Fluctuations in light-matter interaction: black swans and parallel states

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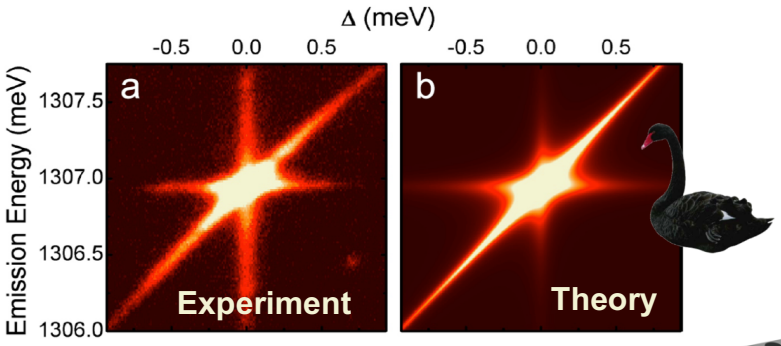
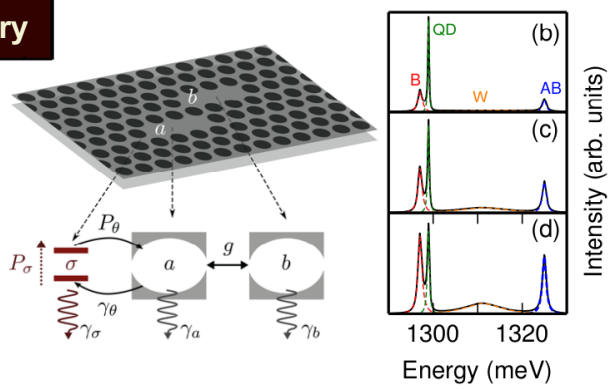
We will unravel the mechanisms behind two experiments from the Walter Schottky Institut in Munich (in collaboration with my group) on the emission of single *quantum dots* (artificial atoms in semiconductor materials) [1,2]. In both cases, exotic peaks were observed in the spectrum of emission at unexpected frequencies and we believe that they are induced by the fluctuations produced by changes in the environment. In this TFM we will describe theoretically (within the *open quantum system* framework, solving a master equation) and simulate (using the *quantum Monte Carlo* method) the dynamics of a quantum dot (modelled by a two-level system or *qubit*) excited by a laser in a fluctuating environment [3]. We will fit and understand the experimental results, which are made at low excitation power, and go beyond, predicting the spectral shapes at high power (some sort of quintuplets). We will propose exciting new experiments to test our theories and possibly take advantage of the, at least in principle, damaging and undesirable fluctuations in semiconductor materials.



Experiment 1:
Quantum dot emission with an unexpected fixed horizontal peak as a function of the laser frequency [1]. This is a ***black swan*** [4], a rare but high-impact event.

Experiment 2:
Quantum dot emission from a photonic molecule (two coupled cavities) with an unexpected "W" peak fixed at the cavity frequency [2]. We see features of both strong coupling between the cavities (peaks B and AB) and weak coupling (peak W), despite being incompatible regimes. Two **parallel states** coexist thanks to fluctuations.



[1] *Fluctuation induced luminescence sidebands in the emission spectra of resonantly driven quantum dots* (arXiv:1207.6952)
[2] *Coexistence of weak and strong coupling with a quantum dot in a photonic molecule* (in preparation)
[3] *Open quantum system approach to single-molecule spectroscopy*, Phys. Rev. A 79, 043804 (2009)
[4] *The Black Swan: The Impact of the Highly Improbable*, N. N. Taleb (2007)