Thermal Radiation Spectra of Nanoplasmonic Structures: Simulation, Theory and Application

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Thermal radiation of nanoplasmonic structures can be radically different from that of a blackbody in both near- and far-fields due to the excitation of surface plasmons. To predict the thermal emission spectra of nanoplasmonic structures, we directly solve stochastic Maxwell equations (SME) using the Wiener-Chaos expansion (WCE) method, in which we expand the random thermal current source onto a series of complete and orthogonal modes and simulate the spectra of each mode. For more complicated structures with high-order symmetry, we developed a new degenerate quasi-normal mode (QNM) theory to study the thermal emission spectra. In this theory, we considered the symmetry of a plasmonic structure and expanded the Green's function of the structure onto all possible degenerate modes caused by the symmetry, where the upper limit of the number of degenerate modes is predicted by group theory. From our new theory, we found that the non-orthogonality between two degenerate modes provides an extra channel for near field heat transfer, which can further enhance the near field radiation between two nanoplasmonic structures.