Light localization and collection systems employing micro/nano-spheres

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Abstract

We demonstrate the utility of quasi-analytic calculations to accurately design light localization, collection, and emission systems using dielectric microspheres or metallic nano-spheres.

Dielectric microspheres can focus light in their near field with low divergence, A phenomenon called photonic nano-jets [1]. We have demonstrated the utility of analyzing the properties of these beams in reciprocal space. Notably, one can demonstrate that the illumination of the microsphere by a focused beam already containing large k-vectors enables the suppression the large z-axis extension of the emerging beam [2,3]. These subwavelength properties recommend photonic jets as a useful tool for high resolution nano-particles detection, fluorescence microscopy improvements and nano-patterning. Despite some their highly desirable properties of low loss and high directivity, systems involving dielectric systems are mico-meter scaled and largely limited by diffraction.
Truly sub-wavelength manipulation of light apparently require systems involving localized plasmon resonances.[4-6]. Recent investigations have been undertaken to move the localized EM field in the metallic structure by modulating the frequency, the polarization and more interestingly the phase of the excitation beam [7-11]. These studies nicely demonstrate that basic manipulation of the excitation beam can produce various field distributions in the near field of the metal structure. In this presentation, we demonstrate through simulations how antennas made of spherical nano-particles enable the control of light localization at nanometer scale. We demonstrate that by simply tuning the angle of illumination of an excitation plane wave, one can control the localization of the EM enhancement with a spatial resolution on the order of $\lambda/10$ [12].
An unfortunate drawback of nano-particles, particularly for nano-antenna applications is the high loss intrinsic to plasmonic systems. We address the issue of loss in a variety of antenna configurations and address issues concerning optimizing the directivity of emitted radiation and increasing intrinsic properties of the emitter such as its quantum efficiency [13].

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