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The Robert W. Courter Seminar Series

3:00-4:00pm, Friday, November 8, 2019
1263 Patrick F Taylor Hall

Extraordinary Heat Transport by Phonons, Electrons, and Spins in Quantum Materials

by Li Shi*

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Efficient heat transport materials have been pursued over centuries for addressing various technological challenges in society. It is known that simple crystals made of strongly bonded light elements can yield a high thermal conductivity contribution from phonons, the energy quanta of lattice vibration. Following these long-held criteria, diamond and graphite exhibit record-high thermal conductivities that are much larger than typical values for metals, where the electronic contribution to the thermal conductivity is dominant and proportional to the electrical conductivity according to the Wiedemann-Franz law. Here we show experimental results that have validated a proposed phonon band engineering approach to achieving unusual high lattice thermal conductivity in semiconducting boron arsenide (BAs), which contains both light boron and heavy arsenic atoms. In addition, our electronic thermal transport measurements of graphene reveal that the Wiedemann-Franz law is violated at low-temperatures by electron-electron interaction and at high temperatures by inelastic electron-phonon scattering, and is recovered at intermediate temperatures due to quasi-elastic electron scattering by low-frequency flexural phonon modes. Meanwhile, the spin degree of freedom can carry a surprisingly high heat flux according to our measurements of spin-heat coupling in spin ladder compounds and across the interface between a heavy metal and a magnetic insulator.

* Li Shi has taken a tortuous path to become both a thermal engineer and a materials physicist. His academic training included a bachelor degree in thermal engineering from Tsinghua University, a master degree and a doctoral degree in mechanical engineering, respectively, from Arizona State University and University of California at Berkeley, where he learned from several inspiring condensed matter physicists. He explored industrial research in an electrical power research institute in China before pursuing graduate studies in the US. He was an IBM Research Member for a year before joining the University of Texas at Austin as an assistant professor in 2002, followed by appointments to the BF Goodrich Endowed Professorship in Materials Engineering and the Temple Foundation Endowed Professorship. His research has been recognized by several awards, including young investigator awards from US National Science Foundation and Office of Naval Research, the O'Donnell Award in Engineering from the Academy of Medicine, Engineering, and Science of Texas, and the Heat Transfer Memorial Award in Science from the American Society of Mechanical Engineering (ASME). He is an elected fellow of ASME and American Physical Society (APS).