Manipulating surface waves and nanoscale torques with nonreciprocal platforms

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Unidirectional surface plasmon polaritons (SPPs) on nonreciprocal material platforms are currently the subject of significant interest and some controversy. It has been known for several decades that, at the interface between a magnetized plasma (a nonreciprocal gyrotropic medium) and an isotropic material, unidirectional surface waves can emerge under certain conditions and in certain frequency ranges. Renewed interest in this topic has been motivated by the emerging field of topological wave physics and its implications in different areas of science and engineering, for example to realize robust-to-disorder classical or quantum light-matter interactions.

Different approaches exist to realize unidirectional surface-wave propagation, also depending on the exact meaning of "unidirectionality" in a given context: backscattering immunity, one-way excitation/propagation, directive diffractionless propagation, etc. (we also note that breaking reciprocity is not always necessary to achieve some forms of unidirectional propagation). In this work, we discuss how to realize unidirectional surface plasmon-polaritons both in the sense of one-way excitation of surface waves, and in the sense of directive diffractionless propagation along the surface. We choose a magnetized plasmonic material as a model system to study the impact of strong and weak forms of nonreciprocity, hyperbolic and elliptical modal dispersion, and emitter polarization on the surface-wave propagation properties. In the second half of our talk, we study the effect of this unidirectional electromagnetic environment on the source/emitter itself. It is well established that SPP modes carry angular momentum, in addition to linear momentum, originating from their electric field elliptical polarization. Due to the inherently asymmetric SPP excitation in our nonreciprocal platform (i.e., asymmetric release of angular momentum), a generic near-field emitter would experience a torque due to momentum conservation (electromagnetic recoil torque), acting to change the emitter orientation. We thoroughly discuss the interaction of the emitter with a gyrotropic platform supporting unidirectional diffractionless SPP beams, and we demonstrate the emergence of strong non-trivial optical torques and the existence of equilibrium directions along which the emitter spontaneously tends to align.