Re: Rovelli on EPR

Source: http://sci.tech−archive.net/Archive/sci.physics.research/2006−05/msg00205.html

- *From*: Eugene Stefanovich <eugenev@xxxxxxxxxxxx>

- *Date*: Fri, 19 May 2006 11:38:50 +0000 (UTC)

rof@xxxxxxxxxxxx wrote:

> On page 71, Mackey introduces "Axiom VII", which says:
> The partially ordered set of all questions in quantum mechanics is
> isomorphic to the partially ordered set of all closed subspaces
> of a separable, infinite dimensional Hilbert space.
>
> That this is an axiom, and not a theorem, is the sense in which
> we do not know why quantum mechanics works. Mackey is refreshingly
> honest about this point:
>
> This axiom has rather a different character from Axioms I through
> VI. These all had some degree of physical naturalness and
> plausibility. Axiom VII seems entirely ad hoc. Why do we make it?
> Can we justify making it? What else might we assume? We shall
> discuss these questions in turn. The first is the easiest to
> answer. We make it beacuse it "works," that is, it leads to
> a theory which explains physical phenomena and successfully
> predicts the results of experiments. It is conceivable that a
> quite different assumption would do likewise but this is a
> possibility that no one seems to have explored. Indeed, one
> would like to have a list of physically plausible assumptions
> from which one could deduce Axiom VII. Short of this one
> would like a list from which one could deduce a set of
> possibilities for the structure of Q, all but one of which
> could be shown to be inconsistent with suitably planned
> experiments. At the moment such lists are not available
> and we are far from being forced to accept axiom VII as
> logically inevitable. ...
>
> Mackey's description of the situation is fairly accurate, and he
> thankfully does not attempt (as, for example, Gottfried does,
> with his "algebra of filters") to dupe the reader into thinking
> that we know why the probabilities assigned by quantum mechanics
> coincide with experimentally observed frequencies of individual
> experimental results. Birkhoff and Von Neumann's argument, which
> Mackey refers to, is the closest that anybody has come, as far
> as I can determine, to providing some justification for the

> use of quantum mechanics, although at best they have shown
> that quantum mechanics is one of a number of procedures which
> could conceivably be used to assign probabilities.

You are right, the Hilbert space is just postulated in Mackey's axioms. However, there were quite a few developments in this field since Mackey's book was published (1963). The most important step is in Piron's book

C. Piron, Foundations of Quantum Physics,
(W. A. Benjamin, Reading, 1976)

Instead of Mackey's axiom VII and instead of the classical distributive law of logic, and instead of Birkhoff−von Neumann "modular law", Piron introduces the "orthomodular law". This law can be formulated in a number of different ways. One of the most transparent formulations is "if proposition x implies proposition y, then x and y are compatible". Then Piron goes on to prove a theorem which says that above axioms can be realized if logical propositions are identified with closed subspaces in a Hilbert space over R, C, or quaternions. Quantum theories with real or quaternionic scalars have been studied, but, as far as I know, nothing interesting came out of this. So, we are left with the usual C−number quantum mechanics whose mathematical apparatus directly follows from Birkhoff−von Neumann−Mackey−Piron axioms via Piron's theorem.

There are quite a few reviews and book where you can find more details. You can check, for example,

E.G. Beltrametti and G. Casinelli "The logic of quantum mechanics" (Addison−Wesley, Reading, 1981)

or search the web for "quantum logic", "orthomodular lattice", etc.

> When somebody says that statements
> have "truth values" which can be complex, I do not know what they
> mean.

In quantum logic the "truth values" are not complex. They are real numbers from the interval [0,1], i.e., the probabilities that the result of the "yes−no experiment" is "yes". Complex numbers arise only after the propositions of quantum logics are mapped into the set of subspaces of the complex Hilbert space via Piron's theorem. This mapping identifies the "truth value" as the square of the modulus of the projection of the state vector on the subspace, i.e., still a real number from [0,1].

> ... those who opt to study quantum logic
> should be warned that it is not a system used to model inference,
> as actual logic is, but that it is a particular mathematical system
> to which actual normal true−and−false logic applies, and that calling
> it logic is just poetry.

I don't think so. In my opinion, classical logic developed by Aristotle and Boole refers only to propositions about classical objects. For quantum objects we need to take into account the statistical nature of measurements and indeterminism. This requires a change in the rules of logic. Quantum logic says that all classical axioms are still OK, except the axiom of distributivity. This axiom wasn't very intuitive in the classical system anyway. Quantum logic uses the "orthomodular law" instead. The distributivity axiom is a particular case of the "orthomodular law".

Eugene.

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