Role of the vacuum field in the transition from classical to quantum mechanics

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The nonrelativistic problem of a bound, charged particle subject to the random zero-point radiation field (ZPF) is revisited, with the purpose of disclosing the mechanism that takes the system from the initial classical regime far from equilibrium, to the final quantum regime characterized by stationary states. The combined effect of the ZPF and the radiation reaction force leads, after a characteristic time lapse, to a loss of memory of the initial conditions and the concomitant irreversible transition of the dynamics to a stationary regime controlled by the field. As a result, the canonical particle variables x,p become expressed in terms of the dipolar response functions to a proper set of ZPF modes. An appropriate ordering of the response coefficients leads to the matrix representation, and to the basic quantum commutator [x,p]=ih/2 π. Further, higher-order effects of the ZPF are shown to correspond to the (nonrelativistic) radiative corrections of QED. These results reaffirm the essentially electrodynamic and stochastic nature of the quantum phenomenon, as posited by stochastic electrodynamics.