Electrically tunable artificial gauge potential for exciton polaritons

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Neutral particles subject to artificial gauge potentials can behave as charged particles in magnetic fields. This fascinating premise has led to implementations of synthetic artificial gauge fields in a number of different optical systems [1-4]. In many cases, however, the design of the optical systems leaves little or no room for fast control of the strength of the artificial gauge field after sample fabrication is completed. On the other hand, it is essential to be able to tune the magnitude of the gauge field during the experiment for many applications [5, 6]. Particularly for the case of nanophotonic structures, fast local control of the gauge field strength may open up new possibilities of investigating many-body physics of light [7].

In this presentation, we report that application of perpendicular electric and magnetic fields can generate a tunable artificial gauge potential for two-dimensional microcavity exciton polaritons [8]. The strength and direction of the artificial gauge potential are controlled electrically. For verification, we perform interferometric measurements of the associated phase accumulated during coherent polariton transport (Figure 1b). Since the gauge potential originates from the magnetoelectric Stark effect, it can be realized for photons strongly coupled to excitations in any polarizable medium. Together with strong polariton-polariton interactions and engineered polariton lattices, we believe that an artificial gauge field could play a key role in investigating non-equilibrium dynamics of strongly correlated photons.

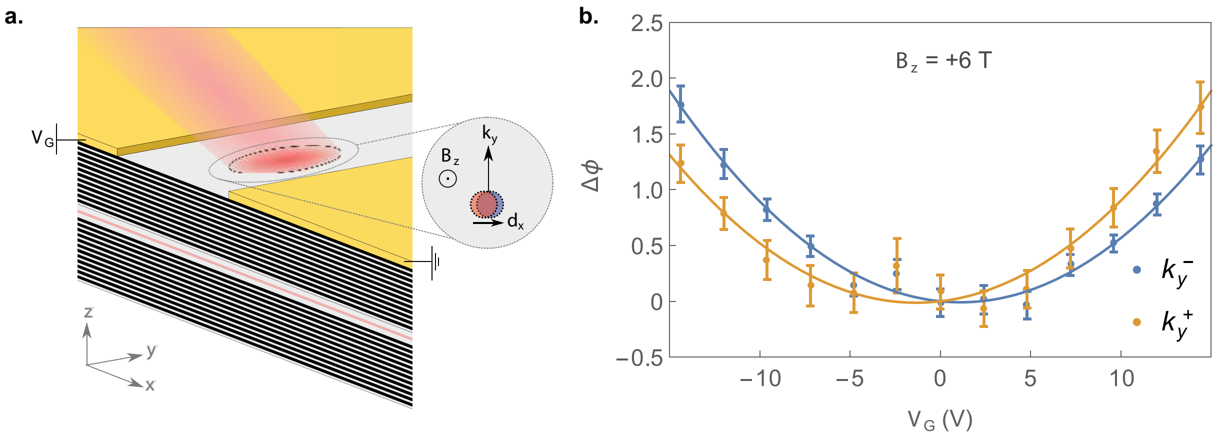

Fig. 1. **a.** The sample, held at 4 K in a helium bath cryostat, contains three $In_{0.04}Ga_{0.96}As$ quantum wells located at an antinode of a cavity formed by two distributed Bragg reflectors (DBRs). An electric potential V_G applied to the metal gates creates an electric field in the x direction. Under a magnetic field along the z direction polaritons excited with in-plane wavevector k_y exhibit a dipole moment d_x. **b.** Change in the extracted phase $\Delta\varphi$ at $B_z = 6$ T between polariton excited with either k_y^+ (yellow) or k_y^- (blue) and the reference beam ($k_y = 0$) as a function of V_G. $\Delta\varphi$ is dependent on both the directions of k_y and B_z.

References

[1] Z. Wang, Y. Chong, J. D. Joannopoulos, and M. Soljacic, Nature **461**, 772 (2009).
[2] M. C. Rechtsman, *et al.*, Nature **496**, 196 (2013).
[3] M. Hafezi, S. Mittal, J. Fan, A. Migdall, and J. M. Taylor, Nature Photon. **7**, 1001 (2013).
[4] N. Schine, A. Ryou, A. Gromov, A. Sommer, and J. Simon, Nature **534**, 671 (2016).
[5] M. Aidelsburger, et al., Phys. Rev. Lett. **111**, 185301 (2013)
[6] G. Jotzu, *et al.*, Nature **515**, 237 (2014).
[7] T. Jacqmin, *et al.*, Phys. Rev. Lett. **112**, 116402 (2014).
[8] H.-T. Lim, E. Togan, M. Kroner, J. Miguel-Sanchez, and A. Imamoglu, Nat. Commun. **8**, 14540 (2017).