Dissipative quantum chaos

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Short note and Related References added by Scholarpedia Editor D.Shepelyansky in May 2020

The time evolution of the density matrix generated by a quantum map which corresponds to the classical dissipative standard map is studied numerically. The system approaches a steady state which is the quantum analogue of a classical ensemble on an attractor. The quantum-statistical steady state is represented both as Wigner quasi-probability density and as the diagonal elements of the density matrix in coherent states. It is compared with the corresponding results for a stochastic classical map that is equivalent to the semi-classical limit of the quantum map [1]. The dynamics generated by the quantized standard map with weak dissipation isstudied numerically on long time-scales. It is found that even extremely weak damping is capable of disrupting the localization in the action variable which suppresses chaotic motion in the conservative quantized standard map, and of restoring diffusion of action. The results are interpreted on the basis of the analogy, originally developed for the conservative map, to Anderson localization in disordered solids [2].This note is taken from [1,2].

Using the quantum trajectories approach, the quantum dynamics of a dissipative chaotic standard map is studied in [3]. For strong dissipation the quantum wave function in the phase space collapses onto a compact packet which follows classical chaotic dynamics and whose area is proportional to the Planck constant. At weak dissipation the exponential instability of quantum dynamics on the Ehrenfest time scale dominates and leads to wave packet explosion (see Fig.1). The transition from collapse to explosion takes place when the dissipation time scale exceeds the Ehrenfest time. For integrable nonlinear dynamics the explosion practically disappears leaving place to collapse.

Related References

1. T.Dittrich, R.Graham, "Quantum effects in the steady state of the dissipative standard map", Europhys. Lett. 4(3): 263 (1987)
2. T.Dittrich, R.Graham, "Effects of weak dissipation on the long-time behaviour of the quantized standard map", Europhys. Lett. 4(3): 263 (1987)
3. G.G.Carlo, G.Benenti, D.L.Shepelyansky, "Dissipative quantum chaos: transition from wave packet collapse to explosion", Phys. Rev. Lett. 95: 164101 (2005)

See also internal links

Chirikov standard map

Category: Quantum Chaos

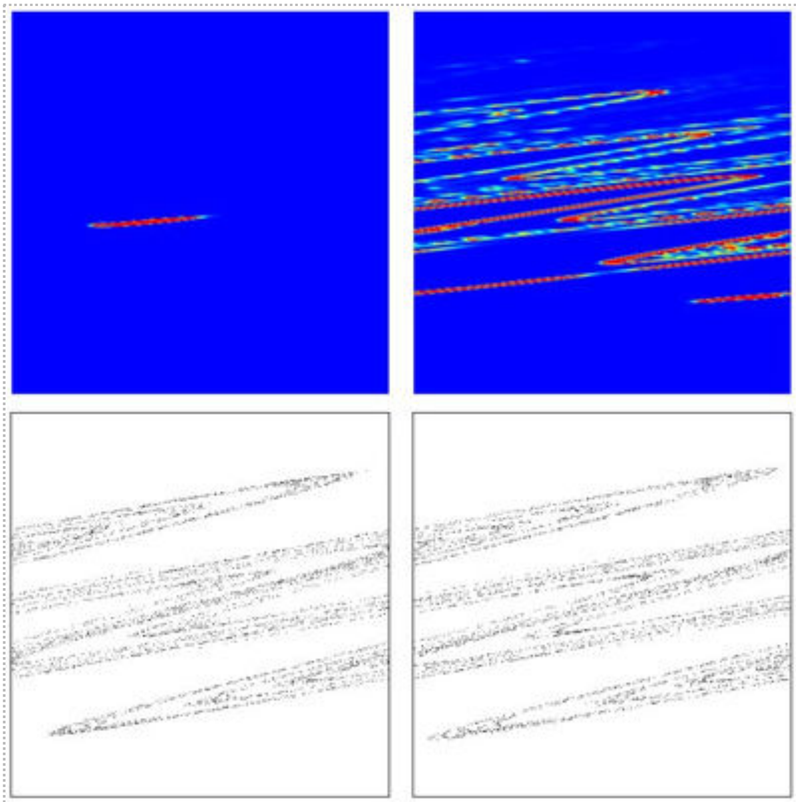

Figure 1: Transition from the wave packet collapse (top left) to explosion (top right). Top: Husimi functions in phase space for a single quantum trajectory taken after $t = 300$ kicks, at $K = 7, \hbar = 0.012$, and dissipation $\gamma = 0.5$ (left) and $\gamma = 0.01$ (right). Here x (horizontal coordinate axis) and p (vertical momentum axis) vary in the intervals $0 \le x < 2\pi$, $-25 \le p \le 25$ (left) and $-100 \le p \le 50$ (right); the width of the p-interval is the same in both cases for comparison purposes. The initial Gaussian wave packet is located at $(\langle x\rangle, \langle p\rangle) = (5\pi/4, 0)$. The color is proportional to density: blue for zero and red for maximum. Bottom: quantum Poincare section (left), obtained from average quantum x, p values for the case of top left panel and its classical counterpart (right); here $0 \le x < 2\pi$ and $-15 \le p \le 15$. (Figure is taken from [3]).