Spin-orbit Interaction Enabled Non-resonance Optical Chirality

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Abstract— Since the discovery of optical activity in quartz crystal in 1811, the concept of chiroptical resonance has been applied to explain most of the unusual responses of both natural substances and artificial materials to left and right circularly polarized (LCP and RCP) light illumination, typically including intrinsic and extrinsic chiroptical effects. The intrinsic optical chirality requires a chiral resonance-eigenmode, i.e., chiroptical resonance, while the extrinsic optical chirality arises from the combination of achiral resonance eigenmodes of different phases. In this work, we report a new mechanism of optical activity, termed non-resonance optical chirality, which originates from the enhanced photonic spin-orbit coupling effect (PSOC) in nanophotonic structures. This non-resonance chiroptical effect requires a well-designed structural symmetry and a specific illumination configuration, where one part of the structure acts as a director to generate a spin-locked electromagnetic field under specific illuminations, and the other part acts as an acceptor to catch this field or not, leading to a spin-dependent interaction between light and structures. We demonstrate this new type of optical chirality in a series of non-resonant chiral metasurfaces with unit cells consisting of two asymmetrically arranged patchy metal particles on a dielectric microsphere, exhibiting a spin-dependent g-factor as large as ~ 0.55. The discovery of such non-resonance optical chirality will open up a new avenue for high-performance CMs and their applications in chiral nanophotonics, such as polarization optics and chiral biosensor.

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