The vacuum electromagnetic field as the source of atomic stability

Ana María Cetto and Eduardo Varela

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

Dedicated to the memory of Luis de la Peña.

Atomic stability has defied physical explanation since Bohr's original proposal of 1913. Here, we address the issue of the stability of the hydrogen atom from first principles within the context of stochastic electrodynamics (SED). To this end, we study the behavior of the adiabatic invariants when the Hamiltonian system is perturbed by the zero-point radiation field (ZPF). Initially, this approach leads to the ground state of the H atom. The excited states are obtained by considering that the field is composed of modes which may enter in phase with the system's orbits. When the system has an unperturbed orbital frequency and one or more associated adiabatic invariants, its long-time dynamics is not determined by the entire random field indiscriminately, but by the cumulative coherent contribution of those specific modes of the ZPF that resonate with the orbit. Steady balance is reached when the driving force of the resonant field modes on the orbiting electron exactly balances out the electron's dissipation due to radiation reaction. The resonant states are shown to correspond to integer values of the associated adiabatic invariant, thereby substantiating the Wilson-Sommerfeld quantization postulate. Furthermore, it is argued that when an orbit enters in phase with a specific mode that connects it with a different invariant state, it may absorb or lose energy coherently from that mode. In this case the adiabatic invariant undergoes a rapid, deterministic transition to a higher or lower value.