FONDATION LOUIS DE BROGLIE

23, quai de Conti. 75006 PARIS

CENTENAIRE DE LOUIS DE BROGLIE 1892-1987

Colloque

La physique quantique Pour raison garder

FONDATION DES TREILLES

T O U R T O U R

83690 SALERNES

15 - 20 Mai 1992

L.ACCARDI. (Rome). Applications of quantum probability to physics.
I.J.R.AITCHISON. (Oxford). Anyons.
S.ALBEVERIO. (Bochum). Recent developments in stochastic processes and quantum theory.
L.E.BALLENTINE. (Burnaby). How do classical properties emerge from quantum mechanics?
A.O.BARUT. (Boulder). Particle-like configurations of the electromagnetic field. An extension of the de Broglie's ideas.
H.DEKKER. (Amsterdam). Mesoscopic physics. From dissipative quantum mechanics to non-equilibrium thermodynamics.
A.J.LEGGETT. (Urbana). Quantum mechanics and macroscopic realism.
H.LICHTE. (Tübingen). Electron wave interferometry. Basic experiments and novel applications.
V.MAN'KO. (Moscou). Time dependant integrals of motion in quantum mechanics.
P.PEARLE. (Clinton). In the equations and not just in the talk.
A.F.RANADA. (Madrid). A topological quantization of the electromagnetic field.
Y.I.VORONTSOV. (Moscou). Standard and non standard quantum limits for measurement errors.
A.ZEILINGER. (Innsbrück). Quantum entanglement and its lesson for the reality quest.

FONDATION
Louis de Broglie
23 QUAI DE CONTI. 75006 PARIS
TÉL. (1) 40.46.05.54
FAX (1) 40.51.08.65

LES TREILLES

15-20 MAI 1992

Réunion en hommage à Louis de Broglie
à l'occasion de son centenaire

LA PHYSIQUE QUANTIQUE

POUR RAISON GARDER

CONFERENCES

Titles and abstracts

H.DEKKER

Luigi ACCARDI

Applications of quantum probability to physics

Three main fields of applications of quantum probability to quantum physics will be reviewed:

(I) **From quantum electrodynamics to quantum noises.** It will be shown how the basic quantum noises (quantum brownian motion, quantum poisson process) arise as approximations of the quantum electromagnetic field under the dipole and the rotating wave approximation. Dropping the RWA does not change qualitatively the picture, but dropping the dipole approximation does and new phenomena arise, both at the mathematical and the physical level.

(II) **From quantum markov chains to valence bond models.** The quantum markov chains, introduced for purely mathematical reasons about 15 years ago, have found applications to describe the so called valence bond states, introduced by Anderson, Affleck and other physicists to describe the phenomenon of high temperature superconductivity.

(III) **The quantum probabilistic approach to the interpretation of quantum theory.** The interpretation of quantum theory, proposed by quantum probability, pinpoints the common origin of all the quantum paradoxes in an inappropriate use of a hidden axiom of classical probability theory. Deep connections with the old problematic of *coherence* in the sense of Ramsey, De Finetti and Savage, have recently emerged. The mathematical model of quantum theory is deduced from a qualitative, model independent, formulation of the Heisenberg uncertainty principle.

Ian J.R. AITCHISON

A n y o n s

An elementary introduction is given to the concept of anyons- quantum particles whose "statistics" interpolates smoothly between that of bosons and fermions. Such particles -or quasi-particle excitations- can occur in two-dimensional systems in which the particles experience strong short range mutual repulsions. These circumstances effectively mean that one has to apply quantum mechanics to a configuration space in which some points are excluded (i.e. it has "holes")- namely, those points where two particles would coincide.
The Aharonov-Bohm effect provides the simplest physical example of quantum mechanics in such a non -simple connected space, and is also fundamental to a simple model for anyons.
A qualitative introduction is given to two currently proposed physical applications of anyons: high temperature superconductivity, and the (fractional) quantum Hall effect.

Sergio ALBEVERIO

Recent developments in stochastic processes and quantum theory

Survey of recent developments in the theory of stochastic processes in their interaction with quantum theory (quantum mechanics, quantum field theory, including connections with geometrical objects like gauge fields and strings).

Leslie E. BALLENTINE

How do classical properties emerge from quantum mechanics?

I will examine different methods for studying the classical limit of quantum mechanics, and show how they lead to different views of what is "the classical limit" and the criterion for its validity. The analysis of the classical limit and the analysis of the measurement process both lead to certain inferences about the proper interpretation of quantum mechanics. An understanding of these conceptual/ interpretational issues is necessary in order to understand how classical properties (including chaos) can emerge from a limit of quantum mechanics.

Asim O. BARUT

Particle-like configurations of the electromagnetic field

An extension of the de Broglie's ideas

This talk presents the combination of two topics: spherical electromagnetic waves and their particle-like motions. It expands previous studies relating to de Broglie's ideas, where in particular, localized solutions of the massless scalar equation was generalized and "extended to the electromagnetic case. The intent is to explore the possibility of developing a wave model of a spinning particle, which could exhibit a wave -particle duality as originally envisaged by de Broglie. This has important application to a Qantum Theory of Single Events: the associated wave function would involve the 'internal' parameters necessary for the description of individual events, and would be quite distinct from the usual quantum mechanical wave function, with its statistical (Born) interpretation.

H. DEKKER

Mesoscopic Physics

From dissipative quantum mechanics to non-equilibrium thermodynamics

The role of quantum mechanics in the macroscopic realm will be discussed on the basis of recent developments related to Josephson junction tunneling devices. Both dissipation and finite temperatures will be argued to be important for the understanding of complex macroscopic systems. The relation between the coherent two-level quantum system and the incoherent classical process of thermal activation in a bistable potential will be investigated. Finally, the implications of macroscopic smallness for possible non-isothermal events will be considered.

Anthony J. LEGGETT

Quantum mechanics and macroscopic realism.

The notorious "quantum measurement paradox" rests essentially on the belief that the formalism of quantum mechanics can be extrapolated to the point where it predicts superposition of macroscopically distinct states. Iwill rview the current experimental status of this belief, in particular in connection withe experiments done over the last decade on "macroscopic quantum tunnelling" in Josephson devices and other systems, and discuss an experiment, currently at the construction stage, which if successful should test the predictions of quantum mechanics definitely against those of a class of theories embodying the principle of "macroscopic realism".

Hannes LICHTE

Electron wave interferometry

Basic experiments and novel applications

Since its invention in 1954, the Möllenstedt electron biprism has turned out the most powerful device for the production of two beam electron interference phenomena. It was successfully applied for the investigation of basic peculiarities of electron waves such as the electron wavelength, the coherence properties, and the phase shifting effects arising from electric and magnetic fields. Likewise, the Doppler shift of electron waves and the Sagnac phase shifting effect was experimentally realised. Additionally, since approximately a decade, electron holography was developed to high performance, which allows to make use of the phase of electron waves for the improved characterisation of the structure of matter at atomic dimensions.

Vladimir MAN'KO

Time-dependent integrals of motion in quantum mechanics

New integrals of motion are found for systems with time-dependent hamiltonians. Floquet monodromy operator for finding quasi-energy spectra is generalized to be integral of motion of periodical quantum systems. Uncertainty relation by Schrödinger is connected with squeezed and correlated states created by parametric excitation of multimode electromagnetic field in a cavity. Geometric phase is related to squeezing and quasi-energy. Symplectic group representation and hermite polynomials are shown to describe transition probabilities in the time-varying photon system.

Philip PEARLE

In the equations and not just the talk

The Dynamical Reduction program will be presented. This is the idea of modifying the Schroedinger equation so that the state vector reduction is "in the equations, and not just the talk" (John Bell). In this view, state vector reduction is a real physical process that has been left out of the description of nature given by standard quantum theory. A non standard quantum theory, the non relativistic Continuous Spontaneous Localization (CSL) theory will be discussed together with its rational, the gambler ruin analogy, the important work of Ghirardi, Rimini and Weber, and possible experimental tests. Then attempts to make a relativistic CSL theory will be sketched, as will the associated physical pictures of how reduction procedes in spacetime.

Antonio F. RANADA

A topological quantization of the electromagnetic field

The electric and magnetic lines of radiation fields can be understood as the level curves of two complex functions θ,ϕ. Since complex functions can be interpreted as maps $S^3 \to S^2$, there is a topological structure in electromagnetism in vacuum with homotopy classes of fields labelled by the value of two Hopf indexes, which are topological constants of the motion. One of them coincides with the magnetic helicity, so that $\int \mathbf{A}.\mathbf{B}\ d^3r=n$, n being an integer number, **B** the magnetic field and **A** the vector potential, a similar equation holding for the electric helicity. Using this scheme to generate electromagnetic fields, the ensuing structure coincides locally with the standard theory, but there is an important difference from the global point of view, which manifests in a topological quantization. Moreover there is an associated mechanism for the quantization of the electric charge which turns out to be always equal to an integer multiple of $1/4\pi$ (in natural units).
It is argued that this could be helpful for a better understanding of the idea of quantization.

Yuri I. VORONTSOV

Standard and non standard quantum limits for measurement errors

Quantum limits for measurement errors originate from the back action of meter on to a system. This action has no effect on the value of the variable A to be measured only if the conditions of the quantum non demolition measurement are fullfilled. Otherwise, the back action can be removed by means of appropriate correlation of conjugate meter variables, from the meter reading, but not from the value of variable A proper. The equation that connects the r.m.s. measurement error of the variable A with the r.m.s. perturbation of variable B is not analogous to the uncertainty relation fo A and B if $[A,B]$ is an operator. The error of energy measurement in non-conservative system can be less than h/t where t is the duration of measurement, but cannot be less than h/t^*; t^*- the relaxation time of the system. The quantum limit for the sensitivity of detection of force action on a system depends on the initial state of the system, on the form of the system evolution and on the wave form of the force. In test body experiments, the meter interacts simultaneously with a large number of test body degrees of freedom. Therefore some previous quantum formulas for measurement errors are not valid in this case.

Anton ZEILINGER

Quantum entanglement and its lesson for the reality quest.

Entanglement to Erwin Schrödinger did contain the essence of quantum mechanics. In the talk a tutorial introduction to entanglement and its relation to the Einstein-Podolsky-Rosen Paradoxon and Bell's Inequality will be given. Recent developments concerning momentum/ energy entangled states and entanglement in multiparticle systems will be emphasized.