Fast dynamic control of emitter-graphene interactions

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The ability to control single-photon emitters through the manipulation of their environment is an important aspect of current nanophotonic research, and highly interesting for many applications, including data communication and quantum technologies. Here we demonstrate that graphene is in many ways an ideal environment, as it enables highly effective and very fast dynamic control of erbium emitters. Erbium emitters are technologically important, as they emit in the C-band of optical communication systems (1.54 microns) and can be used for quantum memories.

We have developed a hybrid erbium-graphene system containing a very thin (~12 nm) layer with erbium emitters having emission properties very similar to emitters in bulk. Graphene is placed directly on top of this thin layer of emitters, and is gate tunable via both a *p*-doped silicon backgate and a polymer electrolyte topgate. In this system, we observe erbium ions with a decay rate that is enhanced by a factor 1,000 and higher, indicating extremely efficient emitter-graphene interaction: 99.9% of the energy of these excited erbium emitters flows to graphene.

Furthermore, we actively and dynamically modulate this interaction using moderate electrical signals (<10 V) that tune the Fermi energy of graphene. The erbium-graphene interactions are thus dynamically modulated between the regime where the emitters lead to interband transitions in graphene, and the regime where they lead to excitation of intraband plasmons. Remarkably, we show modulation frequencies up to 300 kHz, many orders of magnitude faster than the intrinsic decay rate of erbium ions (75 Hz).

This constitutes an enabling platform for integrated quantum technologies, for example opening routes to quantum entanglement generation by collective plasmon emission or photon emission with controlled waveform.

References

[1] D. Cano et al. *submitted*