Giant conductance oscillations in van der Waals heterostructures at high temperatures

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Quantum oscillations, which refer to periodic variations in conductance as a function of the external magnetic/electric field, are powerful tools for probing the electronic properties of materials and play a crucial role in quantum physics and technology. However, they are typically observed only at cryogenic temperatures, which limits their practical application. Two-dimensional materials and their van der Waals (vdW) heterostructures provide a promising platform for investigating these phenomena at high temperatures owing to their strong Coulomb interactions and enhanced quantum confinement effects [1, 2].

We report the observation of giant conductance oscillations at temperatures above 100 K in vdW heterostructures made of black phosphorus (BP) and ruthenium (III) chloride (α-$RuCl_3$). While BP is an ambipolar semiconductor with a high carrier mobility, α-$RuCl_3$ has a large work function and acts as a strong p-type dopant layer. The measured temperature-dependent conductivity of the heterostructure showed a transition from metallic to insulating behaviour at around 150 K. Large conductance oscillations as a function of the external magnetic field were observed at temperatures near this transition point. We discuss several possible mechanisms that could lead to this behaviour, including Aharonov-Bohm quantum interference [3], electron-hole correlations [4, 5], and the notion of an unconventional Fermi surface in an insulating state [6].

References

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