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Topological non-Hermitian origin of surface Maxwell waves

Franco Nori

RIKEN, Saitama, Japan, and The University of Michigan, Ann Arbor, USA

In 2018, the group of Federico Capasso published this very interesting work: "Three-Dimensional Measurement of the Helicity-Dependent Forces on a Mie Particle.", Phys. Rev. Lett. 120, 22. physrevlett.120.223901.pdf. That work showed that a Mie particle in an evanescent field ought to experience optical forces that depend on the helicity of the totally internally reflected beam. We will provide a summary of the theory work leading to these discoveries.

More than 60 years ago it was shown that interfaces between optical media (including dielectrics, metals, negative-index materials) can support surface electromagnetic waves, which now play crucial roles in plasmonics, metamaterials, and nano-photonics. We have shown that surface Maxwell waves at interfaces between homogeneous isotropic media described by real permittivities and permeabilities have a topological origin explained by the bulk-boundary correspondence. Importantly, the topological classification is determined by the helicity operator, which is generically non-Hermitian even in lossless optical media. The corresponding topological invariant, which determines the number of surface modes, is a $Z4$ number (or a pair of $Z2$ numbers) describing the winding of the complex helicity spectrum across the interface. Our theory provides a new twist and insights for several areas of wave physics: Maxwell electromagnetism, topological quantum states, non-Hermitian wave physics, and metamaterials.

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