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# The Modal Interpretation of Quantum Mechanics and Some of Its Relativistic Aspects

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The modal interpretation of quantum mechanics is an attempt to relate the mathematical formalism of quantum mechanics to physical properties ("be-ables," "existents") in such a way that the property attribution reflects the mathematical structure as much as possible—no additional structure is superimposed on the quantum mechanical formalism. In this article the main features of the modal interpretation are explained and the question is discussed of how this interpretation deals with some well-known problems of quantum measurement theory (relativistic covariance and the question of whether or not there is superluminal causation).

## 1. INTRODUCTION

The modal interpretation tries to avoid the notorious interpretational problems of quantum mechanics by construing the theory as not being about measurement outcomes, but about the properties of physical systems ("be-ables," "existents"), and as valid in the macroscopic as well as in the microscopic domain. In it, measurements are treated as physical interactions and the concept "measurement" therefore does not have a fundamental status. According to the modal interpretation (in the version explained here), quantum mechanics deals with what there *is*, also in situations in which no measurements are being made.

The central idea of the new interpretation is to stay as close as possible to the mathematical formalism and to look upon the mathematical states as codifications of physical properties and their probabilities. Two preliminary observations are helpful here.

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First, mutually exclusive physical properties correspond to orthogonal projection operators in the formalism; second, if $W$ is the reduced density operator of a partial system (obtained by "partial tracing" from the pure state of a compound system), $W$ has a (diagonal) decomposition in terms of such orthogonal projections which looks like a classical mixture:

$$W = \sum_i p_i |\psi_i\rangle\langle\psi_i|, \qquad \langle\psi_i|\psi_j\rangle = \delta_{ij}$$

This decomposition is almost always unique (the case of nonuniqueness will be discussed later).

This suggests that it is possible to attribute to the partial system *one* of the properties corresponding to the projectors $|\psi_i\rangle\langle\psi_i|$ with probability $p_i$. However, within the standard interpretation there is a well-known objection to this suggestion. The problem is that the partial system, if it really has the property corresponding to $|\psi_j\rangle\langle\psi_j|$, according to the traditional rules must be in the pure state $|\psi_j\rangle$. Analogously, the remainder of the total system must also be in some pure state if it possesses some distinct property. But then the total state necessarily is the product state of the two partial pure states. This is in conflict with our initial assumptions: if the total state has the form $|\psi_j\rangle \otimes |\xi_j\rangle$, the reduced density operator of the first partial system is $|\psi_j\rangle\langle\psi_j|$ and not $\sum_i p_i |\psi_i\rangle\langle\psi_i|$.

To sidestep this objection, we now propose to *change the rules which give a physical interpretation to the mathematical formulas of quantum mechanics*. In particular, we propose to drop the idea that a system can only possess a well-defined value of a physical magnitude if it is described by an eigenstate of the corresponding observable. Instead, we shall formulate a new interpretative rule according to which the mathematical state in a probabilistic manner relates to "be-ables" (objectively existing physical properties) also if this state is not an eigenstate of the corresponding Hermitian operators. The basic idea of this way of interpreting the formalism has been put forward, with some variations, by several authors (van Fraassen, 1981, 1991; Kochen, 1985; Healey, 1988; Dieks, 1989*a*,*b*).

## 2. THE MODAL INTERPRETATION OF QUANTUM MECHANICS

Consider the formal quantum mechanical description of a composite physical system. The total Hilbert space can be decomposed: $\mathscr{H} = \mathscr{H}_1 \otimes \mathscr{H}_2$ (the following is meant to apply to all such decompositions). According to a well-known theorem (Schmidt, Schrödinger) there is a corresponding *biorthonormal decomposition* of every state vector in $\mathscr{H}$:

$$|\psi\rangle = \sum_k c_k |\psi_k\rangle \otimes |R_k\rangle \tag{1}$$

with $|\psi_k\rangle$ in $\mathscr{H}_1$, $|R_k\rangle$ in $\mathscr{H}_2$, $\langle\psi_i|\psi_j\rangle = \delta_{ij}$, and $\langle R_i|R_j\rangle = \delta_{ij}$. This decomposition is unique if there is no degeneracy among the values of $|c_k|^2$.

The modal interpretation gives the following *physical meaning* to this mathematical state.

The *partial* system represented by vectors in $\mathscr{H}_1$ possesses exactly *one* of the physical properties associated with the set of projectors $\{|\psi_k\rangle\langle\psi_k|\}$ (and analogously for the correlated property of the environment represented in $\mathscr{H}_2$). It follows that all physical magnitudes represented by maximal Hermitian operators with spectral resolution given by $\sum a_k |\psi_k\rangle\langle\psi_k|$ are applicable to the system and possess one of their possible values, say $a_l$. The probability that the $l$th possibility is actually realized is given by $|c_l|^2$.

In the case of degeneracy, that is, $|c_j|^2 = |c_i|^2$, for $i, j \in I_l$ ($I_l$ is a set of indices), the one-dimensional projectors have to be replaced by more-dimensional projectors $P_l = \sum_{i\in I_l} |\psi_i\rangle\langle\psi_i|$; the physical properties now correspond to these projectors. The class of applicable physical magnitudes now contains only nonmaximal Hermitian operators characterized, through their spectral resolution, by the set of these more-dimensional projectors. The probability of value $a_i$ is given by $\sum_{i\in I_l} |c_i|^2$.

By means of this interpretation rule a number of definite physical properties are ascribed to partial physical systems. It is important to note that such properties are ascribed even if the total theoretical state is a superposition of eigenstates of the corresponding observables. By contrast, in the usual interpretation a definite physical property is only attributed if the mathematical state is an eigenstate of the pertinent observable. This traditional link between properties and states gives rise to the need for the notorious "collapse of the wave function" in a measurement. The argument is that if a definite result is obtained in a measurement, the state immediately after the measurement should reflect the presence of the corresponding property and should therefore be the appropriate eigenstate. The measurement must therefore induce a transition—the collapse—from a superposition of eigenstates to one of the terms in that superposition.

In contradistinction to this, in the interpretation proposed here the presence of a physical property is not in conflict with a theoretical description by means of a superposition. In our interpretation the situation after a measurement will in general be described by a superposition of the form (1), with $|\psi_k\rangle$ denoting states of the object system and $|R_k\rangle$ states of the measuring device ("pointer position states"). The physical meaning of this mathematical state is that one of the "pointer positions" is actually realized.

There is therefore no need for the projection postulate, or collapse of the wavefunction. The evolution of the theoretical state is assumed to be unitary (and time-reversible) at all times, in accordance with the Schrödinger equation (or one of its generalizations). Measurements are treated as physical interactions; measuring device and object system are both treated by quantum mechanics.

It is important to note the difference between this proposal for a *new physical interpretation* of the formalism of quantum mechanics and "hidden-variables theories." In hidden-variables theories the standard interpretation of the quantum formalism, in terms of probabilities of *measurement outcomes*, is accepted. "Hidden variables" are then introduced as parameters that obey a theory at a deeper level, about which the quantum formalism has nothing to say (except that the statistical predictions of quantum mechanics should be respected). In contrast to such proposals, the interpretation expounded here posits a direct link between the quantum formalism and physical properties; so here quantum mechanics *does* make pronouncements about the properties in question—they are not "hidden." The quantum state completely determines which physical magnitudes apply to a system (and which magnitudes do not). Admittedly, the interpretation is *indeterministic*: the state only yields *probabilities* for the various possible values of these physical magnitudes. But it is not part of the interpretation that there exists a more precise (perhaps deterministic) description which is hidden beneath the level of quantum mechanics. From the point of view of the modal interpretation, quantum mechanics is an inherently stochastic theory; it could well be a fundamental theory that says all there is to be said about the values of physical magnitudes.

## 3. CONDITIONAL PROBABILITIES

The probabilities specified by the interpretational rule are not conditional on values of physical magnitudes. They only depend on the total mathematical state. It is natural to ask whether conditional probabilities can be defined that do pertain to the values of physical magnitudes and their evolution. Given that a system possesses value $a_i$ of physical magnitude $A$ at time $t_1$, can the question be answered: What is the probability of the system possessing value $b_j$ of magnitude $B$ at time $t_2$?

To make the question meaningful within the modal interpretation, we must obviously suppose that at time $t_1$ the state has a biorthonormal decomposition in terms of eigenstates of $A$, and at $t_2$ in terms of eigenstates of $B$:

$$\sum_i c_i |a_i\rangle \otimes |X_i\rangle \rightarrow \sum_j d_j |b_j\rangle \otimes |Y_j\rangle$$

The arrow stands for the time evolution $U(t_1, t_2)$; $|X_i\rangle$ and $|Y_j\rangle$ represent the environment states at $t_1$ and $t_2$, respectively. According to the rule that we have proposed, the (unconditional) probabilities for the presence of value $a_i$ at $t_1$ and $b_j$ at $t_2$ are $|c_i|^2$ and $|d_j|^2$, respectively.

Conditional probabilities $P(b_j|a_i)$ (which in this case are the same as transition probabilities) should satisfy the relation

$$P(b_j) = \sum_i P(a_i)P(b_j|a_i)$$

That is, the several terms in the superposition at time $t_1$ should contribute to the probability of $b_j$ without interfering with each other. A situation in which this condition is fulfilled obtains if the state at time $t_2$ contains a "memory" of the separate terms in the superposition at $t_1$. Thus, suppose that a more detailed account of the evolution is provided by

$$\begin{aligned}\sum_i c_i|a_i\rangle \otimes |X_i\rangle &= \sum_i c_i|a_i\rangle \otimes |x_i\rangle \otimes |y_0\rangle \\ &= \sum_{i,j} c_i\langle b_j|a_i\rangle|b_j\rangle \otimes |x_i\rangle \otimes |y_0\rangle \\ &\to \sum_{i,j} c_i\langle b_j|a_i\rangle|b_j\rangle \otimes |x_i\rangle \otimes |y_j\rangle \end{aligned} \tag{2}$$

This represents the case in which part of the environment (represented by $\{|x_i\rangle\}$) "records" (retains traces of) the physical situation at $t_1$. The probability for $b_j$ at time $t_2$ is now given by $\sum_i |c_i\langle b_j|a_i\rangle|^2$ (remember that the partial system states occurring in the decomposition must be normalized before the interpretation rule can be applied). So we find

$$P(b_j) = \sum_i P(a_i)|\langle b_j|a_i\rangle|^2$$

and

$$P(b_j|a_i) = |\langle b_j|a_i\rangle|^2 \tag{3}$$

In this case it is therefore indeed possible to conditionalize on the values of the physical quantities which are present in the initial situation; the conditional probabilities are given by the usual expression for transition probabilities.

We thus find a justification, within the modal interpretation, for a number of prescriptions of the usual approach. For example, according to the modal interpretation, the situation after a preparation procedure will generally be described by a state of the form of the left-hand side of equation (2). The situation after a subsequent measurement can be represented by the right-hand side of (2). Equation (3) now gives the probability of measurement result $b_j$, given outcome $a_i$ of the preparation procedure (this outcome has been recorded by means of $|x_i\rangle$). We thus find the usual values of probabilities of measurement outcomes, but with a very different state ascription. In the modal interpretation the full superposition is maintained, whereas the traditional approach takes it that after the preparation the system is described by one of the eigenstates $|a_i\rangle$.

If some terms in the superposition at $t_1$ (reflecting the various possible values of quantities at $t_1$) completely merge during the evolution, with the result that no traces of the corresponding properties are left at $t_2$, the information that among those properties $a_i$ was realized at $t_1$ does not have a discriminating value; the conditional probabilities $P(b_j|a_i)$ must therefore be equal for all $|a_i\rangle$ which merge. For example, if the evolution takes the form

$$\begin{aligned}
&\sum_{i,k} c_{i,k}|a_{i,k}\rangle \otimes |x_{i,k}\rangle \otimes |y_0\rangle \\
&\quad \rightarrow \sum_{i,k} c_{i,k}|a_{i,k}\rangle \otimes |X_k\rangle \otimes |y_0\rangle \\
&\quad = \sum_{i,k,j} c_{i,k}\langle b_j|a_{i,k}\rangle|b_j\rangle \otimes |X_k\rangle \otimes |y_0\rangle \\
&\quad \rightarrow \sum_{i,k,j} c_{i,k}\langle b_j|a_{i,k}\rangle|b_j\rangle \otimes |X_k\rangle \otimes |y_j\rangle
\end{aligned} \tag{4}$$

the conditional probability $P(b_j|a_{i,k})$ cannot depend on $i$. Simple calculation shows that

$$P(b_j|a_{i,k}) = \frac{|\sum_i c_{i,k}\langle b_j|a_{i,k}\rangle|^2}{\sum_i |c_{i,k}|^2}$$

## 4. MODALITY

The interpretation is "modal" in the following sense. If the total state has the biorthonormal form

$$|\Psi\rangle = \sum_k c_k |\psi_k\rangle \otimes |R_k\rangle$$

with $0 < |c_k|^2 < 1$, one way of expressing this is to say that the partial systems possess the attributed values of physical magnitudes **contingently**, with a chance smaller than one. If the total state is

$$|\Psi\rangle = |\psi_l\rangle \otimes |R_l\rangle$$

the partial systems possess their properties **necessarily**, with chance 1.

A distinction can thus be made between different *modalities* of the same actual state of affairs: a value of a physical magnitude can be there contingently or necessarily.

A less "metaphysical" way of expressing the same thing is that the physical properties which are actually present at one instant do not completely fix the theoretical state. For the determination of the state, information is needed not only about what is actual at a given instant, but also about what *could* have been the case. However, differences in "modality" of the same actual situation generally *do* have empirical consequences for the situation at other moments. If there are interactions, the evolution of the superposition $|\Psi\rangle = \sum_k c_k |\psi_k\rangle \otimes |R_k\rangle$ will in general be very different from the evolution of $|\Psi\rangle = |\psi_l\rangle \otimes |R_l\rangle$. Through the interpretational rule this will lead to different sets of applicable physical magnitudes, and thus to different actual states of affairs.

## 5. CONTEXTUALITY

The properties attributed to physical systems are **contextual**: they depend, via the biorthonormal decomposition, on the *total* state of the system *and its environment*. This has a number of consequences that are unexpected from a classical point of view.

First, there can be situations in which a system taken as a whole has properties that do not simply follow from the properties which are found if the system is analyzed in terms of its parts. Consider, for example, the following theoretical state:

$$\sum_i c_i |a_i\rangle \otimes |b_i\rangle \otimes |E_0\rangle$$

with $\langle a_i | a_j\rangle = \langle b_i | b_j\rangle = \delta_{ij}$. This state represents a compound system, consisting of two parts, in a passive environment. The two partial systems taken by themselves possess properties defined by the given decomposition. But the *total* system has with probability 1 the property defined by the projection operator on the vector $\sum_i c_i |a_i\rangle \otimes |b_i\rangle$. On the level of physical quantities there is no simple connection between these value attributions. Knowledge of the properties of the total system only gives probabilistic information about the possible properties of the parts; given properties of the parts are compatible with many possibilities for the properties of the whole.

Second, the question of what physical magnitudes apply to a system can only be answered if a hyperplane is specified upon which the state is considered (because the total state is only defined with respect to such a hyperplane). As an illustration of this contextuality consider a particle—

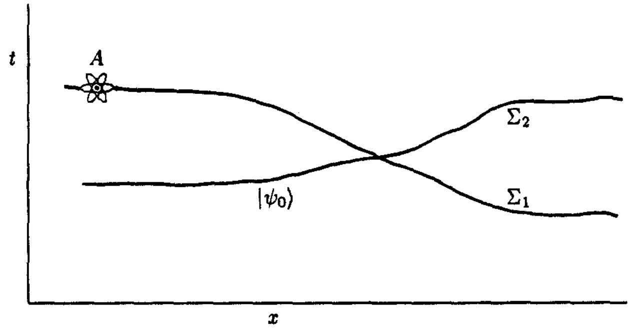


**Fig. 1.** A particle which may be detected in space-time point $A$. $\Sigma_1$ and $\Sigma_2$ are two space like hyperplanes; on $\Sigma_1$ the state is $c_1|\psi_1\rangle|g\rangle + c_2|\psi_2\rangle|e\rangle$.

represented by a nonlocalized wave function $|\psi_0\rangle$—in interaction with a localized detector (metastable atom with excited state $|e\rangle$ and ground state $|g\rangle$). The evolution is given by

$$|\psi_0\rangle \otimes |e\rangle \rightarrow c_1|\psi_1\rangle|g\rangle + c_2|\psi_2\rangle|e\rangle$$

with $|\psi_1\rangle$ localized at the detector position and $|\psi_2\rangle$ "elsewhere." That means (see Fig. 1) that on hypersurface $\Sigma_1$ the system is localized at $A$ or "elsewhere." On hypersurface $\Sigma_2$ the system is not localized. The applicability of physical magnitudes (concepts) is therefore dependent on the hypersurface on which the system is being considered.

## 6. COVARIANT DESCRIPTION OF MEASUREMENTS

The observation about the hyperplane dependence is important for the relativistic treatment of measurement. The conventional treatment of measurement makes use of the projection postulate and an instantaneous collapse of the wave function. This leads to inconsistencies in the context of relativity theory, because different observers use different simultaneity relations to define what "instantaneous" means. They therefore may attribute different and mutually inconsistent wave functions to a system. For example, an observer who uses $\Sigma_1$ (Fig. 1) as his simultaneity hyperplane may attribute a wave function to the particle which is everywhere zero except in the neighborhood of $A$; whereas an observer associated with $\Sigma_2$ assigns a wave function on his hyperplane which is nowhere zero. This leads to an inconsistency because $\Sigma_1$ and $\Sigma_2$ intersect. One way of avoiding such inconsistencies is to assume that there is an absolute simultaneity relation governing the collapses; but this of course conflicts with the basic tenets of relativity.

The modal interpretation avoids these well-known problems by denying that a collapse ever takes place. The full superposition, with its unambiguous space-time evolution, is retained at all times. But the *meaning* of this theoretical description in terms of physical properties is only given by the interpretation rule if a complete space-time hyperplane is specified. As illustrated in the figure, application of the interpretation rule to different but intersecting hyperplanes can lead to the attribution of completely differing physical properties.

However, the description furnished by the modal interpretation is Lorentz covariant. This is so because it is an objective fact which hyperplanes are associated with which attributions of physical magnitudes (of course, hyperplanes are themselves Lorentz-invariant space-time objects). There can never be a situation in which different observers reach different conclusions with respect to one and the same hyperplane. Whether or not the interaction with the detector has resulted in a change in concepts applicable to the particle system is objectively determined once the hyperplane has been specified on which the state is considered.

## 7. SUPERLUMINAL CAUSATION?

It follows from the remarks just made that if part of a hyperplane is shifted so that it passes the interaction region (see Fig. 1), which concepts are applicable changes over the whole hyperplane. This seems to pose the threat of superluminal causation: if the hyperplane is taken to define a simultaneity relation, the applicability of concepts changes instantaneously.

However, it is not at all clear whether the "applicability of concepts" can be viewed as something which causally operates or propagates. The hyperplanes $\Sigma_1$ and $\Sigma_2$ in Fig. 1, with different applicable physical magnitudes, intersect each other. This rather suggests that there are *no local* changes in their region of overlap, which is at spacelike separation from the detection event. Of course, other regions of overlap could have been chosen by considering hyperplanes of other shapes.

Moreover, *every* inherently stochastic theory for measurement outcomes which respects conservation laws exhibits similar features. Here, by "inherently stochastic theory" a theory is meant which does not suppose the existence of an underlying hidden-variables structure. Think, for instance, of a theory which makes predictions about the detection probabilities of a particle and does not operate with the assumption that there exist underlying particle trajectories. If the theory is about *one* particle (this is the "conservation law"), detection of a particle at any position seems necessarily to lead to an instantaneous "collapse" of detection probabilities elsewhere. If the theory is taken as a fundamental description, the particle cannot be considered as characterized by any position before the interaction, but it does have a position afterward. Just as in quantum mechanics, there thus is an instantaneous change in applicable concepts. It is therefore not clear whether this feature must be seen as a consequence of superluminal causation; it may rather reflect characteristics connected with fundamental indeterminism.

In order to have prospects of making progress, we need a clear criterion to assess whether or not there is a cause–effect relation in any given situation. Because the issue is whether or not there can be superluminal causation between separate regions in space-time, we have to focus on local properties of physical systems. We therefore now suppose that it is possible to define local observables associated with space-time regions. In nonrelativistic quantum mechanics this is not problematical [think, for example, of observables like $\sigma \otimes P(R)$, where $\sigma$ represents spin and $P(R)$ is a projection operator associated with space-time region $R$; these observables are relevant in the EPR-Bohm case]. In nonrelativistic quantum mechanics it also makes sense to speak of parts of the wave function associated with space-time regions. The modal interpretation then fits in with the idea of local properties in the following way. If a particle is described by a wave function, defined over some hyperplane, and if there is a local interaction with the environment in two space regions $I$ and $II$, respectively, the total state could look like

$$\sum_i c_i |\psi_{I,i}\rangle \otimes |A_{I,i}\rangle + \sum_j d_j |\psi_{II,j}\rangle \otimes |B_{II,j}\rangle + |\psi_{\text{rest}}\rangle \otimes |E_{\text{rest}}\rangle$$

The states $|\psi_I\rangle$ and $|\psi_{II}\rangle$ represent the parts of the particle wave function pertinent to regions $I$ and $II$, respectively; $|A_I\rangle$ and $|B_{II}\rangle$ stand for the correlated environment states. The modal interpretation is that one of the local properties $A_{I,i}$ is present in $I$, and similarly for $B_{II,j}$ in $II$ (with probabilities $|c_i|^2$ and $|d_j|^2$, respectively).

It is characteristic for the modal interpretation that the maximum information about the physical situation in any space-time region consists of a specification of the values of physical magnitudes attached to that region *and their probabilities* (the modal aspect). A very natural proposal for a causality criterion is therefore the following. A local intervention has a causal influence in another space-time region iff there exists at least one physical magnitude $O$ in that other region such that if $O$ is applicable, the chances of $O$'s possible values change by the interaction in the first region (get a different value from what they would have in the absence of the interaction). This criterion is equivalent to the requirement that a causal interaction between the two space-time regions should at least sometimes result in a change of at least one value of at least one physical magnitude which could be applicable in the effect region.

To apply this criterion, we assume that an intervention takes place in space-time region $I$ (an example is the interaction with the localized detector of Fig. 1). In the modal interpretation such an intervention must be described as a physical interaction; let us say with interaction Hamiltonian $H$. We further assume that in region $II$ a local interaction with the local environment determines (via the interpretation rule, see the above example of the form of a total state) that physical magnitude $O$ is applicable there. We now ask under which circumstances the interaction $H$ could lead to a change in the probabilities of the values of at least one such $O$ (so we look at all physical magnitudes that could be applicable in region $II$, namely if a suitable environment were present).

The answer to this question can easily be given. We are really asking for the conditions under which some observables in region $II$ are not conserved in the interaction. The given criterion for the presence of causal influences is therefore equivalent to the following. There is a causal effect of the local intervention represented by $H$ on the situation in another region iff for at least one local physical magnitude $O$ associated with that other region the commutator between $H$ and $O$ does not vanish: $[H, O] \neq 0$. In other words, there is no causal influence on the other region iff for all local observables associated with that other region $[H, O] = 0$ holds.

This requirement, that $[H, O] = 0$ for regions $I$ and $II$ with spacelike separation, is just the "local causality requirement" from local field theory. Actually, the situation in relativistic quantum field theory is more complicated than just described; although there are local *observables* in field theory, in general there are no local *states*. To apply the modal interpretation in that context, the interpretation rule has to be reformulated in terms of observables rather than in terms of states. Instead of the biorthonormality condition on states, we now get the condition that $\rho(A \otimes B) = \sum_i |c_i|^2 A_i B_i$, with $\rho$ the state, defined as a functional on the local observable algebras, $A$ and $B$ applicable observables with $A_i$, $B_i$ as their possible values, and $|c_i|^2$ the probability of these values. Of course the application of the modal interpretation to relativistic quantum field theory should be worked out in much more detail; however, such an elaboration does not fit into the present article. It seems that as far as the issue of superluminal causation is concerned, the same results are found as discussed here.

The modal interpretation says that *if* it is true that local interventions and local properties can be defined as sketched above, and if the local observables associated with space-time regions with spacelike separation commute, there is *no superluminal causation* between those regions. Of course, if by contrast it were possible to change the system in region $I$ by an interaction which has a nonvanishing commutator with at least one $O$

of region *II*, there *would* be superluminal causation—if it were possible to measure Newton–Wigner position locally, this would furnish an example. But that is only to be expected. The interesting thing is that the modal interpretation *denies* the existence of such superluminal causal links in the context of EPR-like situations, in which all observables of region *I* (quantities like particle/spin-density) commute with those of region *II*.

It should be noted that this result essentially depends on the central idea of the modal interpretation, namely to retain the full superposition as the theoretical state at all times and to derive all probabilities from this state. It is not assumed that the probability of a property becomes 1 as soon as this property is realized; in the modal interpretation there is no collapse of probabilities. It is exactly the assumption of a collapse of probabilities which is responsible for the verdict, given by some authors (Butterfield, 1992), that there *is* superluminal causation in quantum mechanics.

## 8. CONCLUSION

The modal interpretation attributes physical properties to physical systems in such a way that the mathematical structure of quantum mechanics is accurately reflected. It treats measurements as physical interactions, and makes no use of the projection postulate. I have sketched the general outline of the interpretation; a more detailed exposition, with a discussion of some objections recently put forward in the literature (Albert and Loewer, 1990), would transcend the scope of this paper and will be reserved for another one. Here, I hope to have made it plausible that:

1. The modal interpretation treats the measurement process in a way that is consonant with the covariance requirements of relativity theory.
2. In this treatment the applicability of physical magnitudes depends on the hyperplane on which the state is considered.
3. But there is, according to the modal interpretation, no superluminal causation as long as the condition of local commutativity is fulfilled.

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