Supersonic Electron Flow and Hydraulic Jump in Bilayer Graphene

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Electronic systems with global momentum conservation can be described as a hydrodynamic fluid. Clean material systems with strong carrier-carrier interactions, such as graphene [1], PdCoO2 [2] or WTe2 [3], can reach this regime, leading to novel electronic phenomena such as whirlpools, superballistic conductance and Poiseuille flow, all analogues of incompressible flow.

Compressible flow, where the drift velocity of the carriers is comparable to the sound velocity of the fluid and the fluid density is no longer constant, has been unexplored in electronic systems. In this work, we use the low electronic sound velocity in bilayer graphene to realize an electronic de Laval nozzle [4]. The de Laval nozzle geometry accelerates the carriers to supersonic speeds, which then relax abruptly to subsonic velocities at a shock.

Our work investigates discontinuities in electronic transport consistent with supersonic flow. Kelvin probe force measurements identify the regions with supersonic flow and observe a hydraulic jump in the local potential, the equivalent of a shock wave for liquids. This is the first demonstration of compressible electron flow, and we will discuss its effects on dissipation. compressibility and reversibility of electron flow.

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