and a philospher, while stylistically incompatible with the rest, allows informal discussion of God and science. For Schlegel the nonrational experiences reinforce and motivate the search for unity or "coherence." They might also sustain his somewhat isolated position. He acknowledges, for example, that his analysis of the clock paradox contradicts Einstein and other relativists.

Still, Schlegel's varied discussion can prove valuable. The potential audience is broader than the physicists, physics-oriented scientists and philosphers whom he addresses. His exposition is characteristically lucid. For the novice, *Superposition and Interaction* will introduce some of the most difficult, exciting problems in contemporary science and philosophy of science.

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Quantum Physics in America, 1920–1935

K. R. Sopka
Arno, New York, 1980. $42.00

This doctoral dissertation, completed in 1976 and published here as an unrevised "reprint" in the Arno Press collection, *Three Centuries of Science in America*, makes a useful addition to the growing body of scholarship on the history of modern American physics. Sopka proposes that this country's

Edwin Kemble (left) and John Van Vleck in a photograph taken by E.B. Boatner.

"coming of age" in physics during the interwar years resulted from two symbiotic sets of circumstances: a concatenation of social, economic, and institutional conditions that made for opportunity and growth in the environment of professional physics; and the entrance into the discipline of many talented people who were drawn by the excitement and challenge of the rapidly developing quantum theory. Both in overall interpretation and in substance, Sopka covers much ground that, while comparatively fresh in 1976, is now rather familiar. Her contribution consists in the detailed attention she gives to the development of the American corps of theoretical physicists.

Circa 1920 there were few American theorists, and by 1935 there were many more. What spurred the growth over that period, Sopka argues reasonably, was the ascendancy of quantum physics. She fleshes out the argument with estimates of the number of American theorists and dissertations in theory at five-year intervals. She also demonstrates that a small but able cadre of Americans, not all of whom were theorists, collectively contributed to quantum theoretical physics in the early 1920s, before the intensive European migration to the United States. The contributions included the work on band spectra of Edwin S. Kemble and Robert S. Mulliken, John Van Vleck's extension of the correspondence principle and William S. Duane's quantization of momentum transfer. Some of this effort caught the attention of Europeans, a number of whom, like Arnold Sommerfeld, visited the United States after World War I and carried home the word that American physics was growing up.

Sopka spotlights the generally unrecognized importance, for the development of theory in America, of Kemble at Harvard University. Between 1920 and 1935, 85 theoretical theses were produced at American universities; 26 of them were directed by Kemble or his former students, notably Van Vleck. Yet while the acquisition of theorists was indubitably essential to America's coming of age in physics, one wishes that Sopka had given more attention to the actual role of theorists in the work of the community, particularly their importance to experimentalists. There is a certain confusion in this study between the significance to the discipline of theorists on the one hand and, knowledge of theory on the other. Hardly all experimentalists of the period would concede that it was quite so critically important as Sopka suggests to have theorists around; relying on their own knowledge of quantum mechanics, experimentalists like I. I. Rabi did excellent physics. One also wishes that Sopka's dissertation had been available to scholars through the normal—and much lower priced—channels when it was originally completed. But, even if this expensively, better late than never.

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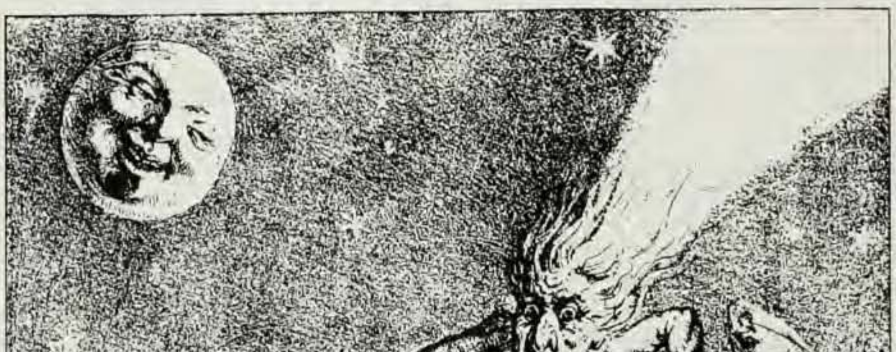

In 1857 this caricature of a comet smashing into the Earth was published in France. It appears as one of many illustrations in Nigel Calder's *The Comet is Coming* (160 pp. Viking, New York, 1981. $12.95). Anticipating the return of Halley's comet in 1985–86, Calder describes the history of sightings and the popular and scientific speculations they have provoked over hundreds of years. Courtesy American Museum of Natural History.

Introduction to Quantum Theory. Gauge Fields

L. D. Faddeev, A. A. Slavnov
246 pp. Benjamin/Cummings, Reading, Mass., 1980. $28.50

In 1971, Gerard 't Hooft solved a problem that had totally befuddled the leading lights of particle physics. The subject was gauge fields, which provide a geometrical and group theoretic foundation for fundamental forces. They generalize the concepts of connection and covariant derivative that underlie electromagnetism and general relativity. 't Hooft's particular contribution concerned the renormalization of perturbation theory, which involves the taking of subtle limits to get physically significant predictions. With these issues clarified after over a decade of confusion and contradictory claims, people finally took seriously Steven Weinberg's 1967 gauge theory of weak and electromagnetic interactions. Experimental support was there for the asking in the form of neutrino-induced interactions that had hitherto been thrown out as neutron background events. Soon thereafter, the detailed calculations made possible by 't Hooft's analysis revealed that gauge fields were also ideally and even uniquely suited for the description of the strong forces that hold quarks together into nucleons. So by 1974, gauge fields formed the basis for all known fundamental interactions.

Ludwig Faddeev and Andrei Slavnov wrote their monograph, *Gauge Fields: Introduction to Quantum Theory*, in 1977. Faddeev had pioneered the study of quantized gauge fields, but this work, too, had gone largely unnoticed and was translated into English only after 't Hooft had rekindled widespread interest in the subject. Slavnov's contributions in this area came soon on the heels of 't Hooft's publications and offered a more traditional analysis to substantiate 't Hooft's very original and occasionally idiosyncratic treatment.

Gauge Fields provides a reasonably complete and concise description of the quantization and renormalization of gauge theories as appropriate for weak-coupling calculations. It stresses those aspects that are particular to gauge interactions, arising from the presence of variables that do not represent true dynamical degrees of freedom. It describes techniques developed specifically for these problems, such as analytic continuation in the number of spatial dimensions, as well as older techniques,