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Phonon and magnon heat transport and drag effects

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Thermoelectric generators and coolers constitute today's solid-state energy converters. The two goals in thermoelectrics research are to enhance the thermopower while simultaneously maintaining a high electrical conductivity of the same material, and to minimize its lattice thermal conductivity without affecting its electronic properties. Up to now the lattice thermal conductivity has been minimized by using alloy scattering and, more recently, nanostructuring [1]. In the first part of the talk, a new approach to minimize the lattice thermal conductivity is described that affects phonon scattering much more than electron scattering. This can be done by selecting potential thermoelectric materials that have a very high anharmonicity, because this property governs phonon-phonon interaction probability. Several possible types of chemical bonds will be described that exhibit such high anharmonicity, and particular emphasis will be put on solids with highly-polarizable lone-pair electrons, such as the rock salt I-V-VI2 compounds (e.g. NaSbSe2). The second part of the talk will give an introduction to a completely new class of solid-state thermal energy converters based on spin transport. One configuration for such energy converters is based on the recently discovered spin-Seebeck effect (SSE). This quantity is expressed in the same units as the conventional thermopower, and we have recently shown that it can be of the same order of magnitude. The main advantage of SSE converters is that the problem of optimization is now distributed over two different materials, a ferromagnet in which a flux of magnetization is generated by a thermal gradient, and a normal metal where the flux of magnetization is converted into electrical power. The talk will focus on the basic physics behind the spin-Seebeck effect. Recent developments [2] will then be described based on phonon-drag of spin polarized electrons. This mechanism has made it possible to reach magnitudes of SSE that are comparable to the highest values of classical thermopower measured in semiconductors. This work is supported as part of the Revolutionary Materials for Solid State Energy Conversion (RMSSEC), an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, by AFOSR MURI "Cryogenic Peltier Cooling" Contract #FA9550-10-1-0533and by NSF-CBET-1133589.

[1] J. P. Heremans & al., Nature Nanotechnology **8,** 471-473 (2013)
[2] C. M. Jaworski & al., Nature, **487**, 210-213 (2012)

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