REVIVALS AND QUANTUM BEATS IN ROTOR-LIKE SPECTRA

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Quantum revivals or autonomous rephasing phenomena (not to be confused with ”photon echoes”) were first noticed by Eberly [1] in numerical studies of atom-cavity QED and earlier studies of Fermi Golden Rule violation. A spectacular type of revival phenomena, known as fractional or cloning revivals, has appeared more recently [2-5] in systems with nearly quadratic quantum level structure such as molecular rotors, Rydberg orbitals, Morse oscillators, and quantum dots or particles-in-a-box. The latter, in particular, have been shown to undergo a seemingly chaotic time dependence and produce what Berry has named a quantum fractal. [4,5] Many aspects of revival phenomena can be explained qualitatively and quantitatively by following two complimentary approaches. [6] The first approach is a semi-classical one that analyzes wave phase and group velocity by tracking space-time behavior of wave peaks and nodes, particularly, the nodes. The second approach is a quantum and group theoretical one that analyzes wave phase by tracking interference and quantum beats at wave peaks and nodes, particularly the peaks. Either approach benefits by physical analogy with resonance of multiple coupled pendulums and related optical systems such as diffraction gratings. The semi-classical approach introduces a number-theoretic construct called the Farey sum, a technique used in chaos studies and named after a 1800's geologist, John Farey. As in studies of classically chaotic resonance, a Farey sum tree provides a useful catalog and prediction scheme for quantum revivals. The quantum approach introduces a group theoretic construct which is based on dynamic group characters, in this case, of the family of cyclic or Cn groups. The fundamental group structure of nested Cn families of groups and subgroups is exhibited quite clearly in discrete models of revival dynamics. Both approaches have deep roots in number theory, particularly, Gaussian modular arithmetic. The possibility emerges for using revivals in construction and operation of base-N memory and processors of quantum or optical computer circuits. A model of such a circuit is shown that uses revival dynamics to autonomously and clearly exhibit all factors of a small integer. [1] J. H. Eberly, Phys. Rev. A 23, 236(1981). [2] I. S. Averbukh and N. F. Perelman, Phys. Letters 139, 449 (1989). [3] D. L. Aronstein and C. R. Stroud Jr., Phys. Rev.A 55, 4526 (1997). [4] M. V. Berry, J. Phys, A: Math. Gen. 29, 6617 (1996). [5] F. Grosmann, J. M. Rost, and W. P. Schleich , J. Phys A. :Math. Gen. 30 L277 (1997). [6] W. G. Harter, Phys. Rev. A (in press).