INTEGER QUANTUM HALL EDGE IN CONTACT WITH SUPERCONDUCTING CONTACTS

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The hybrid superconductor-semiconductor (SU-SE) systems combine the macroscopic superconducting properties of the superconducting leads with the microscopic degrees of freedom of the semiconductor. Recently proposals have predicted new phases of matter can emerge at this interface in the quantum Hall regime. Quantum Hall systems host a variety of novel states of matter that can be controlled by magnetic fields, electrical gating and doping. In addition, excitations in quantum Hall systems carry electrical charge, which allows for their control and utilization in quantum circuit elements [1]. Although techniques for semiconductor and superconductor growth are individually well established, combining them experimentally is a formidable task. The magnetic fields needed for the quantum Hall effect are generally deleterious to superconductivity, but some superconductors can tolerate such fields.

In this presentation we discuss the requirements and challenges toward realization of such SU-SE systems. We study properties of InAs heterostructures, NbTi superconducting thin films and hybrid NbTi-InAs junctions in presence of perpendicular magnetic field. We have studied several high mobility InAs heterostructures at low temperatures and extracted transport properties of the two-dimensional electron gas. We have also studied integer and searched for fractional quantum Hall states in these samples. Figure 1 highlights our findings. The spectroscopy on SU-SE junction shows signatures of Andreev reflections at zero magnetic fields with a transparency calculated to be better than 80%. In perpendicular magnetic field, a zero bias peak is developed that its strength and shape depends on whether the system is in an integer quantum Hall state or not. We discuss the possible explanations within current theoretical models.

Our work is supported by the Microsoft Research. A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by NSF Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. DOE.

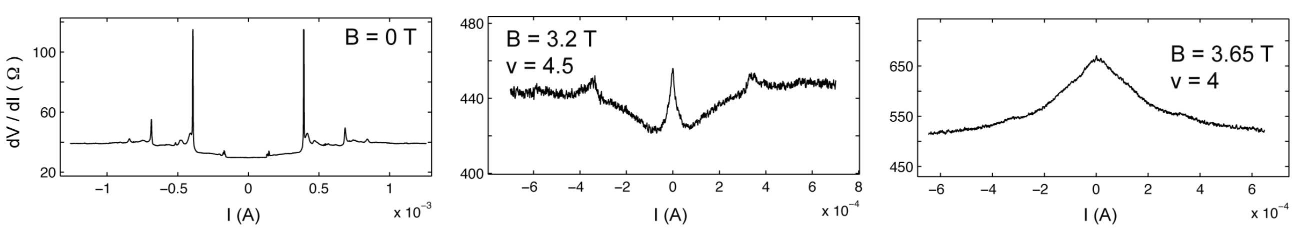

Figure 1. dV/dI measurement of a NbTi-InAs device at (a) B = 0 T (b) 3.2 T (v = 4.5) (c) 3.65 T (v = 4).

[1] David J. Clarke, Jason Alicea and Kirill Shtengel, Nature Physics 10, 877–882 (2014).

Category: QH and SC
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