

Preface

Quantum plasmonics is a very rapidly developing field that emerged recently at the border of two fields, both rich in fundamental physics and highly innovative in technology: quantum optics and plasmonics (the latter can also be viewed as nanophotonics of metal structures).

Nanophotonics concerns with the interaction of nanostructures with light, thereby aiming at providing photonic capabilities at smaller length scales and lower energy requirements. But even more importantly, nanophotonics also aims at engineering the light–matter interaction at unprecedented high strengths and/or subwavelength spatial resolutions. The latter usually involves the use of metals as these support surface electromagnetic modes (known as surface plasmons), which are confined to metal surfaces within subwavelength distances. In the last fifteen years, studies in what became known as “plasmonics” have been concentrated on plasmonic circuits (composed of subwavelength-sized waveguides and waveguide components), optical antennas (as efficient transducers between the far- and near-field wave components, squeezing in volume and boosting up in strength local fields), and surface-enhanced spectroscopic techniques (as “surface plasmon resonance sensing” and “surface-enhanced Raman spectroscopy”), with implications to diverse fields including photonics, optoelectronics, material science, bio-imaging, medicine, and energy.

These research directions continue to flourish but, additionally, plasmonics has now acquired a level of maturity that paves the way toward new venues, notably those involving quantum effects that arise from the interaction between plasmons (understood as quanta of localized or propagating surface plasmon excitations) and quantum systems characterized by a few discrete energy levels, such as molecules or quantum dots. This interaction opens up many different possibilities. Plasmons can be exchanged between quantum emitters, modifying their effective interaction and thus their physical properties. Alternatively, few-level systems can be used to induce efficient plasmon–plasmon interactions, leading eventually to strong non-linear optical properties at the single-photon level. Additionally, when the interaction between plasmons and matter is strong enough, the combined system may acquire completely different (to those of the constituents) properties, opening

new possibilities for the design of materials with novel functionalities. Another important area of research in quantum plasmonics refers not so much to the quantum features of plasmons, but to the influence of electron tunneling in the optical response of plasmonic nanostructures. This aspect, usually termed as “quantum effects in plasmonics,” has a paramount importance in the properties of metal structures containing nanometer-sized gaps.

After a rapid initial evolution of quantum plasmonics [1], it became clear in 2014 that there is a need for a monographic workshop that would bring together researchers, belonging to different communities and covering various aspects of this nascent field. In 2015, we undertook this task and launched a workshop in the “Centro de Ciencias” in the beautiful village of Benasque, located in the heart of the Spanish Pyrenees. The success of the workshop, being reflected both in the quality of presentations and in the spirit of scientific discussions, indicated the aptness and importance of putting together the present state of the art in an easy-to-access manner. The same motivation has also been the origin of this book that, although not being a book of conference proceedings, is a compilation of the research done by several of the more representative groups attended the 2015 Benasque meeting.

This book addresses the following aspects:

- (i) Quantum optics in the few-emitter and few-plasmon limit (Chaps. 1–4).
- (ii) Single-photon sources and nano-lasers based in metal structures (Chaps. 5 and 8).
- (iii) Polariton condensation and collective strong coupling between organic molecules and nanophotonic structures (Chaps. 6 and 7).
- (iv) Plasmon-enhanced effects in Schottky and tunnel junctions (Chaps. 9 and 10).
- (v) Non-local effects in metamaterials and metal nanostructures (Chaps. 11–13).

Understanding of quite complicated topics covered by these chapters requires certain knowledge of the fundamentals that can be refreshed by making use of recent introductory textbooks [2–6].

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