Fractal dynamics in chaotic quantum transport

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Fractal patterns can be commonly observed in nature, e.g., in snowflakes, fern leaves, coastlines, and also in the fluctuations of human-generated time series as in heartbeats [1] and music [2, 3]. Remarkably, these self-affine structures have also been found in magnetoconductance of chaotic, e.g., stadium-shaped nanostructures [4].

So far, quantum mechanical transport simulations on realistic chaotic cavities have been beyond the computational capabilities. Here, we have carried out such calculations in real space and real time for a two-dimensional stadium cavity [5]. Our results show that the conductance of the system as a function of magnetic field has a distinctive fractal scaling. Moreover, the estimated fractal dimension qualitatively agrees with the experimental data [4]. We show that the detrended fluctuation analysis (DFA), a widely used method in time-series analysis, is a powerful tool in the fractal analysis of the magnetoconductance.

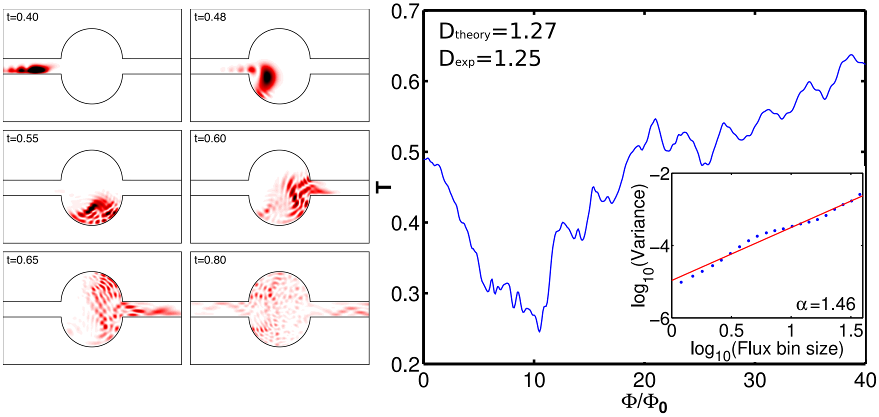

Figure 1: Left: Density snapshots of the electron transport through the stadium nanostructure. Right: Transmission coefficient as a function of magnetic flux through the stadium at $t = 1.4$. Inset: Determination of the scaling exponent α obtained with DFA.

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