Quantization of plasmon-polaritons with localized nanostructures

H.R. Jauslin, V. Dorier, J. Lampart, S. Guérin [1]**,**

ICB - Laboratoire Interdisciplinaire Carnot de Bourgogne, Universit Bourgogne Franche-Comt, Dijon, France

We present a new approach to the quantization of the electromagnetic field in configurations involving nanostructures of finite size. The presence of dispersion and dissipation prevents the quantization of the phenomenological Maxwell equations with a space and frequency dependent dielectric coefficient, which is standardly used in the classical treatment of such systems. We follow the approach, started by Hopfield, in which the medium is described by a microscopic Hamiltonian system composed of harmonic oscillators, which interact with the electromagnetic field by a dipole coupling. This type of model was used by Huttner and Barnet [1] to construct a quantum model for a bulk homogeneous. Using techniques developed by U. Fano they diagonalized the Hamiltonian and characterized the plasmon-polariton excitations as the fundamental excitations of the system. This work was later extended to inhomogeneous media [2,3,4] , and applied to the treatment of different phenomena, like the Purcell effect in spontaneous emission or like Casimir effects, among many others. Il was noted by several authors [5,6] that the diagonalization of inhomogeneous systems adapting the Fano technique leads to results that are not consistent when the medium is of finite size. In particular these results do not yield the correct properties when one takes the limit of vanishing size of the medium or of the coupling. It was however not clear what step in the diagonalization procedure is responsible to this apparent contradiction.

We are going to present a different approach to the diagonalization that is conceptually close to the method of Bogoliubov transformations, and which leads to a diagonalization of the quantum plasmon-polariton model that gives a complete result and that yields the correct limit when the coupling vanishes.

References

[1] B.Huttner, S.M.Barnett; Phys. Rev. A 46 (1992) 4306.
[2] L.G. Suttorp, A.J. van Wonderen; Europhys. Lett. 70 (2004) 766.
[3] T.G. Philbin; New J. Phys. 12 (2010) 123008.
[4] W. Vogel, D.-G. Welsch; Quantum Optics; Wiley-VCH, 2006.
[5] O. Di Stefano, S.Savasta, R.Girlanda; J. Mod. Opt. 48 (2001) 67.
[6] A. Drezet; Phys. Rev. A 95(2017)023831.