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Nonlinear light-matter interactions in engineered optical media[1]

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In this talk, we consider fundamental optical phenomena at the interface of nonlinear and singular optics in artificial media, including theoretical and experimental studies of linear and nonlinear light-matter interactions of vector and singular optical beams in metamaterials. We show that unique optical properties of metamaterials open unlimited prospects to "engineer" light itself. Thanks to their ability to manipulate both electric and magnetic field components, metamaterials open new degrees of freedom for tailoring complex polarization states and orbital angular momentum (OAM) of light. We will discuss several approaches to structured light manipulation on the nanoscale using metal-dielectric, all-dielectric and hyperbolic metamaterials. These new functionalities, including polarization and OAM conversion, beam magnification and de-magnification, and sub-wavelength imaging using novel non-resonant hyperlens are likely to enable a new generation of on-chip or all-fiber structured light applications. The emergence of metamaterials also has a strong potential to enable a plethora of novel nonlinear light-matter interactions and even new nonlinear materials. In particular, nonlinear focusing and defocusing effects are of paramount importance for manipulation of the minimum focusing spot size of structured light beams necessary for nanoscale trapping, manipulation, and fundamental spectroscopic studies. Colloidal suspensions offer as a promising platform for engineering polarizibilities and realization of large and tunable nonlinearities. We will present our recent studies of the phenomenon of spatial modulational instability leading to laser beam filamentation in an engineered soft-matter nonlinear medium. Finally, we introduce so-called virtual hyperbolic metamaterials formed by an array of plasma channels in air as a result of self-focusing of an intense laser pulse, and show that such structure can be used to manipulate microwave beams in a free space.

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