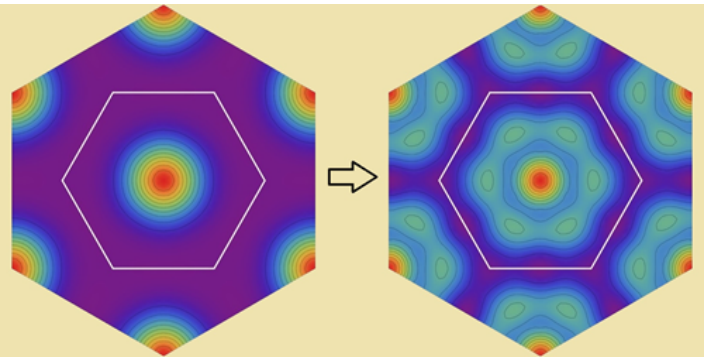
Bilayer Graphene Reveals Hidden Topology

Small rotations of a graphene layer relative to its neighboring layer expose previously unseen topological phases.

By **Ryan Wilkinson**

Stacking two sheets of graphene—and slightly twisting one relative to the other—creates a material that exhibits a rich array of electronic phenomena. Ranging from exotic insulating behavior to unconventional superconductivity, such effects arise from an interplay between strong electron–electron interactions and topologically nontrivial electronic bands. The flat, low-energy bands of twisted bilayer graphene are central to many of these phenomena, but the coupling of those bands to higher-energy ones has been poorly understood. Now Pierre Pantaleón of IMDEA Nanoscience in Spain and his colleagues have studied how changing the twist angle affects this coupling and, in turn, the material's electron density and topological properties [**1**]. The results could help scientists use twisted bilayer graphene for applications in quantum computing and other quantum information technologies.

In their theoretical analysis, the researchers found that, as they slowly decreased the twist angle, the bilayer material underwent multiple topological phase transitions. These were driven by the band coupling and were accompanied by changes in the material's electron distribution and topological properties. Such properties included the Chern number, which characterizes the bands' overall topology, and the quantum metric, which quantifies the difference between nearby electronic states in momentum space. The analysis also showed that the flat, low-energy bands could exhibit topological phases with Chern numbers of –2 and +2, previously unreported in twisted bilayer graphene. The team says that these phases could be accessible experimentally and used to achieve strongly correlated phases such as so-called fractional Chern insulators, which have potential uses in fault-tolerant quantum computing.



Credit: L. A. Navarro-Labastida *et al.* [**1**]

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REFERENCES

1. L. A. Navarro-Labastida *et al.*, "Topological phase diagram of twisted bilayer graphene as a function of the twist angle," **Phys. Rev. B 113, 085124 (2026).**