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Electromagnetic Properties of Complex Metamaterials: From Near Field Imaging with Super Resolution to Mimicking Celestial Phenomenon in Laboratory Conditions

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Summary

This talk will first review the physical principles behind the possibility to implement metamaterials for imaging with unsurpassed optical resolution. A novel type of media will be proposed that allows the guidance of deep sub-wavelength beams of light over large distances under minimal transmission losses. This optical transformer can operate in any spatial dimensions and could be used for near field lithography or far field optical imaging with resolution up to $\lambda/30$. Next, the first theoretical prediction of sub-wavelength discrete solitons in nonlinear metal-dielectric waveguide arrays (MDWGA) is to be presented. These solitons result from the three-fold interplay between periodicity, nonlinearity, and surface plasmons tunneling in nano-scaled nonlinear metallic waveguide array and display anomalous behavior, comparing to conventional lattice solitons. Specifically, the dispersion band for the MDWGA is opposite to that of the pure dielectric waveguide arrays displaying negative (anomalous) curvature at the band center. The anomalous diffraction due to surface plasmon polariton tunneling between neighboring waveguides can be arrested by moderate optical Kerr nonlinearity leading to lattice solitons with sizes substantially smaller then the diffraction limit in the media. To the best of our knowledge this is the first sub-wavelength bulk solitons demonstrated so far and may serve as a benchmark not only for fundamental studies in non-linear optics but also for a range of practical applications.

Finally, a new direction for the development of the area of metamaterials is proposed that is to mimic with photons celestial phenomenon such as orbital motion, light trapping and formation of chaos. Specifically, realistic metamaterial designs will be presented that provide laboratory environments for studies of light in close proximity to massive objects and in particular Schwarzschild black holes. Revision of the Bertrand theorem for the stability and closeness of orbital motion for photons will be presented with important ramifications for development of highly stable photonic traps and cavity lasers.

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