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Thermoelectricity in correlated matter

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Thermoelectricity is a foundational topic in statistical mechanics, dealing with reversible heat generation from a current flow. Kelvin established reciprocity using thermodynamic arguments in the nineteenth century. This is mysterious since transport is not within the domain of thermodynamics, and indeed Onsager later gave the correct framework during his seminal work on reciprocity. With regard to the Kelvin, I point out the origin of the mysterious "flaw in the ointment". Interestingly enough, Kelvin's argument produces a fairly useful, if inexact estimator of thermopower in certain situations. After this amusing historical footnote, I turn to the transition metal oxide Correlated materials, which are classical Mott Hubbard systems. A new formalism, using dynamical heat response, enables a quantitative understanding of the sodium cobaltate materials. It also provides some new predictions for as yet unknown materials, with extremely large thermopower. I summarize a novel hydrodynamic approach that gives a clear physical picture of the new operators introduced by us, and shows that the dimensionless figure of merit ZT couples the energy and charge modes.