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Light interaction with resonance

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Thanks to an efficient and intuitive quasi-normal mode formalism valid for micro and nanoresonators made of dielectric as well as lossy and dispersive materials, we shine new light on the physics and modelling of light interaction with electromagnetic resonances [1]. In particular in the present context, we will discuss the role of quenching for light emission in metallic nanogap devices and will revisit the perturbation theory of electromagnetic resonance.

Simply because they enhance the electromagnetic field, micro/nano resonators play an important role in modern photonics. Perhaps they are as important as waveguides. A resonance mode is a solution of Maxwell's equations without source with a complex frequency, and the resonance quality factor Q equals the ratio between the real and imaginary parts of the frequency.

However, the maturity level of the theory and computation of resonances is ridiculously small compared to that reached for waveguides (see, e.g., the books by Marcuse, Snyder and Love, Vassalo …). As a matter of fact, very few scientists in nanophotonics and optics would be able to calculate and properly normalize the resonance modes with a complex frequencies.

As the frequency is complex, the resonance field exponentially diverges as the distance r to the resonator increases, exp(ikr) $\rightarrow\infty$ since k=w/c is complex, making a mode normalization difficult. We have recently challenged the longstanding normalization issue of resonance modes, and have been able to define (properly?) the "famous" mode volume [1].

Thanks to this theoretical upstream work, we explain why an emitter placed in a metallic nanogap (thickness < 10 nm) does not quench much despite the small distance to the metal, and the consequences for nanogap antenna [2] and revisit perturbation theory of resonator [3].

References

[1] C. Sauvan, J. P. Hugonin, I. S. Maksymov, and P. Lalanne, *Theory of the Spontaneous Optical Emission of Nanosize Photonic and Plasmon Resonators*, Phys. Rev. Lett. 110, pp. 237401, 2013
[2] R. Faggiani, J. Yang, P. Lalanne, *Quenching, Plasmonic, and Radiative Decays in Nanogap Emitting Devices*, *ACS Photonics 2* (12), pp 1739-1744, 2015
[3] J. Yang, H. Giessen, P. Lalanne, *Simple Analytical Expression for the Peak-Frequency Shifts of Plasmonic Resonances for Sensing*, Nano Lett. 15 (5), pp 3439-3444, 2015