

STEPS TOWARD A QUANTUM THEORY OF MEASUREMENT

New Techniques and Ideas in Quantum Measurement Theory

Edited by Daniel M.
Greenberger

*New York Academy of Sciences,
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The 2nd International Symposium on Foundations of Quantum Mechanics in the Light of New Technology

Edited by Mikio Namiki,
Yoshio Ohnuki, Yoshimasa
Murayama and Sadao
Nomura

*Physical Soc. Japan, Tokyo,
1986. 386 pp.*

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Reviewed by Bernard d'Espagnat

Physics is knowledge—but knowledge of what? Though this problem may seem absurd (or outrageously philosophical) it is now posed by the very structure of our branch of science. Advances toward its solution call for a type of reflection that explicitly aims beyond the mere “good recipes”—the purely operational—while making use of all the precise elements of information that the powerful tools of physics have nowadays made obtainable. The great interest of the two conference proceedings reviewed here is that both provide plentiful material for feeding such reflection.

Like most conference proceedings, these two contain a wealth of information; hence I shall here just simply mention those contributions that

I happened to find particularly interesting. By this criterion I must mention first the work of H. Rauch and coworkers on neutron interferometry. They began their classic work in the early 1970s; nevertheless both books present quite interesting new information. The experiments described all concern self-interference occurring during a time interval when at most one neutron is in the interferometer. They therefore constitute realizations of tests of quantum mechanics that had been described beforehand as merely *gedanken* experiments. The many different experiments of groups in Vienna and Missouri confirm in great detail the validity of the general rules of quantum formalism; the latter tested gravitationally induced quantum interference (see *New Techniques*). Anton Zeilinger shows in *New Techniques* that experiments of this type could disprove Alfred Landé's alternative explanation of particle diffraction. Concerning a connected field, namely *electron* interferometry, Hannes Lichte reports in the same volume on how this technique was applied to improve the performance of electron microscopes.

Other experimental confirmations of quantum mechanical rules reported in the proceedings are photon experiments of the so-called delayed-choice type (by groups at Munich and College Park, Maryland; see both books), of the single-particle interference type (by the Orsay group; see *New Techniques*) and of the Einstein-Podolsky-Rosen correlations type. Experiments of the last kind have, as is well known, the additional interest of checking for nonseparability through violation of the Bell inequalities. Hans Kleinpoppen created the photon pairs involved by decay of the metastable state of hydrogen (see *New Techniques*); nonlinear down-conversion served in the same role at College Park (see the *International Symposium* proceedings). Progress is also reported on the problems of random-

izing the changes in the detectors' directions and testing the no-enhancement hypothesis.

The *International Symposium* volume contains important sections on the Bohm-Aharonov effect, the quantum Hall effect, microfabrication and quantum mechanics; and *New Techniques* has a section on magnetic flux effects. This shows that the perspectives of the two books are very far from being confined to abstract questions of principle.

Quantum measurement theory and the associated “Schrödinger cat” problem are, directly or indirectly, the subjects of several reports, most of the authors of which share the controversial view—in my opinion—that the problem would be solved if it could be shown that the statistical operator of the composite system (quantum system plus apparatus plus possibly even the environment) is observationally indistinguishable from that of a proper mixture of states corresponding to definite “pointer positions.” Some theories (for example, Mikio Namiki's in *New Techniques*) assert that this result follows from the macroscopic nature of the apparatus and that the environment plays no decisive role. By contrast, other theories (for example, W. H. Zurek's in the same volume) claim that “in a sense the environment measures the system and in doing so allows the state of the system to acquire a classical reality.” Both types of theories refer to superselection rules (continuous for the first type, environment-induced for the second). On the other hand, Shigeru Machida in *International Symposium* grants that the theory of which he is coauthor with Namiki is “only approximate” because continuous selection rules are but idealizations. And similarly Zurek grants that “the collapse of the wavefunction is only apparent” and that “coupling with the environment does not settle all of the problems of quantum measurement.”

E. Joos, in *New Techniques*, broad-

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