Coulomb-induced drag between 1D wires in the nonlinear regime

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Owing to their strong interactions arising from reduced screening and dimensionality, one-dimensional (1D) systems are predicted to exhibit exotic quantum properties, such as spin-charge separation and topological superconductivity. However, little is experimentally known about how
Coulomb-coupled one-dimensional systems behave.

Utilizing the ultra-quiet electromagnetic interference environment and immersion cooling available in the MagLab High B/T facility, the electron currents in 1D quantum wires only 15nm apart from one another (**Figures 1a and b**) were studied as the current in one wire drags along electrons in a nearby wire through Coulomb scattering. By extending the study of the Coulomb drag signal to the non-linear regime, our observation of a non-monotonic drive-current/drag-voltage dependence (**Figure 1c**) confirms theoretical predictions. In addition, telltale signs of Luttinger liquid physics in the form of a non-monotonic temperature dependence (**Figure 1d**) have also been observed. Crucially, the non-linear signal offers a novel self-consistent way to extract the electron-electron interaction strength in these
1D systems with low electron temperatures. This study also underscores the
co-existence of both reciprocal and rectified signals in 1D wires, providing essential insight needed to understand the quantum origin of both contributions.

Characterizing coupled 1D systems is critical for the future development of quantum devices employing strong electron-electron interactions, such as heat harvesters and novel platforms with induced topological superconductivity.

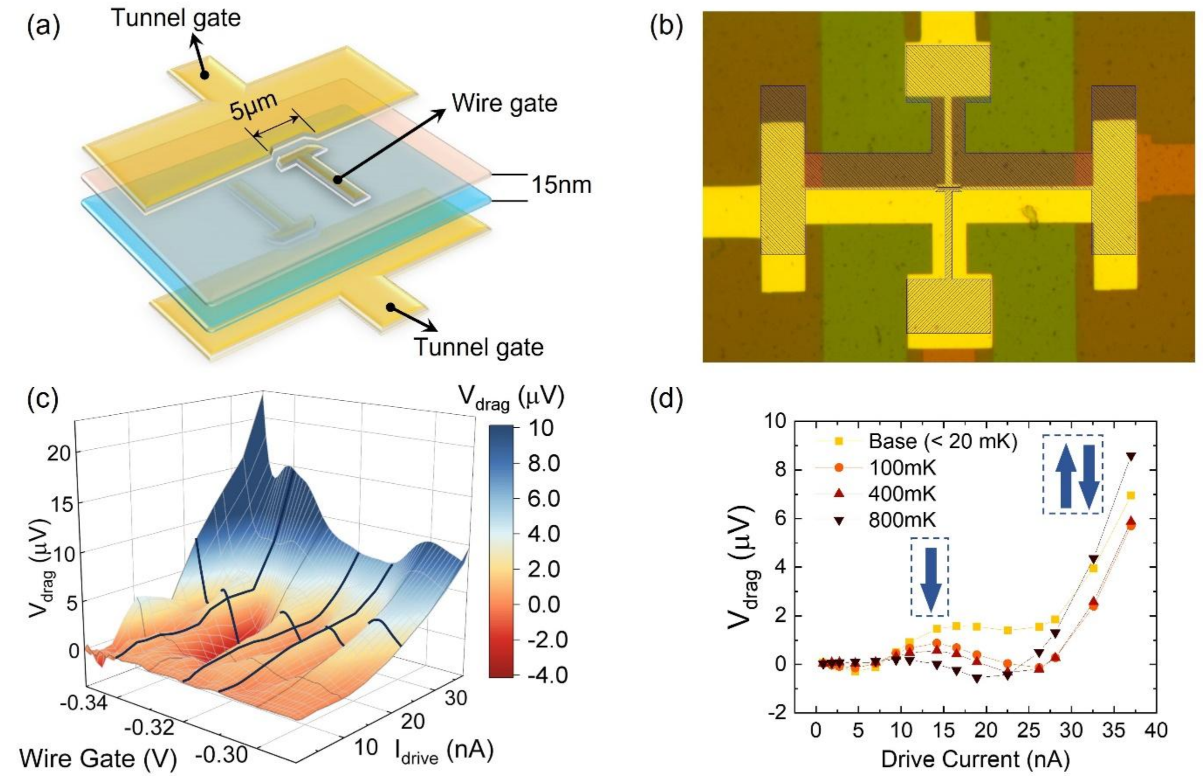

Figure 1. (a) Schematic and (b) Optical pictures of the coupled quantum wires device. (c) Nonlinear drag response with drive current at different biasing voltages. (d) Non-monotonic temperature dependence of 1D Coulomb drag at low electron temperatures to below 20mK.

Facilities and instrumentation used: High B/T facility, Bay 1 (dry dilution refrigerator during cryogenic testing phase prior to 14T magnet delivery and installation).

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