

3. Hidden variables interpretation.

This is the position (Alternative 4 - Introduction) that Ψ is not a complete description of the system. It is assumed that the correct complete description, which would involve further (hidden) parameters, would lead to a deterministic theory, from which the probabilistic aspects arise as a result of our ignorance of these extra parameters in the some manner as in classical statistical mechanics.⁴ It is therefore regarded as a description of an ensemble of systems and not a single system. Einstein, Bohm,² Wiener and Segal³ are proponents. Proponents of this interpretation include — Einstein, Bohm,² Wiener and Segal³.

Einstein hopes that a theory along the lines of his general relativity, where all of physics is reduced to the geometry of a space-time continuum, could satisfactorily explain quantum effects. In such a theory a particle is no longer a simple object but possesses an enormous amount of structure, i.e. it is thought of as a region of space time of high curvature. It is conceivable that the interactions of particles could depend in a sensitive way on the details of this structure, which then play the role of the "hidden variables".⁴ However these theories are non-linear and it is enormously difficult to obtain any conclusive results. Nevertheless, this possibility cannot be discounted.

Bohm considers Ψ to be a real force field, acting on a particle which always has a well-defined position and momentum. ^(which plays the role of the Schrödinger equation) It is pictured as being somewhat analogous to the electromagnetic field, satisfying Maxwell's equations, although for a particle the Ψ field is in a 3-m dimensional space.

⁴ For an example of this type of theory see Einstein-Rosen Phys. Rev. 1935

With this interpretation Bohm succeeds in showing that in all actual cases of observation the best predictions that can be made are those of the usual theory, so that no experiments could ever rule out his interpretation in favor of the ordinary theory. Our main criticism of this view is on the grounds of simplicity, namely, if one ~~believes~~^{desires to hold} the view that ψ is a real field, the associated particle is superfluous since, as we have shown, the ^{pure} wave theory is itself satisfactory.

Weinan Siegel have developed a theory which is more closely tied to the formulation of quantum mechanics. From the set of all ~~linear~~^{for a system} non-degenerate linear Hermitian operators, which have complete sets of eigenstates, a subset I is chosen such that no two members of I commute, and every element outside I commutes with at least one element in I . I is then a maximal sub-base of non-commuting non-degenerate operators, i.e., it contains precisely one operator for each orientation of the principal axes of the Hilbert space for the system. It is postulated that each of the operators of I corresponds to an independent observable, which can take any of the real numerical values of the spectrum of the operator. This ^{in its present form} theory is a theory of infinitely many hidden variables, since a system is pictured as possessing at each instant a ~~finite~~ value for every one of these "observables" simultaneously, with the changes in these values obeying precise ^(deterministic) dynamical laws. However, the changes of any one of these variables with time depends upon the ~~values of all other~~^{to the other} variables, so that it is impossible to ever discover by measurement the complete set of values for a system (since only one variable at a time can be observed). Therefore statistical ensembles are introduced, ~~which are independent of the variables~~.

the values of
in which all of the ~~isotropic~~ observables are independently
distributed), by means of a measure on a "differential space".
It is then shown that the resulting statistical theory
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, in which the values of all of the observables are
related to points in a "differential space" which is a Hilbert space
contains a measure for which each (differential space)
coordinate ~~is independently distributed~~ has an
independent, normal distribution. It is then shown that
the resulting statistical dynamics is in accord
with the usual form of quantum theory.

~~The~~ cannot be disputed that these theories are
after appealing, and might conceivably become important
should future discoveries indicate serious inadequacies
in the present scheme (i.e., ~~theory such as Bohm's might~~
~~they might be more easily modified to encompass new~~
~~experience~~). But from our point of view they are
~~not necessarily at present as cumbersome~~ usually
~~more cumbersome to work with and conceptually~~
~~more difficult less simple~~ than the
conceptually simpler theory based on pure wave mechanics.
Nevertheless, these theories have great ^{theoretical} importance simply as
~~models as complex that such theories are indeed possible~~
~~because they illustrate that "hidden variable" theories are~~

A stochastic theory which emphasizes
the particle (rather than wave) aspects of quantum
theory has been investigated by Bopp