Quantum-Classical Correspondence in the Appearance of Resonances

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Abstract

For nonlinear conservative Hamiltonian systems, the evolution of phase space as energy inceases involve appearance of chains of islands corresponding to periodic orbits or *classical resonances*. For 2 degrees of freedom systems, we can characterize a resonance by means of its order of resonance ω_x:ω_y, where ω_i is the frecuency for i-coordinate. Then, as energy increases, we can observe a sequence of appearance of resonances ω_{x1}:ω_{y1}, ω_{x2}:ω_{y2}, ω_{x3}:ω_{y3}, ...

On the other hand, in quantum mechanics we can represent the correlation diagram of eigenenergies versus a system parameter, obtaining different avoided crossings or *quantum resonances*. For 2 degrees of freedom systems, we can characterize a resonance by means of its order of resonance ω_x:$\omega_y = |\Delta n_y|$:$|\Delta n_x|$, where Δn_i is the difference between quantum numbers, for i-coordinate, of both eigenstates involved in avoided crossing.

In this context we have found, in a model of Li-CN molecule, series of quantum resonances in the correlation diagram of eigenenergies versus Planck's constant. As energy (and $\hbar$) increases we observe the next sequence of appearance of series of resonances: 1:6, 2:14, 1:8, 2:18, 1:10, 1:10, 1:8. Moreover, we observe a *similar* sequence of appearance of classical resonances: 1:6, 1:7, 1:8, 1:9, 1:10, 1:10, 1:8 ... This is a very interesting result that shows the importance of periodic orbits in quantum-classical correspondence. This result also shows the power of correlation diagram E-$\hbar$ as a tool for understanding quantum chaos.