

## **Thermal Fluctuations and Radiative Heat Transfer in Inhomogeneous and Nonlinear Nanostructured Materials**

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We describe novel theoretical techniques for modeling and understanding the radiative properties of highly inhomogeneous and nonlinear nano-structured materials. To begin with, we demonstrate that powerful methods based on the volume-integral formulation of electromagnetic scattering can be readily extended to study not only thermal radiation, but also fluorescence and spontaneous emission from wavelength-scale bodies with large thermal gradients and/or inhomogeneous dielectric permittivities. We show that if properly formulated, the volumetric scaling of these methods is not an impediment to large-scale thermal radiation calculations of bodies with arbitrary shapes and materials, a consequence of the rank-deficient nature of the underlying scattering matrices. Moreover, we demonstrate that one can exploit these techniques to obtain the far-field modal contributions to the thermal radiation of complex bodies, paving the way for potential design methodologies that exploit robust and increasingly powerful large-scale optimization techniques. We illustrate these features by presenting results in a number of new structures. Time permitting, we will switch gears and describe an entirely different set of problems involving nano-structured materials designed to enhance the interaction of thermal radiation with material nonlinearities. Such materials can no longer be described via the well-known fluctuation–dissipation theorem of linear materials, and can lead to various temperature-tunable phenomena, including strong spectral alterations and enhanced thermal radiation at selective wavelengths, even exceeding the black body radiation for bodies out of equilibrium.