Missing Link Between Probability Theory and Quantum Mechanics: the Riesz-Fejér Theorem

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Quantum mechanics is spectacularly successful on the technical level but the meaning of its rules remains shrouded in mystery even more than seventy years after its inception. Quantum-mechanical probabilities are often considered as fundamentally different from classical probabilities, in disregard of the work of Cox (1946) – and of Schrödinger (1947) – on the foundations of probability theory. One central question concerns the superposition principle, i. e. the need to work with interfering wave functions, the absolute squares of which are probabilities. Other questions concern the relationship between spin and statistics or the collapse of the wave function when new data become available. These questions are reconsidered from the Bayesian point of view. The superposition principle is found to be a consequence of an apparently little-known mathematical theorem for non-negative Fourier polynomials published by Fejér in 1915 that implies wave-mechanical interference already for classical probabilities. Combined with the classical Hamiltonian equations for free and accelerated motion, gauge invariance and particle indistinguishability, it yields all basic quantum features – wave-particle duality, operator calculus, uncertainty relations, Schrödinger equation, CPT invariance and even the spin-statistics relationship – which demystifies quantum mechanics to quite some extent.

Key words: Superposition Principle; Wave Packets; Logical Inference; Wave-Particle Duality; Quantum Mechanics.

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