Nonreciprocal subwavelength optical nanoantennas

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Optical nanoantennas have recently become an active field of research, offering a number of potential applications, including sensing, lasing, photovoltaics, and medical treatment. The functionality of an antenna is determined by the ability of a dynamic tuning of its radiation pattern, i.e. active beam steering, and on the ability to differentiate between transmitted and received signals. At microwave frequencies these conditions are achieved by the use of complex electronic and modular systems, for example, with the help of phase array antennas, or by applying signal processing tools. However, at optical frequencies such as visible, IR and THz wavelengths these well known techniques are not readily applicable. Furthermore, it is highly desirable to keep optical antenna dimensions below the subwavelength limit. Utilizing material response in optical nanoantenna engineering might provide additional degrees of freedom. In particular, magneto-optical materials provide additional nonreciprocal coupling between electric field components and can be tuned by an applied magnetic field.

In this work using analytical methods and numerical simulations we demonstrate that merging the magneto-optical response with the plasmonic subwavelength nanoantennas leads to novel and interesting effects. In particular, we show that at certain conditions plasmon excitation in a nanoantenna in presence of magneto-optical activity provides a significant symmetry breaking, implying an essential tilt of antenna far- and near-field field patterns. We study the mechanism of such symmetry breaking and predict conditions for which such a magneto-optically induced symmetry breaking is enhanced with plasmonic fields. We theoretically show that the rotation of the radiation patterns can be sizeably altered with the variation of magneto-optical activity. Furthermore due to the essential break of time reversal symmetry we demonstrate that in such an optical plasmonic antenna the transmission and reception radiation patterns differ significantly. The observed effect allows achieving nonreciprocal beam steering in nanoantennas with dimensions essentially smaller than the operating wavelength.