Integer quantum Hall effect modified by a tunable cavity

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Quantum Hall effects and cavity quantum electrodynamics are two pillars of modern quantum physics. We recently proposed an experimental platform [1], which allows studying the transport of charged particles strongly coupled to cavity vacuum fields.
By measuring at mK temperatures the linear transport regime, we showed that the amplitude of the Shubnikov de Haas oscillations is modified by the presence of a cavity [1], even without external illumination. We also studied the effects of vacuum field fluctuations on the integer quantum Hall effect, showing a breakdown of most quantized odd plateaus [2] due to cavity-mediated electron hopping [3].
We present here an experiment where we modulate the cavity field by means of a movable metallic plate (Fig.1). This allows to modify the electromagnetic environment and the enhancement of the vacuum fields without changing the properties of the 2D electron gas.
We show (Fig. 2) that the longitudinal resistance exhibits a change at odd integer filling factors for the hall bar immersed in the cavity vacuum fields. The transport properties of a reference hall bar, measured at the same time, on the same chip are not modified.
This platform, offering a more direct way of controlling the vacuum field distribution sensed by the Hall bar, paves the way to experimentally test predictions on the cavity modification of the quantization of the integer Hall effect[4].

References

[1] G.L. Paravicini-Bagliani et al., Nat. Phys, 15.2 (2019) 186-190
[2] F. Appugliese et al., Arxiv, 2107.14145 (2021)
[3] C. Ciuti, Arxiv, 2107.09435 (2021)
[4] V.Rokaj et al., Arxiv, 2109.15075v1 (2021)

Figures

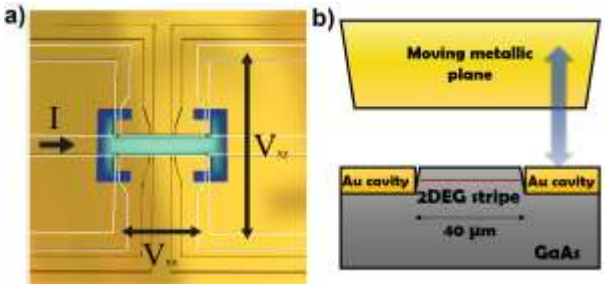

Figure 1: a) representation of the hall bar immersed in the field of a complementary split ring resonator. b) Schematics of the experiment where a movable mirror modifies the properties of the split ring resonator without modifying the 2D electron gas

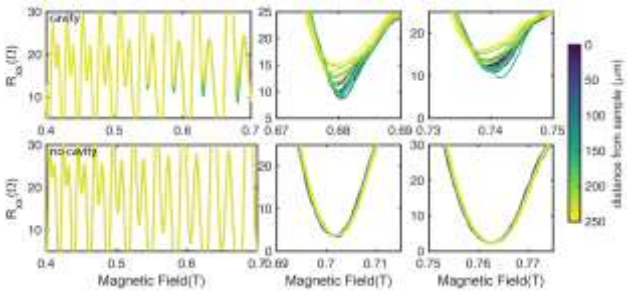

Figure 2: Longitudinal resistance for different positions of the metallic plane. While the reference Hall bar shows no response, a change at odd integer filling factors is visible in the cavity embedded Hall bar.