Quantum Scattering and Transport in Classically Chaotic Cavities: An overview of Old and New Results [1]

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We develop a statistical theory describing quantum-mechanical scattering of a particle by a cavity when the geometry is such that the classical dynamics is chaotic. This picture is relevant to a variety of physical systems, ranging from atomic nuclei to mesoscopic systems to microwave cavities; the main application to be discussed in this talk is to electronic transport through ballistic microstructures. The theory describes the regime in which there are two distinct time scales, associated with a prompt and an equilibrated response, and is cast in terms of the matrix of scattering amplitudes S. The prompt response is related to the average of S. We construct the ensemble of S matrices using a maximum-entropy approach: the ensemble is determined by (1) general physical features– symmetry, causality, and ergodicity, (2) the specific average of S, and (3) the notion of maximum-entropy of the ensemble. This ensemble, known as Poisson's kernel, is meant to describe those situations in which any other information is irrelevant. This formulation has a remarkable predictive power: from the distribution of S we derive properties of the quantum conductance of cavities, including its average, its fluctuations, and its full distribution in certain cases, both in the absence and in the presence of a prompt response. We obtain good agreement with the results of the numerical solution of the Schrödinger equation for cavities in which the assumptions of the theory hold. We also discuss situations that have been found recently, in which the notion of ergodicity does not seem to be fulfilled (perhaps due to the presence of other time scales, although this point remains to be investigated), and yet Poisson's kernel gives a very good description of the data. As a result, Poisson's kernel seems to be valid beyond the situation where it was originally derived; however, at the present moment we are unable to give an explanation of this fact.

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