Towards ultrafast, electrically reconfigurable photonic quantum gates with interacting 'dipolar dressed photons'

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We demonstrate light circuits based on photons confined in planar waveguide geometries that are quantum mechanically hybridized with 2D-excitons. These 'exciton-polariton' quasi-particles can be electrically polarized using electrical gates, allowing formation of polaritons which carry effective dipole moments, leading to 'interacting dipolar photons'. This new concept leads to novel ways to control polariton motion electrically, as well as tuning the position and strengths of their mutual interaction, that can reach surprisingly huge values allowing a two-photon blockade.

A new class of planar waveguide devices are shown, that elucidate the exciting physics that can be explored and the promising quantum-photonic applications that can be developed with such on-chip dipolariton circuits:

- we show that such "dipolar light" can very effectively undergo coherent scattering from local electrical potentials, in a manner consistent with quantum scattering theory of ultra-light dipolar particles beyond the s-wave approximation.
- We demonstrate an ultrafast, electrically-controlled few photon transistor with a GHz switching time, based on enhanced dipolar interactions between slow polaritons.
- Finally, we demonstrate photon correlation measurements of resonantly injected dipolaritons, displaying both anti-bunching and bunching, known as (partial) *photon quantum blockade and anti-blockade*, reconfigured and tuned simply by changing a gate voltage.

Such electrically controlled planar geometry of waveguided dipolaritons is a very promising platform for complex interacting light circuitry for quantum-photonics applications, and in particular for realizing a true universal 2-photon quantum gate, and study quantum manybody dipolar physics, which still hold a few puzzles.

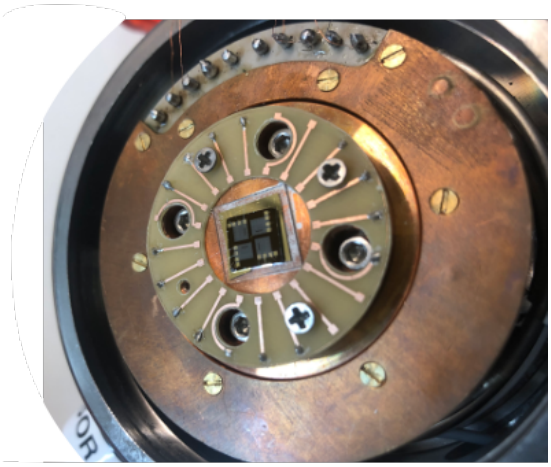

Figure 1: An image of an electrically gated chip that host various dipolar polariton devices based on gated GaAs waveguide photonic hetero-structures.

References

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