Title:

Experiments with Superconducting Microwave Resonators Simulating Artificial Graphene

Abstract:

I will report on experiments that were performed with superconducting microwave photonic crystals, that is, flat resonators containing circular scatterers arranged on a triangular grid, so-called Dirac billiards (DBs). The eigenfrequencies of wave propagation as function of the two quasimomentum components exhibit a band structure which comprises two Dirac points (DPs), where two bands touch each other conically, and in between them a nearly flat band. This is reminiscent of a combined Honeycomb-Kagome lattice. The high-precision measurements allowed the determination of complete sequences of several thousands of eigenfrequencies. Around the DPs the density of states (DOS) of DBs is similar to that of graphene and well described by a finite tight-binding model which includes first-, second-, and third-nearest-neighbor couplings. At the band edges DBs are governed by the non-relativistic Schrödinger equation of the quantum billiard, around the DPs by the Dirac equation of the graphene billiard of corresponding shape, respectively. We analyzed the spectral properties of DBs of various shapes and compare them to those of graphene billiards and relativistic & non-relativistic quantum billiards.

Literature:

[1] B. Dietz, T. Klaus, M. Miski-Oglu, and A. Richter
Spectral properties of superconducting microwave photonic crystals modeling Dirac billiards
Phys. Rev. B. **91**, 035411 (2015)
[2] B. Dietz, T. Klaus, M. Miski-Oglu, A. Richter, M. Wunderle, and C. Bouazza
Spectral Properties of Dirac Billiards at the van Hove Singularities
Phys. Rev. Lett. **116**, 023901 (2016)
[3] Wulayimu Maimaiti, Barbara Dietz, and Alexei Andreanov
Microwave photonic crystals as an experimental realization of a combined honeycomb-kagome lattice
Phys. Rev. B **102**, 214301 (2020).
[4] B. Dietz, T. Klaus, M. Miski-Oglu, A. Richter, M. Bischoff, L. von Smekal, and J. Wambach
Fullerene C60 Simulated with a Superconducting Microwave Resonator and Test of the Atiyah Singer Index Theorem
Phys. Rev. Lett. **115**, 026801 (2015)
[5] Weihua Zhang and Barbara Dietz
Microwave photonic crystals, graphene, and honeycomb-kagome billiards with threefold symmetry: Comparison with nonrelativistic and relativistic quantum billiards
Phys. Rev. B **104**, 064310 (2021)
[6] Weihua Zhang, Xiaodong Zhang, Jiongning Che, M. Miski-Oglu, and Barbara Dietz
Properties of eigenmodes and quantum-chaotic scattering in a superconducting microwave Dirac billiard with threefold rotational symmetry
Phys. Rev. B **107**, 044308 (2023) , arXiv:2302.10094