Exploiting and Engineering non-Hermiticity in Photonics

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Abstract: The non-Hermiticity is an unavoidable feature of any photonics system based on sound models and experiments. It has been used for mapping and optimizing the Q factor of photonic modes. Here we discuss its exploitation for engineering three effects: i) exciton light traps via radiative Lamb shift, ii) Purcell effect beyond the dipole approximation and iii) shaping the Fano LDOS via engineering the cavity losses.

At the basis of many relevant photonic accomplishments is the control of the lineshape and spatial extension of the photonic local density of states (LDOS) and consequently the manipulation of any light-matter interaction process. The so-called Purcell effect, i.e. the enhancement of the spontaneous emission rate is controlled by the quality factor (Q) and the modal volume (V) of the microresonators [1]. Important progress has been achieved on the description of photonics as a non-Hermitian open system by means of quasi normal modes (QNMs) with complex eigenvalues, which has led to deep modification of the common picture for V [2]. The complex-valued character of V, with its imaginary part linked to the non-Hermitian nature of open systems, is now established and experimentally confirmed [3,4]. At the same time, non-Lorentzian LDOS lineshapes have been experimentally observed even in carefully designed photonic systems displaying relatively low optical losses [5]. More recently, the map of the imaginary part of the modal volume has been used for driving the optimization of the in-plane and out-of-plane Q factor of any photonic modes [6].

In this contribution we review three recent achievements where the complex modal volume is engineered and exploited: i) enhancement and control of the Lamb Shift for exciton light trapping [7], ii) tailoring the CDOS for shaping the Purcell effect beyond the dipole approximation [8] and iii) controlling the in-plane losses for shaping the Fano LDOS [9].

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