Controling solid state phases through vacuum fields

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While the effect of vacuum fields on atomic system (such as through the Lamb shift) is well known, there is a recent interest in controlling the many-body phases of solid-state systems using vacuum fluctuations strongly coupled to such a system inside a microcavity. In such a system, the strength of the electric field caused by the vacuum fluctuations, which can be maximized in circuit-based resonators with a scaled down volume to deep subwavelength values. We have used transport to probe the ultra-strong light-matter coupling and shown that the latter can induce a breakdown of the integer quantum Hall effect. We have also explored the effect of a cavity on the fractional quantum Hall effect using a hovering cavity experiments[1] and recently demonstrated the orientation of a stripe phase using an analog to a Casimir torque[2].

[1] Enkner, J. et al. Tunable vacuum-field control of fractional and integer quantum Hall phases. Nature 1–6 (2025) doi:10.1038/s41586-025-08894-3.

[2] Graziotto, L. et al. Cavity QED Control of Quantum Hall Stripes. arXiv.org https://arxiv.org/abs/2502.15490v1 (2025).