ANNALS OF THE NEW YORK ACADEMY OF SCIENCES

Volume 755 April 7, 1995

FUNDAMENTAL PROBLEMS IN QUANTUM THEORY: A CONFERENCE HELD IN HONOR OF PROFESSOR JOHN A. WHEELER⁴

Editors

DANIEL M. GREENBERGER and ANTON ZEILINGER

Conference Organizer

Daniel M. Greenberger

Conference Organizing Committee
YAN HUA SHIH and CARROLL ALLEY

Scientific Advisory Committee

YAKIR AHARONOV, MICHAEL BERRY, CLAUDE COHEN-TANNOUDJI,
DANIEL M. GREENBERGER, DAVID KLYSHKO, ANTHONY LEGGETT,
LEONARD MANDEL, N. DAVID MERMIN, JÜRGEN MLYNEK, MIKIO NAMIKI,
HELMUT RAUCH, MARLAN SCULLY, ABNER SHIMONY, AKIRA TONOMURA,
HERBERT WALTHER, RICHARD WEBB, SAMUEL WERNER, CHEN-NING YANG,
and Anton Zeilinger

CONTENTS		
Preface. My Daniel M. Greenberger	XIII	
Part I. Multiphoton Processes and Downconversion		
Two-Photon Downconversion Experiments. By L. Mandel	1	
Quantum Optics: Quantum, Classical, and Metaphysical Aspects. By D. N. KLYSHKO	13	
Second-Order Photon-Photon Correlations and Atomic Spectroscopy. By ULRICH W. RATHE, MARLAN 0. SCULLY, and SUSANNE F.YELIN	28	
EPR and Two-Photon Interference Experiments Using Type-II Parametric Downconversion. BY.H.SHIH,A.V.SERGIENKO, T.B. PITTMAN, and M.H. RUBIN	40	
Frustrated Downconversion: Virtual or Real Photons? By H. Weinfurter, T.HERZO G,P.G.KwIAT,J.G.RARI~, A.Zeilinger, and M. ZUKOWSKI	61	

'This volume is the result of a conference entitled Fundamental Problems in Quantum Theory! A Conference Held in Honor of Professor John A. Wheeler, which was sponsored by the New York Academy of Sciences and held on June 18–22, 1994, in Baltimore, Maryland.

Part II. Quantum Optics and Micromasers

Atoms and Photons in High-Q Cavities: New Tests of Quantum Theory. By SERGE HAROCHE
Quantum Measurement in Quantum Optics. By H. J. Kimble, O. Carnal, Z. Hu, H. Mabuchi, E. S. Polzik, R. J. Thompson, and Q. A. Turchette.
Entangling Photons Radiated by Independent Pulsed Sources. By Marek ZUKOWSKI, ANTON ZEILINGER, and HARALD WEINFURTER
Can We Measure the Wave Function of a Single Wave Packet of Light?: Brownian Motion and Continuous Wave Packet Collapse in Repeated Weak Quantum Nondemolition Measurements. By ORLY ALTER and YOSHIHISA YAMAMOTO
Quantum State Engineering in Pump-coupled High-Q Micromasers. By PAL BOGÁR JÁNOS A. BERGOU, and MARK HILLERY
Two-Photon "Ghost" Image and Interference-Diffraction. By Y. H. SHIH, A. V. SERGIENKO, T. B. PITTMAN, D. V. STREKALOV, and D. N. KLYSHKO
Part III. Atomic Processes
Experiments with Single Atoms in Cavities and Traps. By H. Walther
A Heisenberg Microscope for Atoms. By CH. Kurtsiefer, T. Pfau, S. Spälter C. R. Ekstrom, and J. Mlynek
Stern-Gerlach Atomic Interferometry with Space- and Time-dependent Magnetic Fields. By J. Robert, O. Gorceix, J. Lawson-Daku, S. Nic Chormaic, Ch. Miniatura, J. Baudon, F. Perales, M. Eminyan, and K. Rubin
Possibility of Quantum Revivals in Long-Time Spin Dynamics of ³ He- ⁴ He Solutions. $\bar{B}y$ Daniel L.
Part IV. Electron, Neutron, and Atomic Interference
Interferometry with Atoms and Molecules. By David E. Pritchard, MICHAEL S. CHAPMAN, CHRISTOPHER R. EKSTROM, TROY D. HAMMOND, JÖRGSCHMIEDMAYER, ALANLENEF, RICHARDRUBENSTEIN, ~~~
Stefan Wehinger
Observations of the Wave Nature of an Ultracold Atom. By H. TAKUMA, K. Shimizu, and F. Mod.
Recent Advances in Electron Interferometry. By AKIRA TONOMURA
Neutron Interferometry Tests of Quantum Theory. By Samuel A. Werner
More Quantum Information due to Postselection in Neutron Interferometry. **By Helmut Rauch**
Experimental Tests of the Foundations of Quantum Mechanics Using Neutrons: The Scalar A-B Effect. By A. G. Mm.
Diffraction in Time and a New Type of Interferometry with Nonseparated Beams. By A. I. Frank and V. G. NoSov

Quantum Interference, State Engineering, and Quantum Eraser. By D. SI KRAHMER, K. VOGEL, V. M. AKULIN, and W. P. SCHLEICH
Varieties of Quantum Measurement. By W. G. 🗷 560
Making Sense of the Kochen-Dieks "No-Collapse" Interpretation of Quantum Mechanics Independent of the Measurement Problem. By ROB CLIFTON 570
Limitation to Quantum Measurements of Space-Time Distances. By Y. Jack Ng and H. van Dam 579
Part X. Quantum Equalities and Inequalities
Two-Particle versus Three-Particle EPR Experiments. By Daniel M. Greenberger 585
The EPR Argument and Nonlocality without Inequalities for a Single Photon. By LUCIEN Max
The Best Version of Bell's Theorem. By N. David Mermin 610
Interference of Single Photons from Separate Sources. By J. G. RARITY 624
Parametric Downconversion Photon Sources, Beam-Splitters, and Bell's Inequality. By A. GARUCCIO 632
Three-Particle Bell Inequalities. By T. E. KIESS. 641
A GHZ Argument for a Single Spinless Particle. By Gordon N. Fleming 646
Part XI. Quantum Entanglement
The Entanglement of Virtual Photons. By J. D. ham. 654
Multipath Interferometry of the Biphoton. By Michael Horne and Abner
SHIMONY 662
Degree of Entanglement. By Abner Shimony 675
Statistics of Entangled-Photon Coincidences in Parametric Downconversion By T. S. Larchuk, M. C. TEICH, and B. E. A. 32
Part XII. Information Theory and Quantum Communication The Lattice Dynamics of Completely Entangled States and Its Application to
Communication Schemes. By Daniel I. Fivel. 687
Sending Classical Bits via Quantum Its. By Paul Hausladen, Benjamin Schumacher, Michael Westmoreland, and William K. Wootters 698
Bounds for Accessible Information in Quantum Mechanics. By CHRISTOPHER A. FUCHS and CARLTON M. CAVES
Quantum Teleportation and Quantum Computation Based on Cavity QED. By Tycho Sleator and Harald Weinfurter
Part XIII. Decoherence and Consistent Histories
A Review of the Decoherent Histories Approach to Quantum Mechanics. By J. J. Lum. 720
Decoherence and Vacuum Fluctuations. By L. H. FORD

Part XIV. Randomness in Nature

	Cryptogram? By T. 🔤	748
		757
	Part XV. Other Theoretical Considerations	
	Вив	761
		768
	Field Theory. By JEREMY MAN.	/08
Ge	ometry of Quantum SAMUEL L. CARLTON CAVES	786
	Selleri	798
	By Shepard	812
	Stapp	822
Or	the Computational Power of Physical Systems, Undecidability, the Consistency of Phenomena, and the Practical Uses of Paradoxes. <i>By</i> K. M.	834
	Part XVI. Poster Papers	
Pu	mp-coupled Micromasers. By PÁL BOGÁR, JÁNOS A. BERGOU, and MARK HILLERY	842
	QC: An Experiment for Detecting Macroscopic Quantum Coherence with a System of SQUIDs. By P. CARELLI, M. G. CASTELLANO, F. CHIARELLO, L. CHIATTI, M. CIRILLO, C. COSMELLI, G. DIAMBRINI PALAZZI, D. FARGION, R. LEONI, G. ROTOLI, F. SCARAMUZZI, and G. TORRIOLI Failure of Einsteinian Reality in an Unequal-Arm Interferometer. By HYUNG SUP CHOIL	845
	CHARLES E. ENGELKE CHARLES WI	0.0
	ENGELKE CHARLES WI	850
		855
	Multiray	858
	GASTÓN GARCIA-CALDERON	861
	HIROTAL	863
G	eometrical Phase Effects and Bohm's Quantum Potential. By R. E. KASTNER	866
N	oise Limits for Nonlinear, Phase-invariant Amplifiers. By DMITRI KOUZNETSOV, ROBERTO ORTEGA, and DANIEL ROHRLICH	868
N	J. KRAUSE Gon-Abelian Quantum Kinematic Foundations of Quantum Dynamics. By	8 7 1
E	ntangled Entanglement Ry GÜNTHER KRENN and ANTON ZEILINGER	873

Potentials and Fields on the Quantum Mechanical Phase of Matter Waves. By Marc Nicklaus and Franz Hasselbach	877
The Einstein-Podolsky-Rosen Paradox and the Pauli Exclusion Principle. By Paul O'Hara	880
Interplay of Aharonov-Bohm and Berry Phases for a Quantum Cloud of Charge. By Sandu Popescu, Yakir aharonov, Sidney Coleman, Alfred S.Goldhaber, Shmuel Nussinov, Benni Reznik, Daniel Rohrlich, and Lev Vaidman	882
Effective Mass-enhanced Deflection of Neutrons in Noninertial Frames. By K. RAUM, M. KOELLNER, A. ZEILINGER, and R. GAHLER	888
Hidden-Variables Model and Nonlocality in the Bohm/EPR Experiment. By Kenneth H. Schatten	892
First-Order Dark Matter and the Effectiveness of Mathematics in the Natural Sciences. By Anthony Ellsworth Scoville	896
Geometric Phase Shifts in Pilot-Wave Theory. By Erik SJOQVIST	898
Tunneling Times and Weak Measurements. By Aephraim M. Steinberg	900
Is Quantum Mechanics an Exotic Probability Theory? By SAUL YOUSSEF	904
Index of Contributors.	907

Financial assistance was received from:

Supporters

- . CITYCOLLEGEOFNEWYORK
- . DEPARTMENT OF ENERGY
- . RICHARD LOUNSBERY FOUNDATION
- . NATIONAL SCIENCE FOUNDATION
- . OFFICE OF NAVAL RESEARCH
- . ALFREDP.SLOAN FOUNDATION

Contributors

- . HITACHI LIMITED
- .NEC RESEARCH INSTITUTE

The New York Academy of Sciences believes it has a responsibility to provide an open forum for discussion of scientific questions. The positions taken by the participants in the reported conferences are their own and not necessarily those of the Academy. The Academy has no intent to influence legislation by providing such forums.