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The Long Historical Path Towards the Logic of Quantum Mechanics

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We historically retrace the path towards the construction of a logic for quantum mechanics, starting from the analysis of J. von Neumann's seminal contributions, which include his work with G. Birkhoff on quantum logic, and his first paper on operator algebras with F. J. Murray. The emerging feature is his growing dissatisfaction with the Hilbert space formalism, because of the ensuing infinite and not a priori normalizable quantum probability, which led him to look for a new mathematical structure for quantum logic, later identified with the modular projection lattice of the type II1 factor. These works generated a wide debate; after critically analysing the main contributions to it, we concentrate on a more recent proposal by A. Drago and A. Venezia, who suggested that the sought for logic is intuitionist logic. Their proof was limited to the examination of the uncertainty relations, which have been considered by von Neumann in a second time; hence, it did not address the full quantum theory. Later, G. Morchio and F. Strocchi rigorously formalized Dirac's formulation of quantum mechanics using C*-algebras. This allows reformulating the theory as a problem-based theory whose aim is to solve the problem of the relationship between classical mechanics and quantum theory; in turn, the problem is solved by making use of doubly negated propositions and ad absurdum proofs, allowing to argue that the underlying logic is the intuitionist one, and fully realizing Drago and Venezia's proposal. The analysis of Morchio and Strocchi's work ends our reconstruction.

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