Abstract: The electronic states of materials have an intrinsic angular momentum known as “spin”. The coupling between diffusive currents of spin and heat in materials is the basis of the emerging field of “spin caloritronics”. Analogous to a thermocouple where a temperature difference produces a voltage that can be used to measure temperature, heat currents in magnetic materials produce currents of spin that can be used to manipulate magnetization. Our work in this field takes advantage of recent advances in the measurement and understanding of heat transport at the nanoscale using ultrafast lasers. We use picosecond duration laser pulses as a source of heat (the pump) and detect changes in temperature and magnetization using a combination of thermoreflectance and magneto-optic Kerr effect (the probe). Our pump-probe optical methods enable us to generate enormous heat fluxes on the order of 100 GW m$^{-2}$ that persist for ~30 ps.

Spin caloritronics effects can be divided into two broad categories: effects arising from thermal excitations of independent electrons (spin-dependent Seebeck effect) and effects arising from collective excitations of spin waves (spin Seebeck effect). The spin-dependent Seebeck effect of a perpendicular ferromagnetic layer converts a heat current into a spin current, which in turn can be used to exert a thermal spin transfer torque on a second ferromagnetic layer with in-plane magnetization. Using a [Co,Ni] multilayer as the source of spin, an energy fluence of $\approx 4$ J m$^{-2}$ creates thermal STT sufficient to induce $\approx 1\%$ tilting of the magnetization of a 2 nm-thick CoFeB layer. We study the spin Seebeck effect driven by an interfacial temperature difference between electrons in a normal metal (Au or Cu) and spin-waves in a ferromagnetic insulator ($Y_3Fe_5O_{12}$). The spin Seebeck coefficient provides new insights on the coupling of excitations across material interfaces.

Biography: David Cahill is the Willett Professor and Department Head of Materials Science and Engineering at the University of Illinois at Urbana-Champaign. He joined the faculty of the U. Illinois after earning his Ph.D. in condensed matter physics from Cornell University, and working as a postdoctoral research associate at the IBM Watson Research Center. His research program focuses on developing a microscopic understanding of thermal transport at the nanoscale; the discovery of materials with enhanced thermal function; the development of new methods of materials analysis using ultrafast optical techniques; and advancing fundamental understanding of interfaces between materials and water. He received the 2015 Touloukian Award of the American Society of Mechanical Engineers and the Peter Mark Memorial Award from the American Vacuum Society (AVS); is a fellow of the AVS, American Physical Society (APS) and Materials Research Society (MRS); and a past-chair of the Division of Materials Physics of the APS.