Geometric Phase-driven Scattering Evolutions

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Abstract— We discover a novel form of geometric phase in scattering systems and establish a comprehensive framework of explicit formulations and applications for it.

Conventional approaches for scattering manipulations largely rely on the technique of field expansions into spherical harmonics (electromagnetic multipoles), which nevertheless is not only non-generic (expansion coefficients depend on the origin position of the coordinate system) but also more descriptive than predictive.

Here we explore this classical topic from a different perspective of controlled excitations and interferences of quasi-normal modes (QNMs) supported by the scattering system. Scattered waves are expanded into coherent additions of QNMs, among which the relative amplitudes and phases are crucial factors to architect for scattering manipulations. Relying on the electromagnetic reciprocity, we provide full geometric representations based on the Poincaré sphere for those factors, and *discover the hidden geometric phase of QNMs* that drives the scattering evolutions. Further synchronous exploitations of the incident polarization-dependent geometric phase and excitation amplitudes enable efficient manipulations of both scattering intensities and polarizations. Continuous geometric phase spanning 2π is directly manifest through scattering variations, even in the rather elementary configuration of an individual particle scattering waves of varying polarizations.

We have essentially established a profoundly all-encompassing framework for the calculations of geometric phase in arbitrary scattering systems that are reciprocal. Our theoretical model will greatly broaden horizons of many disciplines not only in photonics but also in general wave physics where geometric phase is generic and ubiquitous.

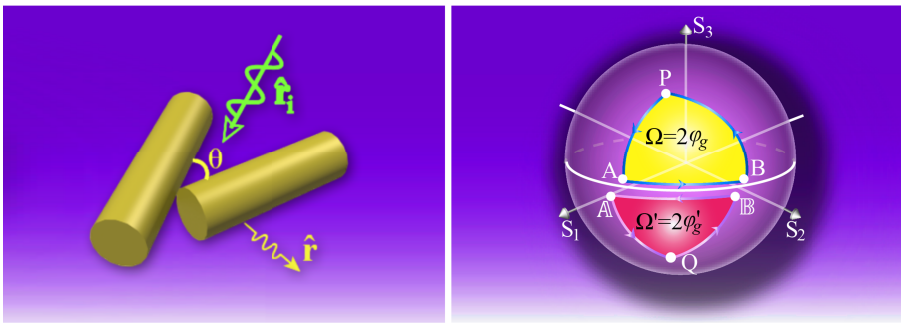

Figure 1: Geometric representations on the Poincaré sphere for the geometric phases underlying a scattering process. Two sorts of geometric phases emerge: one (Ω) incuded by the incident polarization projection and the other (Ω') induced by the final scattering polarization projection.

REFERENCES

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