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Project Abstract/Summary:

The proposed research is to develop new concepts to create new functional materials using light shaped by optical phase and polarization (in space and time) that tailor meso-scale electrodynamic interactions amongst the constituent nanoparticle (NP) elements. The research is at the nexus of nanoscience and photonics. The proposed research builds on recent work in Scherer's lab that has elucidated the "rules" for optical trapping of a range of metal NPs (e.g. spheres, cubes, bipyramids, rods, wires). More importantly, it builds on the electrodynamic interactions, termed *optical binding*, amongst these metal NPs in shaped optical fields. Optical binding is a surprisingly under-developed topic in electrodynamics. The proposed research will use these new insights in more advanced light shaping and interferometry configurations to: (1) create self-organized 3-D arrays of electrodynamically interacting metal NPs and semiconductor Q-dots with meso-scale spacings for fundamental studies in quantum optics (e.g. Purcell effect, creating photonically dark cavities); (2) enable phonon-free photon absorption across the indirect bandgap of Silicon for enhanced detector sensitivity; (3) create meso-scale arrays of nanoparticle-based metamaterials (MM) and advance both the chemical synthesis of the nano-MM elements and their ordering and interactions in 3-Dimensions (3D); (4) use optical beam phase shaping in conjunction with interferometric multi-beam geometries to create interference antinodes with 3-D shapes such as hemi-spheres, parabolas, chiral helicoids etc. that serve as the templates for self-organization of *optical matter*-based optical elements. This last objective will combine elements of the preceding ones for creating micron- to macro-scale shaped materials with plasmonic or hybrid exciton-plasmonic or MM functional attributes. These optical matter materials, to be created in solution to allow self-organization and correction of defects, can be fixed in space (by photopolymerization) and used in novel detector and sensing applications and would be a significant advance toward creating "cloaking" materials and coatings.