DIEKS' REALISTIC INTERPRETATION OF QUANTUM MECHANICS: A COMMENT

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Abstract. D. Dieks has proposed a semantical rule which he claims yields a realistic interpretation of the formalism of quantum mechanics without the projection postulate. I argue that his proposal is unacceptable because it violates a natural requirement of psychophysical parallelism. His "semantical rule" is not an acceptable interpretive rule because it does not identify structures in the theory with structures in our experience, but postulates a merely probabilistic relationship between the two. Dieks' interpretation is contrasted with Everett's relative state interpretation, which attempts the same task but respects psychophysical parallelism.

In his paper, "Quantum Mechanics Without the Projection Postulate and Its Realistic Interpretation" D. Dieks[1] has made a persuasive case for a realistic interpretation of quantum mechanics which rejects the projection postulate. His view has the merit, which I believe it shares with Everett's "relative state" version of the many-worlds interpretation, of not adding any extra physical structure to the picture of the statevector evolving according to the Schrödinger equation-- structure like the hidden variables of the de Broglie-Bohm pilot wave model, or the physically distinct universes of some versions of the many worlds interpretation. But he claims his view is not the same as Everett's many-worlds interpretation. I believe that an acceptable realistic interpretation of the Hilbert space statevector and Schrödinger equation formalism which adds no extra structure must coincide with Everett's, and insofar as Dieks's interpretation differs from it, it violates what I will argue is a plausible principle of psychophysical parallelism.

Dieks' interpretation is based on a "semantical rule," which I will call rule (D), which stipulates that when a composite system has a unique bi-orthonormal decomposition

$$|\psi> = \Sigma c_k |\psi_k> |R_k> \qquad (1)$$

(bi-orthonormal meaning that $<\psi_i|\psi_j>$ and $<R_i|R_j> = \delta_{ij}$), "the partial system represented by the $|\psi_k>$, taken by itself, can be described as possessing *one* of the values of the physical quantity corresponding to the set $\{|\psi_k>\}$. The probabilities for the various possibilities to be realized are given by $|c_k|^2$." Dieks views this as "a new empirical interpretation" of the formalism of statevector subject to unitary Schrödinger evolution. Since measurement processes tend to create statevectors bi-orthonormally decomposable, with the $|\psi_k>$ eigenvectors of the observable measured, this semantic rule allows us to state that an observed system represented by the $|\psi_k>$ will exhibit a definite value of the relevant observable, with the usual quantum mechanical probabilities. This even though the total

system statevector is still a superposition, and no projection occurs. And even though the superposition remains a correct description of physical reality, we supposedly do not have a "many-worlds" interpretation: we observe only *one* measurement outcome, and there are no "other branches" of the world in which our Döppelganger, who have split from us during measurement, observe other measurement outcomes. In a sense, "projection" occurs in the semantical rule which determines the empirical interpretation of the theory, i.e. the theory's relation to observation, but it does not occur at the level of physical reality, i.e. of the statevector.

In Dieks' view, his semantical rule is the sort of thing which is necessary in any attempt to interpret a physical theory: "certain parts of the models [of the theories] are to be identified as *empirical substructures*; i.e., part of the theoretical models have to correspond to observable phenomena." I agree with this general characterization of the interpretation of theories: the "internal meaning" of the terms of the theory, given by the mathematical structures which are models of the theory, needs to be supplemented by "empirical meaning." This is done by showing how the theory relates to our experience. The usual way of doing this will be by identifying certain objects in models of the theory (or in models of the theory plus certain auxiliary assumptions and auxiliary "theories" (possibly rather crude) of how our sense-organs work, etc.) with certain of our experiences.

Implicit in this notion of an empirical interpretation is what I will call the principle of *psychophysical parallelism*: that certain types of physical structure (structure in the mathematical model of the physical theory) correspond to certain types of experience. An example of this would be the semantical rule, which I will call rule (E), that statevectors $|R_k\rangle$ for the state of an observer correspond to an observer seeing a pointer indicating a value α_k, and in a superposition like (1), *each* of the $|R_k\rangle$ corresponds to an observer

seeing a pointer indicating a different value. This, in my view, is Everett's relative-state or many-worlds interpretation. Dieks has a different relation between theory and observation. He does not suppose that $|R_k>$ in a superposition corresponds to an observer seing a pointer indicating a value α_k; his innovation consists precisely in a semantical rule which posits a different correspondence between the mathematical formalism and experiences- - a probabilistic correspondence such that while the statevectors $|R_k>$ *on their own* each do definitely correspond to an observer seeing a result α_k, and the states $|\psi_k>|R_k>$ to an observer seeing such a result while the system is in the kth state, the superposition (1) does not correspond to a multiplicity of such observers, but rather corresponds with probability $|c_k|^2$ to a single observer seeing a single result α_k. I would argue that this is not an acceptable semantical rule. Dieks himself says that "The theory is empirically successful if the structures which can be discerned in observable phenomena can be isomorphically embedded in a theoretical model which is a member of the class of models that defines the theory." But Dieks' semantical rule is not an isomorphism between observations and theoretical substructures, but a probabilistic relationship between the two. While in the relative-state interpretation certain elements of physical reality correspond to certain types of experiences, for Dieks a certain type of physical reality (a superposition like (1), with R a conscious observing system) may correspond to *different* types of experiences, with certain probabilities. Thus the principle of psychophysical parallelism is violated. One and the same physical situation may be the substrate for different configurations of experience. Whereas with the relative-state interpretation, though there are of course many consciousnesses after measurement, the total configuration of consciousnesses has a one-to-one correlation with the overall physical situation.

By putting probabilities into the "semantical rule", Dieks has essentially included some substantive theory in this rule. One might expect such a rule to contain a certain amount of *psychological* theory, inasmuch as it describes what physical phenomena correspond to certain experiences. But the content of Dieks' rule is not of this nature. If one wanted to explicitly model this additional substantive theory-- as I would argue a realist program requires-- one might come up with a structure in which consciousness is linked with some special stuff which only travels down one "branch" of the bi-orthonormal superposition (1). If we call this a "physical stuff" we now have psychophysical parallelism-- consciousness of an experimental result α_k may now be correlated one-to-one with the physical situation described by (1) plus the statement that the special stuff is attached to only one of the superposed components. But this sort of "psychophysical parallelism" has some of the spirit of Cartesian dualism, in that it postulates a special substance linked to consciousness. This view is similar to a version of the MWI considered by d'Espagnat, in which "consciousness is a property of physcial systems which is, at any rate, very different from all the other properties in that it is not described by the state vector, and which, consequently, is a *supplementary variable...*"[(2)] In our case, the special stuff is not consciousness itself, but it *is* an extra structure ("hidden variable" of a sort) imposed on the statevector formalism, and as such clearly not the sort of thing Dieks would find acceptable. But it is what results from making the simplest possible modification of Dieks' theory to respect psychophysical parallelism.

Not only does Dieks argue that his interpretation does not reduce to the MWI, he argues that the MWI 's "methodological position is similar to the position of Bohm's theory, compared to that of conventional quantum mechanics. The interpretation operates with a "model" (the many universes) that contains more than what we propose; but there is no

corresponding excess empirical content. There is no empirical support for the additionally introduced features."[1] I would argue that the situation is roughly the reverse. In discussing the MWI, Dieks seems to have in mind versions which propose a physical structure of multiple worlds (possibly branching, possibly not), like those discussed by Bell[3] and Deutsch[4]. But the version of the MWI which I feel is most plausible is Everett's relative state interpretation, which introduces no such extra structure. (One might therefore wonder if Dieks' interpretation, while he denies it coincides with the MWI, nevertheless coincides with Everett's relative state interpretation. Clearly it does not: Dieks believes there is *no* multiplicity of consciousnesses, and the semantical rule (D) he uses to ensure this differs from the rule (E) used by the relative state view as discussed above.) The relative state theory, as developed by Everett, was intended to allow the derivation of the square amplitude probabilities from the Schrödinger formalism with the aid of Everett's "semantical rule" which specifies the nature of the psychophysical parallelism. Elsewhere I have argued that the relative state interpretation is perfectly consistent and that Everett's semantical rule follows from natural psychological assumptions about how physical substructures corresponding to experiences unify into conscious histories.[5] The derivation of probabilities from the formalism remains problematic, but whether or not this derivation succeeds, I believe Everett was correct to think such a derivation essential to his project of a realistic interpretation of the Schrödinger equation. In contrast, Dieks introduces the probabilities by postulation in his "semantical rule". Dieks' inclusion of such substantive assumptions in this rule vitiates his claim to have provided a realistic interpretation of the Schrödinger formalism: when the probabilistic assumption is given its proper place, in the theory rather than in the semantical rules, the resulting theory is seen to contain "supplementary variables" in addition to the Schrödinger formalism. In my view Dieks'

theory fails to provide a realistic interpretation of the formalism of statevector and Schrödinger equation without the projection postulate or other supplementary structures because it takes the wrong approach, introducing a semantical rule which violates psychophysical parallelism and contains a substantive assumption about probabilities which has no basis in psychology and physics. Everett's theory, though its success depends on the problematical derivation of probabilities from the formalism, at least takes the correct approach of respecting psychophysical parallelism, and attempting to derive the probabilities (which do not appear in the Schrödinger equation) from the Schrödinger formalism and natural psychological assumptions.

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