Ultrafast quantum optics

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The enhancement of light emission with optical antennas has gained considerable attention in the recent years across a broad range of areas from biophotonics to quantum optics. Under continuous weak excitation, the fluorescence signal of an emitter coupled to an optical antenna is proportional to the field intensity and to the apparent quantum yield. The latter accounts for the competition between the radiative and non-radiative decay rates, which are strongly modified by the antenna. Extensive investigations have shown that huge field enhancements can coexist with large quantum efficiencies, making these systems appealing for quantum optical applications and single-molecule spectroscopy. On the other hand, time-resolved techniques, such as pump-probe spectroscopy, coherent control and triggered single-photon sources, to mention a few, rely on (ultrafast) pulsed excitation. The immediate question that arises is thus how an optical antenna affects the response of a molecule under laser pulses of various widths, at room and cryogenic temperatures. Here the important points of concern are the competition between decay times, dephasing and pulse width, the increased interaction strength due to field enhancements, and the dispersion occurring when the pulse duration becomes comparable with the lifetime of the antenna resonance. We have performed a detailed analysis of these phenomena and found that pulsed excitation discloses new challenges and opportunities for optical antennas. We present our findings in a context that ties ultrafast nano-optics with quantum-optics.