# Antidot templates for correlated electronic phases in graphene in the extreme quantum limit

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**Abstract**: High field magnetotransport in graphene antidot devices reveals commensurability peaks, quantum oscillations, and pronounced anomalies at filling ν near and below 1. The observations indicate an interplay between antidot localization, edge-state interference, and interaction-driven correlated electronic phases.

Artificially patterned nanostructures provide a powerful system to control the electron trajectories in two-dimensional electron materials. In graphene, the introduction of antidots generates potential that can markedly modify magnetotransport, particularly in high magnetic fields where the quantum Hall edge states dominate transport. Here we report high field magnetotransport measurements performed on graphene devices patterned with antidots of different diameters and spacing (from 50 to 150 nm).

The measurements were carried out in magnetic fields up to 35 T and temperature down to 80 mK, for several probe configurations crossing the antidot region. At low magnetic fields, the magnetoresistance exhibits oscillations due to quantum commensurability between electron cyclotron orbits and the antidot structure, reflecting the strong influence of the antidot geometry on electron trajectories in the two-dimensional system.

At sufficiently high magnetic fields, B > 5T, the system enters the quantum Hall regime, where the longitudinal resistance goes to zero and the well-defined plateaus develop in the Hall resistance. The ν = 2 and 1 quantum Hall states are clearly observed in both the pristine and antidot regions of the graphene channel, indicating the high quality of the device and the robustness of the quantum Hall effect.

At higher magnetic fields, periodic oscillations emerge in the magnetoresistance measured across the antidot region. The oscillations exhibit approximately constant magnetic field periods, consistent with magnetic flux quantization through effective areas related the antidot dimensions. This behavior indicated that the oscillations originate from quantum interference of edge states moving around localized antidot potentials, analogous to the Aharonov-Bohm oscillations reported in quantum Hall antidot systems, and compatible with interferometric processes involving quasiparticles such as anyons [1]. As the magnetic field increases further and the electrons enters the regime of partially filled Landau levels, strong transport anomalies and enhanced resistance peaks and oscillations develop, with signatures extending toward the fractional quantum Hall regime. In this regime the electron-electron interactions become dominant and the presence of the antidot potential promotes the localization of carriers in the partially filled Landau level. The antidot landscape therefore acts as a template that stabilizes interaction-driven electronic ordering, providing favorable conditions for the formation of correlated insulating phases, pinned by the antidot landscape [2].

In this picture, antidots not only induce quantum interference effects, but also promote the stabilization of collective electronic states in the extreme quantum limit [3].

**References**

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