On time-reversal invariance violation in quantum graphs

Pavel Exner

The talk is concerned with quantum graphs the vertex coupling of which does not preserve the time-reversal invariance; the motivation for such a problem comes from recent attempts to use quantum graphs to model the anomalous Hall effect. As a case study we analyze the simplest example with the asymmetry being maximal at a fixed energy. In this situation the high-energy scattering depends crucially on the vertex parity; we will demonstrate implications of this fact for spectral and transport properties in several classes of graphs, both finite and infinite periodic ones. In particular, we prove the Band-Berkolaiko universality for Kagome lattices with this coupling. Furthermore, we discuss other time-asymmetric graphs and identify a class of such couplings which exhibits a nontrivial $\mathcal{PT}$-symmetry despite being self-adjoint; we also illustrate the role of the Dirichlet component in the vertex coupling and discuss spectrum of the Cairo lattice. Finally, we show how a square lattice with such a coupling behaves in the presence of a homogeneous magnetic field when the two time-asymmetry mechanisms compete, the field effect being dominant at high energies. The results come from a common work with Marzieh Baradaran, Jiří Lipovský, and Miloš Tater.