Particle-hole duality for the investigation of quantum Hall edge channels

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Particle-hole duality is a central concept in the physics of quantum Hall (QH) systems [1] : it follows from the symmetric form of the electron hamiltonian in the first Landau level and it explains the occurrence of QH phases for symmetric values of the filling factor $\nu \leftrightarrows 1-\nu$. Particle-hole duality has also proved to be a useful tool in analyzing complex edge structures such as the one dimensional channels at the border of a QH state at $\nu = 2/3$ [2]. In the beginning of the presentation I shall review the experimental results obtained at NEST on split-gate constrictions in the QH regime where a direct evidence of particle-hole symmetry in the QH edge backscattering is given. I shall thus show finite-bias backscattering measurements of a QH edge channel at filling factor $\nu = 1$ where a markedly non-linear behavior is obtained [3,4]. In such a system both zero-bias enhancement and suppression of the inter-edge tunneling can be obtained in a controllable way as a function of the gate bias. The observed evolution is connected to the local charge depletion in the constriction region and it is in agreement with particle-hole symmetry arguments. Experimental results will also be discussed in relation to the chiral Luttinger liquid theory for edge channels [5,6] and to the link between this interpretation and the particle-hole symmetry. The understanding of the physics of edge-edge interactions in QH constrictions turns out to be also interesting in view of the recent studies on mesoscopic system based on the non-abelian QH state $\nu = 5/2$ [7,8].

Building on the agreement between constriction experiments and particle-hole symmetry, I shall demonstrate how charge-conjugation can be exploited in the design of alternative QH devices where the transport can be naturally interpreted in term of holes in a partially filled Landau level. I shall show in particular how this approach can lead to an easy implementation of submicrometric junctions between different filling factors. I shall focus in particular on the case of the interface between hole filling factors 1 and 1/3 [9].

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