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Acoustic waves and thermal transport at the nanoscale probed by short-wavelength light

Complex material systems with nanometer scale feature sizes can exhibit exotic properties and behaviors beyond what is possible in bulk materials due the increased influence of surfaces, geometry, and interfaces. Moreover, conventional macroscopic models of materials often fail to accurately describe these systems physical behavior and predict their functional properties. Fortunately, quantum-enabled, short-wavelength light sources offer a unique window into energy flow on its intrinsic length- and time-scales. In this seminar, I will discuss novel techniques based on short-wavelength light sources to excite and probe nanoscale acoustic waves. We use these waves to understand the influence of dopants and surfaces on the properties of new semiconductor materials used to increase the computer transistor speed and efficiency. We extend this technique to characterize the structural and elastic properties of complex 3D nanostructured materials. I will also highlight how short-wavelength-based techniques uncover counter-intuitive behaviors of heat flow on nanoscale dimensions, that cannot be describe by traditional theories. Using this data, we validate and develop advanced theoretical approaches of thermal transport—including predictive models based on hydrodynamic-like transport—providing new understanding of heat flow in complex material systems for applications in thermal management of novel devices. By utilizing short-wavelength-based techniques in combination with electron microscopy and traditional measurement tools and in collaboration with theory, we can gain a better fundamental understanding of material physics to guide next-generation nano- and quantum technologies.

Short Bio

Joshua L. Knobloch is a postdoctoral research associate at JILA and the University of Colorado Boulder in the research group headed by Professors Margaret Murnane and Henry Kapteyn. He received his B.S. degree (2014) from Purdue University in physics honors and core mathematics and his Ph.D. (2020) from the University of Colorado Boulder in physics. He was the recipient of the Semiconductor Research Corporation Education Alliance graduate research fellowship. His current research focuses on utilizing tabletop coherent sources of extreme ultraviolet light to gain novel insight into heat flow, mechanical properties, and energy transport in complex nanostructured materials. He is also a part of the STROBE NSF Science and Technology Center, led by Prof. Margaret Murnane, dedicated to advancing imaging science technologies and capabilities.