Controlling Thermal Radiation for Energy and Information Applications

Linxiao Zhu
Postdoctoral Research Fellow
Department of Mechanical Engineering
University of Michigan
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Abstract

Thermal radiation plays important roles in energy conversion processes. The capability to tailor thermal radiation using nanomaterials and photonic structures can represent important opportunities for energy and information applications. In this seminar I will talk about my recent studies on controlling thermal radiation for energy harvesting, active refrigeration, and passive cooling.

First, I will discuss experiments on energy conversion based on nanoscale radiative heat transfer [1-2], which point to new opportunities for thermal energy harvesting. Specifically, I will describe an experiment on nanogap near-field thermophotovoltaics [2], where I demonstrated that the power generation rate can be greatly enhanced (40-fold) by reducing the distance between a hot thermal emitter and a photovoltaic cell to the nanoscale.

Second, I will describe a first experimental demonstration of active photonic refrigeration using incoherent light – thermal radiation, through control of the chemical potential of photons [1]. I will illustrate how net cooling on a surface can be obtained, by placing it in close proximity of a reverse-biased light emitting diode. The cooling arises due to a combination of suppressed thermal radiation from the reverse-biased diode, and enhanced photon emission from the surface across nanoscale gaps. This points to a promising way for solid state refrigeration by combining nanophotonics and optoelectronic devices.

Third, I will discuss how one can use the cold outer space [3-4] as a thermodynamic resource for passive cooling and energy efficiency applications. I will show results of lowering the temperature of a solar absorber by 13 °C while maintaining its sunlight absorption, pointing to a significant efficiency improvement for solar cells [3]. I will next show results of achieving a record-setting temperature reduction as large as 42 °C [4], by using ultra-selective thermal emitter and a vacuum system. Finally, I will give an overview of my future research directions.

Biography

Dr. Linxiao Zhu received his Ph.D. in applied physics and M.S. in electrical engineering, both from Stanford University, and a B.S. degree in physics from the University of Science and Technology of China. His doctoral research is on controlling electromagnetic heat transfer using photonic structures, supervised by Prof. Shanhui Fan. Dr. Zhu is currently a postdoctoral research fellow with Prof. Pramod Reddy and Prof. Edgar Meyhofer in the Department of Mechanical Engineering at the University of Michigan, working on the experiments of near-field based energy conversion. Dr. Zhu is interested in controlling light and heat for energy and information applications. He has been honored in MIT Technology Review 35 Innovators Under 35 (China 2019). His research has received media coverage such as in Discover, Scientific American etc.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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