MODELING THE ELECTRONIC BEHAVIOR OF TWISTED BILAYER GRAPHENE

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FERMI SURFACES

• PREDICTS MATERIAL PROPERTIES
  • ELECTRICAL, THERMAL, MAGNETIC, OPTICAL

• IN GRAPHENE, FERMI SURFACE SHAPE IMPLIES BALLISTIC TRANSPORT
  • DIRAC CONES

\[ E(k) = \hbar v_F k \]
Each point is a Dirac cone!
WHAT ARE LIFSHITZ TRANSITIONS?

• A TOPOLOGICAL SHIFT IN THE FERMI SURFACE

• OLD JOKE… A TOPOLOGIST IS A MATHEMATICIAN WHO CAN’T TELL THE DIFFERENCE BETWEEN A DONUT AND A COFFEE CUP!
Why do we care?

Lifshitz transitions correlate with drastic changes in electronic properties
BUILDING A THEORY OF INTERLAYER INTERACTION

- CONSIDER A GRAPHENE BILAYER WHERE ONE LAYER IS ROTATED AT A SMALL ANGLE WITH RESPECT TO THE OTHER
We’re leaving reciprocal space – let’s translate the \( \Delta k \) vectors to a central point. Every \( \Delta k \) is a ‘hop’ between layers!
HOPPING THROUGH THE PROJECTION LATTICE
We are most interested in the \{1,1\} and the \{3,2\} stars.
SO... NOW WHAT??

• ADDING A HAMILTONIAN TERM ASSOCIATED WITH THIS “HOPPING” BEHAVIOR ALLOWS US TO ACCURATELY MODEL THE FERMI SURFACE

• WE FURTHER ADD A “BIAS VOLTAGE” TERM

  • CERTAIN VOLTAGES CAUSE STARS TO RESONATE, ALTERING THE FERMI SURFACE
CONCLUSIONS

- WORK IS ONGOING
  - RICHNESS OF \{3,2\} STAR NEEDS TO BE EXPLORED
  - CONVERGENCE PROBLEM NEEDS TO BE ADDRESSED
  - IMPLICATIONS OF THE PRESENCE OF LIFSHITZ TRANSITIONS REQUIRE FURTHER INVESTIGATION
IN THE CLASSROOM...

• COMPUTATIONAL MODELING OF 2D MOTION

• STUDENTS INTERACT WITH A COMPUTATIONAL PROJECTILE SIMULATION USING EXCEL MACROS

• STUDENTS COMPARE SIMULATION DATA WITH EXPERIMENTAL PROJECTILE RANGE DATA
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