

Rich Physics of Collective Mie Resonances

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Abstract: Mathematically, the sum of the infinite series $\sum_{n=1}^{\infty} \frac{1}{n}$ diverges to infinity despite the fact that the additive term $\frac{1}{n}$ converges to zero when n increases to infinity. On contrary, the sum of $\sum_{n=1}^{\infty} \frac{1}{n(n+1)}$ converges to one when n increases to infinity. In mathematical modelling of electromagnetic scattering problems, sums of infinite series appear ubiquitously, especially in the theory of multiple resonant scattering. In this presentation, based on exact analytical solutions to the Maxwell equations that govern the electromagnetic scattering by a cluster of spherical particles, we interpret different electromagnetic scattering phenomena by close analogies with the above two diverging and converging sums. For single spherical particles, the stationary scattering phenomenon can be accounted for by the Mie scattering coefficients but one must invoke infinite Debye series to account for the dynamics of the scattering phenomenon. We show that the sum of the infinite Debye series converges to the corresponding Mie scattering coefficient. For a cluster of spherical particles, we show that the collective behavior of the cluster would result in an infinite series of scattering events corresponding to a mathematical sum diverging to infinity when the number of particle increases to infinity. This collective response of the particle cluster results in collective Mie resonances. In the framework of these collective resonances, we present design concepts for photonic and plasmonic high-performance nano-cavities, including gap modes, collective Mie resonances, Feshbach-type BIC modes, photonic-crystal flat bands.

References

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