Observation of 'neutral modes' in the QHE regime via shot noise measurements

Aveek Bid[1], Nissim Ofek[1], Hiro Inoue[1], Merav Dolev[1], Yaron Gross[1], Charles Kane[2], Vladimir Umansky[1], Diana Mahalu[1], and Moty Heiblum[1]

[1] *Department of Condensed Matter Physics, Weizmann Institute of Science, Israel*

[2] *Department of Physics and Astronomy, University of Pennsylvania, USA*

Current propagates in the quantum Hall regime along the edges of a two-dimensional-electron gas via chiral edge modes, with chirality dictated by the applied magnetic field. In the fractional regime, for some fractional states - the so called 'holes-conjugate' states – e.g., between filling factor 1/2 and 1 - early predictions suggested the presence of counter propagating charge modes: a 'downstream' mode with the expected chirality and an 'upstream' mode with an opposite chirality. Since experiments in the (ubiquitous) 2/3 fractional state did not find an upstream propagating edge mode, it was theorized that in the presence of interactions and disorder edge reconstruction may take place with a resultant downstream charge mode accompanied by an upstream 'neutral mode' - with the latter carrying only energy. This explained why upstream charge modes were not detected previously, while neutral modes are more difficult to detect. More recently, neutral modes were predicted to exist in a variety of cases. For example, they are expected to be found when multiple edge modes (such as in filling factor 2 or higher for electrons, or for composite fermions) interact. Alternatively, neutral Majorana modes, which are expected to exist for a few proposed wavefunctions of the non abelian state 5/2, are crucial for the identification of the state.

We will present some of our observations of neutral modes in a few selected quantum Hall states. Neutral mode detection was performed by allowing the chiral neutral mode (being 'downstream' or 'upstream') to impinge on a quantum point contact constriction. Partitioning of the neutral mode led to current fluctuations (with a zero average current) propagating towards the amplifier. We will present some of the characteristics of the observed neutral modes in the integer and fractional regimes of the quantum Hall effect, and show a dual behavior with charge modes.