Foundations of Quantum Mechanics

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The subgroup mainly concerned with the *Foundations of Quantum Mechanics* has firstly completed the publication of the research on the notion of physical proposition in classical mechanics and quantum mechanics (QM), proving that a classical language L(x) can be constructed within the *semantic realism* (*SR*) interpretation of QM worked out by the Lecce group such that the non–Boolean lattice of propositions of quantum logic can be obtained by selecting a subset of testable physical propositions in the poset of all physical propositions associated with sentences of L(x). This result entails, in particular, that classical and quantum notions of truth may coexist in this interpretation, at variance with standard QM [1]. The subgroup has then continued its research on the model recently proposed by one of its members (*extended semantic realism*, or *ESR*, model) with the aim of embodying the mathematical formalism of QM into a broader noncontextual (hence, local) theory, thus avoiding a number of quantum paradoxes (*e.g.*, the objectification problem). It has been shown that the ESR model reinterprets quantum probabilities as *conditional* instead of *absolute* and provides a unified perspective in which *standard Bell–Clauser–Horne–Shimony-Holt* (*BCHSH*) inequalities coexist with *modified BCHSH* and *quantum* inequalities, because these different inequalities have different physical interpretations; it has also been shown that the perspective supplied by the ESR model has an intuitive explanation in terms of an unconventional kind of *unfair sampling* [2,3].

Furthermore, the subgroup has worked out a mathematical representation of the generalized observables introduced by the ESR model that satisfy a simple physical condition as *families of (commutative) positive operator valued* (*POV*) measures. This representation closely recalls the representation of unsharp observables in unsharp QM but differs from it because of some important features. By using the new representation a generalization of the projection postulate of standard QM has been provided that can be justified in terms of a nonlinear evolution of the compound system made up of the (microscopic) measured system and the (macroscopic) measuring apparatus [4,5]. Finally, some previous epistemological criticism to the Bell–Kochen–Specker theorem has been re–proposed [6].

The subgroup has also started a joint research with the subgroup concerned with *Non–Hermitian Dynamics* on the *subentity problem* in QM. It has been proven that, if one adopts the general formulation of QM on quaternionic Hilbert spaces, proper and improper mixtures can be represented by different kinds of density operators. This representation is compatible with the different evolutions of the two kinds of mixtures in complex QM, hence it allows one to distinguish proper from improper mixtures not only from an interpretative but also from a mathematical point of view, which does not occur in standard QM [7].

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