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Project Abstract/Summary
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We propose to introduce and develop entirely new platforms of functional materials and structures for manipulating light, sound, and heat in unprecedented ways, with goals of achieving exciting functionalities for the future optical devices, acoustic and phononic components, and thermal elements. Building on our three-decade experience in electromagnetic materials, we will explore novel approaches for controlling and tailoring thermal distributions, acoustic signals, and electromagnetic and optical waves. We will develop novel nanostructures for sculpting photon paths, with potential for optical processing and computing machines at the nanoscale. We will investigate material structures functioning as "*computing nanomachine with photons*" that will "do math with light". Based on such nanoscale "photonic calculators", we will develop materials that will solve equations with light, and will investigate structures that will do photonic cryptography. We will also develop "photon traffic lights" at the nanoscale for photon traffic control in topologically protected photonic networks. Inspired by the notion of optical asymmetry in electrodynamics, we plan to investigate how we can utilize novel materials and structures to select thermal emission directivity, modify symmetry in thermal distributions, and consequently to "steer heat" in particular directions and channels, with potentials towards thermal management. Analogous to topological insulators in quantum electronics, we will explore the possibility of "*topological phonon/sound insulators*", in which the phonons and sound are distributed at the interface states with little diffusion/penetration into the bulk states, immune to scattering from defects. In all our projects, we will utilize advance theoretical methods, highly efficient computational and simulations tools, and state-of-the-art proof-of-the-concept experimentations. Our research program will lead to new platforms for light-matter, phonon-matter, and heat-matter interaction, with exciting potentials for optically, acoustically and thermally managed environments, and with revolutionary impacts at the forefronts of fundamental knowledge in functional materials for the long-term defense and national security needs.