Beautiful Graphene, Photonic Crystals, Schrödinger and Dirac Billiards and Their Spectral Properties*

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Graphene with a honeycomb lattice composed of two triangular sublattices of carbon atoms has a spectrum that closely resembles a Dirac spectrum for massless fermions [1]. We have recently investigated some of these spectral properties with a microwave photonic crystal modeling Graphene [2,3]. After a brief reminder how flat microwave resonators (also called Schrödinger billiards) can be used as model systems for quantum phenomena, and after remarks on the photonic band structure, the Dirac equation and the effective Hamiltonian at the so called Dirac point the measurements of transmission and reflection spectra are described. The salient features of those spectra are strongly related to the local density of states (LDOS). By placing the photonic crystal into a closed resonator metal box a relativistic quantum billiard (called Dirac billiard) is produced [4,5]. We have constructed such a bounded photonic crystal of 888 metallic cylinders that are arranged in a triangular lattice, have made it superconducting, and because of the high resolution were able to detect altogether about 5000 resonances. From the complete spectrum we determined the dispersion relation and the LDOS very precisely and these quantities seem to indicate an excited state quantum phase transition [6]. Furthermore other spectral properties like the nearest neighbor spacing distribution of levels near the Dirac point were studied.

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