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Abstract

Spontaneous Emission Spectrum of a WS_2 Monolayer under Strong Coupling Conditions †

Vasilios Karanikolas, Ioannis Thanopulos and Emmanuel Paspalakis *

Materials Science Department, School of Natural Sciences, University of Patras, 265 04 Patras, Greece; karanikv@tcd.ie (V.K.); ithano@upatras.gr (I.T.)

* Correspondence: paspalak@upatras.gr

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Abstract: Two-dimensional materials allow for extreme light confinement, thus becoming important candidates for all optical application platforms. Monolayers of transition metal dichalcogenides are direct band gap semiconducting 2D materials featuring bandgaps in the visible and near-IR range, strong excitonic resonances, and high oscillator strengths, among other properties, as well as supporting exciton polaritons. The optical properties of quantum emitters, such as molecules or quantum dots, near single or multilayer transition metal dichalcogenides have been investigated, where the relaxation rate of the quantum emitter increases or decreases. The studies on the coupled quantum emitter—transition metal dichalcogenides remain so far in the weak light–matter coupling regime. In this work, we study the spontaneous emission spectrum of a two-level quantum emitter near a WS_2 layer, in which case the Purcell factor of the QE can take values up to 10^4. We further study the Rabi splitting in the spontaneous emission spectrum at room temperature for a quantum emitter with free-space decay times in the 10 ps to 500 ps range. We observe that at close distance of the quantum emitter to the WS_2 layer, combined with short decay times, the spectrum can feature several peaks. In such cases, the Rabi splitting lies between 0.25 eV and 0.05 eV for increasing free-space decay times, indicating strong coupling conditions for the light–matter interaction between the quantum emitter and the WS_2 layer. Moreover, no simple relation between the inverse free-space decay time and the corresponding Rabi splitting value has been found. As the distance between the quantum emitter and the layer increases farther, the light–matter interaction coupling enters the weak coupling regime, which leads to vanishing Rabi splitting in the spontaneous emission spectrum for free-space decay times larger than a few tenths of ps.

Keywords: Quantum emitter; two-dimensional material; WS2 layer; spontaneous emission spectrum; Rabi splitting; strong coupling

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