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Summary: We revisit the Lee-Friedrichs model as a model of atomic resonances in the hydrogen atom, using the dipole-moment matrix-element functions which have been exactly computed by Nussenzveig. The Hamiltonian $H$ of the model is positive and has absolutely continuous spectrum. Although the return probability amplitude $R_\Psi(t) = (\Psi, \exp(-iHt)\Psi)$ of the initial state $\Psi$, taken as the so-called Weisskopf-Wigner (W.W.) state, cannot be computed exactly, we show that it equals the sum of an exponentially decaying term and a universal correction $O(\beta^2 t^2)$, for large positive times $t$ and small coupling constants $\beta$, improving on some results of C. King [Lett. Math. Phys. 23, No. 3, 215–222 (1991; Zbl 0737.58064)]. The remaining, non-universal, part of the correction is also shown to be of the same qualitative type. The method consists in approximating the matrix element of the resolvent operator in the W.W. state by a Lorentzian distribution. No use is made of complex energies associated to analytic continuations of the resolvent operator to “physical” Riemann sheets. Other new results are presented, in particular a physical interpretation of the corrections, and the characterization of the so-called sojourn time $\tau_H(\Psi) = \int_0^\infty |R_\Psi(t)|^2 dt$ as the average lifetime of the decaying state, a standard quantity in (quantum) probability.

MSC:

- 81V45 Atomic physics
- 35B34 Resonance in context of PDEs
- 81Q05 Closed and approximate solutions to the Schrödinger, Dirac, Klein-Gordon and other equations of quantum mechanics
- 81V80 Quantum optics
- 47A10 Spectrum, resolvent
- 81V10 Electromagnetic interaction; quantum electrodynamics

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References:


