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Topological scattering of an electron gas by edge dislocations

KOUSHIK VISWANATHAN, SRINIVASAN CHANDRASEKAR, Purdue University — A theory of electron scattering by the strain field surrounding an edge dislocation in a linear isotropic medium is presented. When considered on a continuum scale, edge dislocations are topological defects — the underlying elastic medium can no longer be described as a Euclidean manifold, but instead must be mapped to a Riemann–Cartan manifold with nontrivial torsion. An electron gas placed in such a background has additional covariant terms in the Hamiltonian. These act alongside the usual deformation potential arising from the shift in the conduction band minima due to the dislocation strain field. When considered as perturbations, these additional terms scatter electrons from one planewave state to another. For a group of parallel, randomly distributed edge dislocations, it is shown, through an iterative evaluation of the Boltzmann equation, that the contribution of these terms to the electrical resistivity of cold-worked Cu is larger than that of the deformation potential and the resulting specific dislocation resistivity is very close to the experimentally established value. The corresponding effect in the presence of grain boundaries (edge dislocation walls) is discussed and the application of these general results to transport in semiconductors is also presented.

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