Deductive Theoretical Physics

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Principles of Deductive Theoretical Physics

A Proposal for a General Theory Based on Successive Confidence Estimates on Quantum-Mechanical Wave Functions

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Excerpt

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Preface to the 2014 Publication

This publication of mathematical speculations and writings made during the 1970:s and early 1980:s contains the general principles of a proposed deductive approach to theoretical physics and an outline of a mathematical theory. A rigorous and self-contained exposition of the three most basic concepts of the theory, containing the definitions and theorems quoted in Part II, is given in *Successive Confidence Estimates on Solutions to the Many-Particle Schrödinger Equation. Basic Concepts* which is included in this book as Part III. The reference lists are incomplete in the sense that I have not been in a position to do ordinary studies of and make ordinary references to other existing works related to the present work.

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First of all I wish to thank Lars E. Henriksson. It was Lars who, together with and supported by Peje Löfgren, took the initiative to publish these old mathematical speculations and writings of mine. Lars performed and managed all that administration work that was necessary. Without Lars' great, due to my own shortcomings necessary, patience, this publication would not have been realized.

I wish to thank Peje Löfgren for many years of profound mathematical discussions. Many of these have bearing on my own work. Let me just give one example. A central concept in the present theory is that of finite approximations. I owe much to Peje's own work on this subject.

I wish to thank Jan Pilotti. Jan has read Parts I and II of the manuscript critically and has pointed out several important corrections and elucidations.

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To all I wish to express my great gratitude.

Stockholm August 2014

Tomas Blomberg

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Preface

The principal object of the following theory is to treat and develop theoretical physics as a deductive science.

Common theoretical physics, although deductive in certain parts or steps, generally displays an apparent lack of deductiveness. There are excellent examples of completely deductive theories such as e.g. Newtonian point mechanics, but they appear as small isolated and widely separated islands when considered in relation to our complete physical knowledge. Practically every theoretical discussion frequently introduces extra, often implicit, assumptions depending on the specific problem under concern, without deriving the validity of these extra assumptions from basic postulates. In some cases these extra assumptions are more or less obvious or natural (although they might be difficult to prove). In some cases they are rather doubtful. However, it is a remarkable fact that derivations of such extra assumptions are often missing in the literature even in cases where it would be a straightforward task to work out a rigorous proof. For example, we will not take for granted, but derive rigorously, the fact that light propagates along straight lines and with the "velocity of light" c. A rigorous and complete formulation and proof of this statement needs a thorough consideration of confidence estimates on wave packets. Although quite nontrivial, it is obtained by a rather elementary exercise in Fourier transform theory. It ought to be found in any thorough theoretical discussion on light.

A similar situation appears when one theory is a special case of another more general theory. There are seldom any attempts to derive in a more definite way the validity of the basic principles of the special theory from the more general theory. The task of working out such derivations, connecting different theories, is of a central interest in the following theory. Let us note that such a derivation is not only a matter of formality. It is in fact intimately related to the problem of finding the exact conditions under which the special theory is applicable and such conditions have an immediate physical significance. Often the special theory appears as an approximation of the more general theory and one also wants to know the degree of accuracy of this approximation, which also has an obvious physical significance. The lack of derivations discussed means that important physical questions are left outside the theoretical treatment.

A consequence of this general lack of deductiveness is also that it makes it practically impossible to apply the mathematical method effectively. The central position of proofs in the mathematical method is intimately connected to the function of mathematics as an "art of computation". Computations are in fact examples of the deductive method. There is no principal difference between a proof, which in a deductive way leads to a qualitative prediction and a computation, which in a deductive way leads to a quantitative prediction. Thus, we see again that deductiveness is not only a question of formality but has a practical importance. It is only when we have complete deductiveness that we can fully exploit the power of the theoretical method.

Parallel to the lack of rigorous proofs there is in common theoretical physics a pervading lack of precise definitions of important concepts used in the theories.

This indicates that the apparent lack of deductiveness is connected to general conceptual problems of theoretical physics. In order to develop a general deductive theoretical physics we have to solve the following two problems:

1) Establish a general conceptual basis for deductive theoretical physics.

2) Establish a formulation of quantum mechanics with general and unproblematic applicability to physical problems.

These two problems are closely connected since the solution of one of them presupposes a solution of the other. Classical theoretical physics is composed of a set of disconnected theories, mechanics, the electromagnetic theory, thermodynamics, etc., and the only theory, which offers the possibility of a general theory, encompassing these classical theories, is quantum mechanics. On the other hand we claim that a solution of the controversial conceptual problems of quantum mechanics presupposes a general conceptual deductive framework. Our proposal for solving these two problems is the embedding of the Schrödinger equation formalism in a general "physico-logical" structure which we shall call "stochastic event structure". This structure provides basic concepts for direct descriptions both of classical and quantum phenomena in a unified and objectivistic way. The Schrödinger equation then complements this descriptive structure with a general dynamics generalizing and encompassing the classical theories.
The theory proposed in part II below is at the same time a mathematical theory and a physical theory. As a physical theory it has of course a phenomenological character. Thus, the mathematical theory below is suggested by speculations on quantum mechanics, which in turn has its origin in the physical phenomenology, and the purpose of the theory is to describe the physical reality. As any physical theory it then ultimately stands or falls depending on its further success in describing, analyzing and predicting physical phenomena. We can thus distinguish three different steps in the development of a physical theory.

1) Axiomatize the theory. This means that we establish the basic mathematical concepts which are to describe the basic physical concepts of the theory and establish in a mathematical form the basic laws connecting these concepts. The axiomatization thus results in a specific mathematical theory.

2) Develop this mathematical theory.

3) Compare results obtained in the mathematical theory with the physical reality.

It is important for the deductiveness of the theory that we are in a position where steps 1 and 3 present no problems and we can deal mathematically with step 2 in a free way, undisturbed by unformalized physical questions. We claim that the theory proposed below meets this demand.

The purpose of the following exposition is to give the general principles of the theory i.e. establish step 1) above. For the mathematical development of the theory, step 2) above, we refer to the self-contained, purely mathematical exposition given in Part III.

Introduction

In the following we shall give the conceptual foundations of a mathematical formulation of quantum mechanics based on confidence estimates instead of mean values and density operators, used in conventional quantum mechanics and quantum statistical mechanics.

A mathematical formulation of this theory – an approximation theory of L^2-functions of several variables, applied to sequences of interrelated subspaces of solutions to the many-particle Schrödinger equation – is given in Part III. The exposition in Parts I and II can be considered as a physical motivation and a mathematical outline of this theory. For proofs of theorems cited below and for further development of the mathematical technique needed in this theory, we refer to Part III

The main purpose of this exposition is to describe the basic principles of the theory, in the following called “the confidence theory”.

A second and complementary purpose is to discuss the difference between the theory and the conventional formulation of quantum theory and statistical mechanics. Although we reject the Copenhagen interpretation and the formalism built on it, we shall, due to its present overwhelming position, recapitulate it in chapter 2 and criticize it in chapter 3. Conventional statistical mechanics is discussed in chapter 4 (4.1).

The two main purposes of the confidence theory are the following:

1) To modify the conventional theory to give an unambiguous, deductive theory.

2) To propose a general theoretical basis for the treatment of, generally non-stationary, macroscopic systems.

The most important of these is the second. We consider the first purpose, although it has its own conceptual interest, mainly as a means to achieve the (more pragmatical) second purpose.

Since the exposition in Parts I and II is mainly conceptual, it is important to emphasize the mathematical technical character of the confidence theory. The confidence theory is not in first hand a philosophical-logical discussion on the subject “quantum mechanics without the observer”. It consists of a mathematical technique, the above mentioned approximation theory, whose main motivation is the second purpose stated above.

Chapters 1–4 mainly have the purpose of supporting the heuristic derivation of the confidence theory given in chapter 5. An axiomatic exposition of the theory is given in chapters 6 and 7. The systematic exposition of the theory given in chapters 6–7 is “self-contained” in the sense that it does not formally or logically presuppose chapters 1–5.

By a confidence estimate we shall mean an estimate of the form

$$\int_R |\psi(x,t)|^2 dx \geq 1-\varepsilon$$

where $\psi(x,t)$ is a normalized wave function of the time variable t and the configuration space variables x for a set of elementary particles. ε should be a very small positive number and $1-\varepsilon$ is called the "confidence level". According to the statistical interpretation of the wave function, the above estimate means that the particles are, with practical certainty (probability $\geq 1-\varepsilon$) confined to the region R at time t. A reason for using confidence estimates rather than exact localization statements comes from the fact that a wave function $\psi(x,t)$, localized exactly at time t_1 to a region R_1 (i.e. vanishing outside R_1), will, according to the Schrödinger equation, generally spread out in space so that it cannot be localized exactly to any finite region at another time t_2. On the other hand, we can under certain assumptions obtain estimates

$$\int_{R_2} |\psi(x,t_2)|^2 dx \geq 1-\varepsilon$$

at time t_2 with finite region R_2 and very small ε.

The most general basic question of a physical theory is the study of the macroscopic distribution of matter in space at different instants of time. Even if we are studying an experiment observing a single elementary particle, the situation can and should ultimately be described by macroscopic, directly observable, quantities. Thus, the task of establishing an interpretation of the quantum-mechanical wave functions and the task of describing and understanding macroscopic processes from an underlying atomistic point of view are closely connected.

The macroscopic distribution of matter in space can be instantaneously described by the localization of the configuration space variables for the constituting elementary particles to suitable intervals or regions, which are small from a macroscopic, but large from a microscopic point of view. For a quantum-mechanical wave function this means that it has (at a given instant of time) its support in that region i.e. vanishes outside the region. The set of all such wave functions constitute a (closed) subspace of the Hilbert space of wave functions. We shall describe the macroscopic distribution of matter by means of sequences of such subspaces (or equivalently by their corresponding projection operators).

By the preceeding argument, the use of confidence estimates will allow us to describe, with a sufficiently high degree of accuracy, the macroscopic behaviour of systems by consequently using only such subspaces (projection operators). The confidence theory is a theory developed consequently along these lines.

The confidence theory thus gives, in a direct way, a connection between wave functions and macroscopic quantities and therefore presents an alternative to the ensemble (density operator) methods of statistical mechanics. We shall criticize the conventional (classical and quantum) statistical mechanics in chapter 4 and propose an alternative theory based directly on phase-space region localizations. The confidence theory is a quantum-mechanical generalization of this phase-space region theory.

Parts I and II is an attempt to describe the theory (and its relation to the conventional theory) in qualitative, intuitive, verbal terms. Due to the structural and conceptual complexity of the subject, it consists of a network of different aspects and more or less precise arguments. A completely rigorous discussion can of course only be given in an axiomatized mathematical exposition (see Part III).

6.1 The Concept of a Deductive Physical Theory

We shall use the common term “mathematical structure” for a system of sets, mappings, etc. constituting the basis of a mathematical theory. The stipulation of a mathematical structure means a set theoretical way of formulating an axiomatic theory, which is convenient also for (axiomatic) physical theories for two reasons. Firstly, it is in concordance with notations and methods in pure mathematics and is thus the natural one to use if we want to apply the mathematical method to physics and, secondly, it emphasizes and makes definite the conceptual part of the theory.

We state the following general

Definition: A (deductive) physical theory is a mathematical theory built on a mathematical structure $\mathcal{T}$, together with a correspondence between a set $\mathcal{O}_{\mathcal{T}}$ within the structure $\mathcal{T}$ and a set $\mathcal{O}_{\mathcal{Ph}}$ of “physical observables” describing a certain well-defined part of the physical reality. This part of the physical reality, which is described by the theory, is called the scope of the theory.

The mathematical part of the theory consists (as any mathematical theory) of a set of definitions and proved theorems concerning the structure $\mathcal{T}$. That the theorems of the theory are rigorously proved is synonymous to saying that we use the “deductive method”.

The physical part of the theory consists merely of the correspondence or “identification” of elements in the sets $\mathcal{O}_{\mathcal{T}}$ and $\mathcal{O}_{\mathcal{Ph}}$. In the next section we shall give some “principles” which all have the purpose of making this identification (the “interpretation” of the theory) unproblematic.

6.3 Events as Basic Observables

In the following we shall chose as our set of basic observables $\mathcal{O}_{\mathcal{T}}$ a set E_o of events. By an event we shall mean a formal statement about the physical reality of such a character that it can be either true (occur) or false (not occur) or undefined/irrelevant depending on the real situation. This means that if e is an event, then “not e”, which we shall denote by $-e$, is also an event such that if e has occurred, then $-e$ has not occurred and vice versa. If e is irrelevant then $-e$ is also irrelevant.

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For “instantaneous events” we have associated to the events e a value $t(e)$ of the time variable. $e_1|e_2$ then simply means $t(e_1) \leq t(e_2)$. A more general time ordering, suitable for relativistic theories, is defined in the next section.

6.6 Space-time Localization of Events

Definition II.4:31. By space-time we shall mean $\mathbb{R}^4$ considered as $\mathbb{R}^3 \times \mathbb{R}^1$. For a point $X = (x, t) = ((x_1, x_2, x_3), t) = (x_1, x_2, x_3, t)$ in space-time, $x = (x_1, x_2, x_3)$ will be called the space coordinates or components and t will be called the time component or simply the time. We define a time-ordering relation $|$ on $\mathbb{R}^4$ in two different ways.

a) "pure time-ordering": for $X' = (x', t')$ and $X'' = (x'', t'')$ in $\mathbb{R}^4$ we define $X'|X''$ to mean $t' \leq t''$

b) "relativistic time-ordering": for $X' = (x'_1, x'_2, x'_3, t')$ and $X'' = (x''_1, x''_2, x''_3, t'')$ in $\mathbb{R}^4$ we define $X'|X''$ to mean that not both
$(x'_1 - x''_1)^2 + (x'_2 - x''_2)^2 + (x'_3 - x''_3)^2 - (t' - t'')^2 \leq 0$
and $t' > t''$.

In both cases a) and b) we define $R'|R''$, where R' and R'' are subsets of $\mathbb{R}^4$, to mean that $X'|X''$ for any points X' in R' and X'' in R''. (See (1).)

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6.7 Localization of Particles as Basic Events

Let $X = \mathbb{R}^3$ denote the 3-dimensional configuration space. For a system of n distinguishable particles we define our basic events as pairs (Ω, t) where t is an instant of time and Ω is a region in the $3n$-dimensional configuration space X^n. The event $e = (\Omega, t)$ means that at time t, the n-particle system is localized to Ω. We define the operation $-$ ("not e") by $-e = (X^n - \Omega, t)$ if $e = (\Omega, t)$. Thus $-e$ means localization to the complement region $X^n - \Omega$.

For quantum-mechanical particles, some of the n-particles may be identical and thus indistinguishable. We shall then restrict the region Ω to be symmetric in the corresponding coordinates i.e. if particles i and j are identical and $x = (\dots, x_i, \dots, x_j, \dots)$ is a point in Ω, then also $x' = (\dots, x_j, \dots, x_i, \dots)$ is in Ω.

For classical particles these events have a quite obvious meaning. The n-particle system has at every time t a well-defined configuration $x(t) = (x_1(t), \dots, x_n(t)) \in X^n$ where $x_i(t)$ is the position (in $\mathbb{R}^3$) of the i:th particle at time t. (We shall call $x(t)$ as a function of t the "orbit" of the system). $e = (\Omega, t)$ then means that $x(t) \in \Omega$.

For quantum-mechanical particles this point-interpretation is meaningless. Instead we consider the localization to space-regions as a fundamental, axiomatic, irreducible property of "quantum-mechanical particles". For a quantum-mechanical n-particle system, the localization to symmetric region Ω in X^n is a fundamental, irreducible property of the n-particle system. It cannot be reduced to one-particle statements.

This irreducibility is an expression for the "non-classical" properties of quantum systems and an expression for "the indivisible unity of quantum systems" (see Bohm (2)). Having once freed ourselves from the classical point ideas, the meaning of these localization statements should be quite obvious and immediate. The localization of a physical entity to a region in space is perhaps the most basic of our everyday experiences and its generalization to localization to regions in X^n is plain. As an example showing the immediate meaning of many-particle localizations we consider an electron (particle 1) and a proton (particle 2) confined to the 3-dimensional region Ω. Then the region $\Omega_2 \subset X^2 = X \times X$ defined by

$\Omega_2 = \{(x_1, x_2); x_1 \in \Omega, x_2 \in \Omega, |x_1 - x_2| \leq r\}$ expresses that the particles are confined to the region $\Omega \subset X$ and that the electron is bound to the proton (in some way!) to form an "atom" of radius less than r.

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Preface to Part III

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The following is a mathematical theory which describes solutions to the many-particle Schrödinger equation by means of confidence estimates rather than mean values, used in conventional quantum mechanics and quantum statistical mechanics.

Quantum mechanics is not just the question of finding a solution to the Schrödinger equation. A physical course of events may in general contain stochastic quantum transitions. Such a transition corresponds to a "collapse" of the wave function i.e. a transition from one wave function to another. Therefore a general course of events must be described by a sequence of solutions to the Schrödinger equation.

We shall study sequences of interrelated closed subspaces of solutions. The confidence estimates correspond to certain projection operators and the restriction to certain sequences of such projections, called (approximately) equiangular sequences, permits a unified description both of solutions and the corresponding initial and boundary conditions by means of these projection operators. The concept of equiangular sequences of projections can be considered as a generalization of the asymptotic concept of S-matrix (scattering matrix) and its factorizations/subdivisions in subprocesses to processes in finite regions in space and time.

Technically, this is an elementary approximation theory of subspaces of L^2-functions in connection with Fourier transforms and partial differential equations. Although the theory has an obvious physical content, it will be treated formally as a pure mathematical theory, which will meet common standards with respect to precise definitions and rigorous proofs.

III.8 Physical Remarks

Differences to the Conventional Quantum-Mechanical Formal- ism

The present theory can be considered as embedded in the conventional quantum-mechanical formalism. Our series of successive events (projections P) could be considered as a series of conventional quantum-mechanical measurements, with a special prescription for preparation of a state after measurement, namely that measuring P on a "state" u results in "state" $P\ u$. We are then considering apparently special series of measurements of localization observables, (leaving out most of the conventional formalism such as canonical commutation relations, complete sets of commuting variables, density operators, etc.). The restriction to equiangular sequences then means that any state vector (or density operator), which can be prepared from some other previous state by successive measurements of the observables describing the initial conditions, will give (approximately) the same probabilities for the following measurements, so these probabilities can be calculated from a knowledge of these initial observables only.

However, a different point of view is to consider the restriction to equiangular sequences of localization statements as an extra dynamical postulate (a "principle of equiangularity"), restricting the possible combinations of events. This extra postulate is lacking in the conventional formalism, where any state vector or any density operator is a possible state and any selfadjoint operator is a possible observable, which can be measured at any time by applying a suitable external measuring equipment.

In conventional quantum-mechanical formalism, the measurement process has received a central position, connected with the interpretation of the theory. In the present theory, a stochastic quantum transition is considered as a fundamental objective occurrence in reality – it is not considered, as in conventional quantum mechanics, to be a disturbance caused by a measurement. In those cases, where we actually have a measuring equipment, measuring a certain observable P , we can include the measurement apparatus in a larger process containing both the object of measurement and the measurement apparatus. That an object can be forced to undergo a quantum transition is not a phenomenon reserved for measurement situations. Quite generally, the initial and boundary conditions forces a system to undergo quantum transitions. This is described by the concept of stochastic event structure.

To summarize, the present theory differs from the conventional formalism in the following respects:

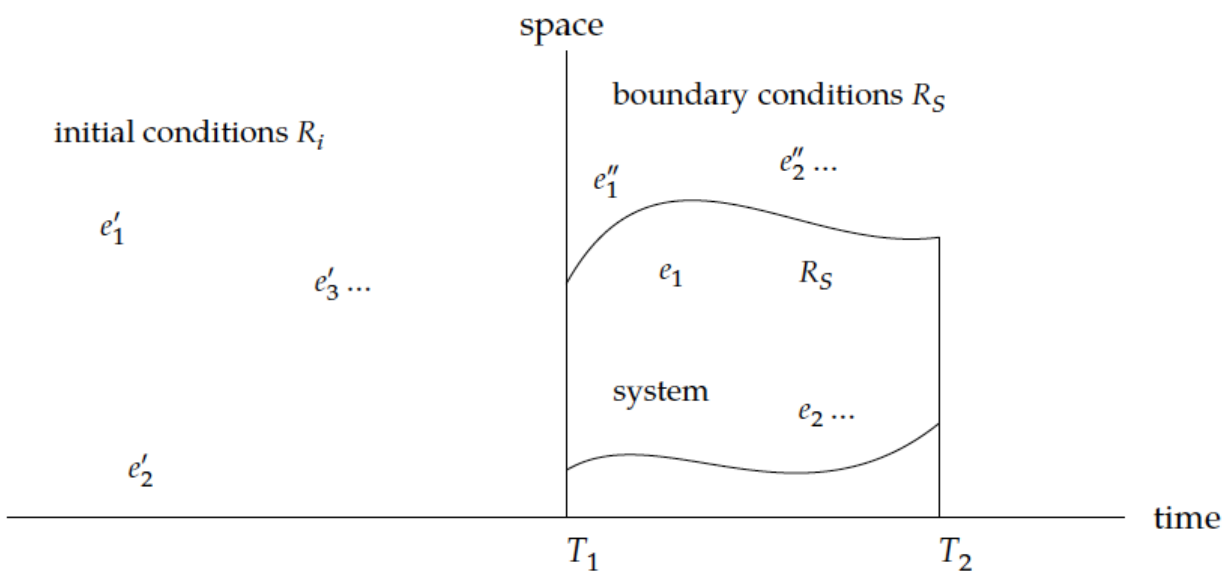
. 1° Theonlyoperatorspostulatedtocorrespondtoobservablesaretheprojection operators corresponding to space localization. All other physical quantities will be indirectly defined in terms of these.

. 2° We avoid use of the concept of "state", described by state vectors or density operators. Instead the theory is based on a description of initial conditions by means of a series of previously occurred events at different times described by the observables according to 1°. The restriction to equiangular sequences of projections makes it possible to determine transition probabilities completely from the projections describing the initial conditions.

. 3° We consider the "collapse" of the wave functions (transition from u to $P\,u$ in our cases) as an integrated part of the formalism. It is not pushed aside to an interpretation of the theory connected with a measurement process. The concept of equiangular sequences of projections describes a series of succes- sive, really occurred "collapses". The observables thus describe objectively occurred events.

. 4° Instead of allowing more or less arbitrary state vectors or density operators and measurement of observables corresponding to arbitrary selfadjoint op- erators, the restriction to equiangular sequences of projections puts a strong restriction on which series of events are possible.

. 5° Instead of introducing an extra statistical distribution(density operator), extra assumptions concerning this distribution and assumptions that certain mean values describe macroscopic systems, the present theory handles macroscopic systems in a direct and deductive way. The confidence estimates can be used at different levels of description. Macroscopic estimates concerning gross dis- tributions of large number of particles can be derived directly from the wave equations just as e.g. a cross-section formula or an estimate of a bound-state energy level can be.



Summary

General principles for deductive physical theories are discussed. It is claimed that a deductive physical theory should in principle be a pure mathematical theory (or a set of coupled mathematical theories) together with an identification of certain quantities/concepts ("observables") in the theory and corresponding observable entities in the real world. This identification – the "interpretation" of the theory - should be unproblematic, both for the theoretician and the experimentalist.

A general basis for a deductive physical theory, comprising both classical and quantum physics in a unified way, is proposed. The theory is based on successive confidence estimates on quantum-mechanical wave functions corresponding to space-localizations of particles. This allows a direct and simple way of describing both macroscopic and microscopic phenomena by means of the same basic concepts. Especially, this gives a simple, direct, kinetic, radical alternative to the ensemble methods of classical and quantum statistical mechanics.

The theory takes as its starting point the general basic ideas and problematics of quantum theory that was formulated in the 1920:s. The theory is thus consistent with conventional quantum mechanics in the sense that it is based on the same mathematical formalism of Hilbert spaces, projection operators, the Schrödinger equation (and its relativistic generalization, the Schrödinger-Schwinger-Tomonaga equation), etc., together with the – although from an axiomatic point of view, as formulated, unsatisfactory – original primitive statistical interpretation.

However, it is claimed that this is only half of the theory – half the set of conditions in a complete set of axioms. This leaves a manifest and obvious ambiguity. It is claimed that this is the root of the controversial interpretation problems and paradoxes of the conventional expositions of quantum theory.

Central in the axiomatics of the outlined theory is the concept of equiangular sequences of projections (projection operators). It describes a successive sequence of "collapses of the wave function". It is proposed that the restriction of general physical processes to fit an underlying structure of equiangular sequences – a "principle of equiangularity" – together with the restriction to projections corresponding to space-localizations of particles could give the extra conditions, constituting the other half of the theory.

From equiangular sequences of projections is abstracted the general structure of "stochastic event structure". It gives an axiomatization of the ordinary (classical!) probability theory (based on classical – not "quantum" – logic) and, at the same time, an axiomatization of the concept of causality, which generalizes the ordinary "deterministic" causality to what we call "stochastic causality". It can be applied to problems far beyond physics.

Characteristic of the outlined theory is the avoidance of the concepts of "states" and "systems" as basic concepts. The basic concept of the theory is the concept of events, represented by projection operators corresponding to confidence estimates of localization of particles to many-particle space regions.

An event can be characterized as a "partial statement" about the actual physical situation. Thus any concrete physical situation is described by a more or less exhausting set of partial statements, complementing each other. This description can often be complemented by other events, for instance on a deeper level of description. The set of – simultaneously often "overlapping" – partial statements can, in the quantum domain, generally not be reduced to the classical concepts of

"system" and "state" and the incomplete instantaneous specification of the situation is complemented by giving events at different times. This is an expression of the so called "quantum unity".

The avoidance of the concept of state as basic concept means that the wave functions, and the corresponding vectors (or rays) in the Hilbert space are not (generally) given the status or meaning as states. The term "state vector" is thus abandoned. The time-dependent wave functions are instantaneously coupled to events of instantaneous space localizations. At other times they are to be considered as auxiliary dynamical quantities for determining probabilities. This is in accordance with the original Heisenberg idea of the S-matrix.

If we detail a description of a process described by events at times t_1 and t_2, $t_1 < t_2$, by intercalating extra events $e', \ldots$ at times $t', \ldots$, between t_1 and t_2, the resulting time-dependent wave function(s) extrapolated to t_2 will, due to the collapses corresponding to $e', \ldots$ change. The axioms of equiangular sequences guarantee the consistency of such intercalations of events.

In the cat paradox case the process can be detailed by a description of what really happens – when the poisoning capsule explodes, when and how the cat dies etc., in case of a finally found dead cat – or, what the cat did during the process, in case it comes out living.

On the other hand, quantum mechanics puts strong limits on what can be detailed with respect to the time development. In a two-split experiment with a single electron we cannot say that the electron has passed through one and not the other slit. An arrangement that would determine through which slit the electron passes is *incompatible* with the two-split arrangement in the sense of the definition of *compatibility* given in the theory.

The limits on detailization is determined by the restrictions of equiangularity and the ultimate restriction to space-localizations together with the dynamics of wave-mechanics.

Another characteristic of the outlined theory is that it is not – contrary to the conventional quantum theory – based on the concept of measurement. The events are to be considered as really occurred "elements of reality" irrespectively of whether or not a systematic measurement or observation is coupled to the object system under concern. For a discussion of measurements in the proposed theory, see Part III.

The concept of equiangular sequences of projections can be considered as a generalization of the concept of S-matrix (and its factorizations/subdivisions into subprocesses) to finite regions in space and time.

It is also a characteristic of the proposed theory that it is fundamentally indeterministic/stochastic. This is contrary to common ideas that physical laws are fundamentally deterministic and time-reversible. This determinism and time-reversibility is formal and concerns only the one half of the theory mentioned above.

The proposed theory gives a basis for a general theory of irreversible processes based directly on quantum mechanics. It gives an alternative definition of entropy and an alternative derivation of entropy increase in irreversible processes. It shows a deep relation between thermodynamics and quantum theory.

Irrespective of physical applicability, the concepts of confidence estimates on L^2 -functions and their Fourier transforms, equiangular sequences of projections and stochastic event structures have interesting properties that deserve a separate, pure mathematical study, see Part III.

A deductive physical theory should in principle be a pure mathematical theory together with an identification of certain quantities/concepts ("observables") in the theory and corresponding observable entities in the real world. This identification – the "interpretation" of the theory – should be unproblematic, both for the theoretician and the experimentalist. A general basis for a deductive physical theory, comprising both classical and quantum physics in a unified way, is proposed. The theory is based on successive confidence estimates on quantum-mechanical wave functions corresponding to space-localizations of particles. This allows a direct and simple way of describing both macroscopic and microscopic phenomena by means of the same basic concepts. Central in the axiomatics of the outlined theory is a concept called equiangular sequences of projection operators. It describes a successive sequence of "collapses of the wave function". The proposed theory gives a basis for a general theory of irreversible processes based directly on quantum mechanics. It gives an alternative definition of entropy and an alternative derivation of entropy increase in irreversible processes.

Tomas Blomberg was born in 1940. He studied and has been teaching mathematics and theoretical physics at the University of Stockholm. He has also been working with IT-systems as programmer and systems analyst. His licentiate of philosophy dissertation was about bound states in S-matrix theory.

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