# A Physical Model of the Quantum Vacuum and its Implications on Wave-Particle Duality

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**Abstract.** In the study of quantum physics, there are two fundamental problems that are still outstanding today: (1) What are the physical properties of the quantum vacuum? (2) What is the physical basis of wave-particle duality? More specifically, does the wave function of a particle represent some sort of physical movement? We think these two questions are closely related. If one understands the physical nature of the quantum vacuum, one may be able to explain why particle has the property of wave-particle duality. In this work, we propose that one can investigate the physical properties of the vacuum based on the Maxwell theory. A key assumption in deriving the final set of Maxwell's equations was the addition of a displacement current into the Ampere's Law. This assumption implied that the vacuum must behave like a dielectric medium. Using the Helmholtz decomposition method, we show that the movement of the vacuum during wave transmission can be described by a change of a newly defined electrical vector potential. Based on this analysis, both the radiation wave and the matter wave can be modeled as a transverse wave propagating in the vacuum medium. Since these waves have their own characteristic energy and momentum, they can behave as particles in a macroscopic sense. This result suggests that both photons and massive particles can be excitation waves of the same vacuum medium.