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Aspects of non-reciprocity and spatial symmetry in scattering and extinction of arbitrary-shaped objects

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When a material object is exposed to an electromagnetic or optical wave, the scattered power density in the far field depends, in general, on the direction of both the incident and scattered fields as well as the polarization state of the incidence. Integrating the scattered power over all directions results in the scattering cross section of the object, a measure how much of the incident power will be lost to scattering. However, this quantity still depends on the two angle parameters that define the direction of the incident wave, and also on its polarization. In cases where material losses are generated in the scatterer, the description has to be supplemented with the absorption cross section of the scatterer. When this is added to the scattering cross section, the result is a quantity called extinction cross section.

A fundamental observation in this context is that if a scatterer is illuminated from opposite directions with the same polarization, the two extinction efficiencies are the same [1]. (For circularly or elliptically polarized incidences, this means that also the handedness is the same: if the incident field is right-handed, also the reversed one has to be right-handed.) This equality of extinctions happens despite the fact that for the two scattering constellations with opposite incidences, the near fields (and also far fields) can be very different for objects of complicated shape [2]. A corollary of this *extinction invariance* or *extinction symmetry* is that for lossless objects, the scattering efficiencies are equal for opposite illuminations, while for a dissipative object (with non-zero absorption cross section), this is not the case: there, only the extinction efficiency remains the same.

Extinction symmetry is valid for dielectric, magnetic, lossy, and anisotropic scatterers. This presentation searches for conditions when it no longer holds. By computational examples, it will be demonstrated how scatterers characterized by non-reciprocity (gyrotropical or made of perfectly electromagnetically conducting (PEMC) material [3]), along with sufficient spatial non-symmetries will lead to broken extinction invariance.

References

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