Zero field Hall effect for particles with spin 1/2

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The integral QHE for Schrödinger electrons (particles described by a Schrödinger operator) in strong magnetic fields results in the quantisation of conductance. It is well-known by now that the remarkable stability of this effect can be traced back to its topological nature: the conductance is given by the Chern number of an adiabatic connection.

We describe a QHE for Dirac fermions (particles described by a Dirac operator with spin 1/2) which is present even without a magnetic field and whose sign depends on the mass of the particles. The motivation for this is twofold: as a continuous limit of lattice models used in physics; and as a case study of the effect of the spectral gap of Dirac operators with mass on transport properties.

We analyze both 'bulk' and 'edge' cases. We show that in the bulk case (on $\mathbb{R}^2$) the conductance can be expressed geometrically as a solid angle whose sign is given by the sign of the mass. In the edge case (on the halfplane $\mathbb{H}^2$) the conductance turns out to be given as a spectral flow through the gap. As such it is stable with respect to perturbations. We show furthermore how this spectral flow depends on the interplay between the sign of the mass and the boundary condition along the edge.

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