UCLouvain
Institute of Condensed Matter
and Nanosciences

Prof. Joseph P. HEREMANS

Ohio State University (Columbus – USA)

IMCN SEMINAR

Principles of spin-based solid-state heat-to-electricity conversion

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Auditoire J.-B. Carnoy (B059)
Croix du Sud, 4-5, 1348 Louvain-La-Neuve

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ABSTRACT

Thermoelectric power generation (TEG) is used in applications such as the Mars Rover or in interplanetary space probes where the advantages of solid-state heat conversion outweigh its main disadvantage: a low thermal efficiency. Thermoelectric cooling (TEC) is used when device size matters, e.g., to cool electronic devices, car seats, or camping coolers. Such solid-state heat engines have no moving parts, do not wear our, require no maintenance, are vibration-free and have an essentially infinite lifetime. If we overcome the efficiency problem, TEGs would be used widely for waste heat recovery and TECs for refrigeration, air conditioning, and cooling of electronics.
The efficiency of a thermoelectric material is governed by its figure of merit *zT*, a measure of irreversible losses due to Joule heating and parasitic thermal conduction through the crystal lattice. *zT* was improved by about a factor of two over 20 years. This improvement resulted mostly from reductions in lattice thermal conductivity, which is now near the amorphous limit: further improvements require new ideas. The newly discovered *spin Seebeck effect* (SSE) opens a new field: thermally driven spin transport or *spin caloritronics.* Adding the concept of spin transport to those of charge and heat transport adds a new dimension to the classical research on thermoelectrics. This talk will explain the basics of thermal spin transport, SSE, and magnon-electron drag (MD). In SSE and MD the temperature gradient pushes a magnon flux in a ferromagnet; this flux interacts with conduction electrons to produce an electric field. More recently, we have shown that one does not need an ordered magnetic structure to see the effects of spin transport: at high temperature in paramagnetic solids, short-range fluctuations of the local magnetization also can result in SSE and MD. This has made it possible to reach $zT>1$ in a simple binary paramagnetic semiconductor, MnTe, without optimization. These concepts open the possibility that many hitherto ignored semiconductors alloyed with magnetic ions might be good thermoelectrics.

BIOGRAPHY

Joseph P. Heremans is an Ohio Eminent Scholar and Professor in the Mechanical and Aerospace Engineering Department at the Ohio State University, with appointments in the Materials Science and Engineering Department and the Department of Physics. He is a member of the National Academy of Engineering, and a fellow of AAAS and the American Physical Society. He joined OSU after a 21-year career in the automotive industry at the General Motors Research Laboratories, where he was the section manager for Semiconductor Physics, and at the Delphi Research Laboratories. His research interests focus on energy conservation and recovery, and lie at the intersection between experimental condensed matter physics and thermodynamics. In the last decade, he worked on the transport of heat, charge, and spin in solids that harbor either magnetism or topologically non-trivial electrons, e.g. Weyl semimetals.

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