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Current Understanding and Unsolved Problems in the Thermal Conductivity of Materials

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Thermal conductivity is a basic and familiar property of materials: silver spoons conduct heat well and plastic does not. High thermal conductivity is desirable for heat exchangers and thermal management while low thermal conductivity is needed for thermal insulation. In recent years, the combined efforts of materials scientists, engineers, physicists, and chemists have succeeded in pushing back long-established limits in the thermal conductivity of materials. Advances in experimental methods, e.g., time-domain thermoreflectance and thermo-optic phase spectroscopy have expanded the range of materials that can be studied with high throughput and high accuracy. Theory and computation are playing an increasingly important role in guiding and interpreting experiments. In this lecture, I will highlight recent discoveries of extremes of thermal conductivity of materials using examples from hard and soft matter (cubic boron arsenide, ultra-high molecular weight polyethylene, disordered layered 2D materials, functional fullerenes) and our work on expanding the upper and lower limits of the thermal conductivity of polymers.