Universal Distance-Scaling of Nonradiative Energy Transfer to Graphene

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Abstract

The near-field interaction between an emitter and a purely two-dimensional material is of great interest since it allows for the exploration of new limits of light-matter interactions. Graphene becomes thus an ideal platform to study these types of interactions [1]. Through lifetime measurements of emitters placed at a distance d from a graphene flake, we observe that due to the two-dimensionality and gapless character of graphene, the near-field nonradiative coupling at distances below 30 nm is greatly enhanced [2]. This enhancement is demonstrated by the strongly modified decay rate of the emitters when placed near the graphene flake, reaching up to 90 times their decay rate in vacuum. Moreover, by measuring the lifetime of the emitters as a function of d (Fig. 1), we show that the behavior is in agreement with a universal scaling law following a d-4 dependence predicted for purely two-dimensional materials. We employ the term universal since we find that the distance dependence of the decay rate is material independent and is governed only by fundamental constants, similar to graphene's universal light absorption reported in ref. 3. Another important aspect that rises from these measurements is that the energy transfer efficiency between the emitters and graphene can reach up to 99% at short distances, making graphene an extraordinary energy sink with promising outcomes for photodetection, energy harvesting and nanophotonics applications.

References

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Figures

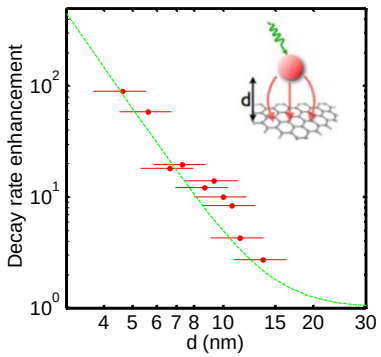

Fig. 1: Decay rate enhancement obtained from lifetime measurements of emitters as a function of graphene-emitter distance, yielding up to a factor 90. The green dashed line represents the analytical model with weighted average over emitter dipole orientations. Insert: schematic representation of the energy transfer between a photo-excited emitter and graphene at a distance d.