Warszawa 23.10.18

ABSTRACT

The aim of this thesis is to present numerical and experimental studies of the elastic enhancement factor $W_{S,\beta}$ and the power spectrum $S(k)$, characterized by $1/f^{\alpha}$ noise dependence, in low-dimensional wave structures simulating quantum systems. For a completeness of the performed investigations, the short- and long-range correlations were also considered. The experimental studies have been conducted with the help of microwave networks and cavities which simulated quantum graphs and two-dimensional quantum billiards. Such simulations are possible due to a formal analogy between the Schrödinger equation that describes the motion of a particle in a graph and the Telegraph equation that describe the monochromatic wave propagating in a network. In the case of microwave cavities and quantum billiards the analogy holds due to the correspondence of the Helmholtz equation that describe the distribution of the electromagnetic field inside microwave resonators and the Schrödinger equation for particles in billiards.

The power spectrum $S(k)$ was also studied in three-dimensional (3D) microwave cavities. In this case the 3D Helmholtz equation is no longer equivalent to the 3D Schrödinger equation. However, it was shown that the properties of 3D chaotic microwave cavities can be modeled by the random matrix theory.

The studies of the elastic enhancement factor $W_{S,\beta}$ in rough and rectangular microwave cavities showed that $W_{S,\beta}$ can be used as a measure of system chaoticity. The elastic enhancement factor $W_{S,\beta}$ measured for a rectangular resonator displayed a transient behavior between integrable and chaotic systems. This behavior can be explained by the presence of microwave antennas used for the introduction and detection of microwave waves. The antennas behave as point-like perturbations which cause the deviations from the fully regular dynamics.

The power spectrum $S(k)$ of level fluctuations was investigated in microwave networks simulating quantum graphs with violated and preserved time reversal invariance. The obtained results indicate that the power spectrum $S(k)$ is highly sensitive to the number of missing levels. This property is extremely valuable in the experimental research where the identification of all levels is difficult or often impossible. Furthermore, the studies of the $S(k)$ distributions were also carried out for the rectangular and tree-dimensional microwave cavities. The obtained results were supplemented by the experimental and numerical evaluation of the short- and long-range correlations related to energy level fluctuations such as the nearest-neighbor spacing distribution, the number variance, and the spectral rigidity. These functions together with the power spectrum $S(k)$ create an extremely useful tool for the determination of the number of missing levels.

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