

Physical explanation for the emergence of the quantum operator formalism and its connection with linear response theory

Ana Maria Cetto and Luis de la Peña

*Instituto de Física, UNAM, Mexico, Circuito de la Investigación Científica, CU, 04510
México, DF, Mexico*

To address the question of the physical origin of the quantum operator formalism, we follow the approach of stochastic electrodynamics by considering the interaction of matter with the full radiation field, including the zero-point field. We take an atomic system in a stationary state and analyze in detail its linear, resonant response to the driving field. A one-to-one relation is established between the (c-number) response variables and the corresponding operators; the Poisson bracket of the response variables with respect to the driving field amplitudes takes the form of the (x,p) commutator, the response coefficients playing the role of matrix elements. The results obtained allow to establish a natural contact with linear response theory at the fundamental quantum level. To account for the order of the response variables, which is reflected in the non-commutativity of the operators, we introduce the concept of ordered covariance, both for the atomic system and for the field.