# Artificial electrostatic crystals: a new platform to studying novel electronic phases

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The electronic properties of solids are determined by the crystal structure and interactions between electrons, giving rise to a variety of collective phenomena including superconductivity, strange metals and correlated insulators. The mechanisms underpinning many of these collective phenomena remain unknown, driving interest in creating artificial crystals which replicate the system of interest while allowing precise control of key parameters. Cold atoms trapped in optical lattices provide great flexibility and tunability [1,2], but cannot replicate the long range Coulomb interactions and long range hopping that drive collective phenomena in real crystals. Solid state approaches support long range hopping and interactions, but previous attempts with laterally patterned semiconductor systems were not able to create tunable low disorder artificial crystals, while approaches based on Moire superlattices in twisted two-dimensional (2D) materials [3,4] have limited tunability and control of lattice geometry.

Here we report the development of highly tunable artificial crystals by superimposing a periodic electrostatic potential on the two-dimensional electron gas in an ultrashallow (25 nm deep) GaAs quantum well. [5] The 100 nm period artificial crystal is identified by the formation of a new bandstructure unique to the artificial triangular lattice through low field Hall effect measurements. Hall resistance shows multiple transitions from electron-like to hole-like behaviour as the chemical potential is swept through the different artificial bands, consistent with our band structure calculations. The artificial bandstructure can be continuously tuned from parabolic free-electron bands into linear graphene-like and flat kagome-like bands in a single device. This approach allows the formation arbitrary geometry two dimensional artificial crystals, opening a new route to studying novel electronic phases.

References

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