Abstract

Research Objective: We seek to significantly advance the capability for arbitrary control of the flow of light and heat, beyond the conventional constraints, through the developments of meta-photonics concepts.

Technical Approach: Our program is centered around two thrusts. In Thrust 1, we will develop the concept of photonic gauge potential, which arises from photonic structures undergoing refractive index modulation, as the mechanism to achieve non-reciprocal light flow in real space, and in a synthetic space with a frequency dimension in order to manipulate the spectrum of light. We will also develop large-scale numerical techniques that enable first-principle simulations and optimizations of dynamic meta-photonic structures. In Thrust 2, we will explore thermodynamics of meta-photonic structures. We will build upon our recent demonstrations of day-time radiative cooling and develop photonic structures with ultra-broad-band spectral control spanning both solar and thermal wavelength ranges. Also, while most design of thermo-photonic structures are fundamentally constraint either by local thermal equilibrium conditions or by reciprocity, we propose to explore structures that are not subject to these constraints in order to create new capabilities for thermal radiation control.

Anticipated Outcome and Impact of Proposed Research: The vast majority of current work on photonic structures is constraint by reciprocity. Exploring non-reciprocal structure will enable the control of the flow of light in ways that fundamentally cannot be achieved in reciprocal structures. Similarly, our work on thermal photonic structures explore the interdisciplinary area between photonics and thermodynamics. The research aiming at developing non-equilibrium thermal photonic structures will result in novel mechanisms for controlling photon-based heat flow that cannot be achieved in equilibrium systems. The success of our program will significantly advance the fundamental science of photonics and thermodynamics, and also impact a number of technological areas of critical importance for DoD such as energy and information technology.

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