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Universality of the Edge-Tunneling Exponent of Fractional Quantum Hall Liquids[1]

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Fractional quantum Hall states are characterized by their topological order. For example, the edge physics is uniquely determined by the bulk and gives a non-Ohmic relation $I \propto V^{\alpha}$ for tunneling into the edge, where the exponent α is a universal constant. In the simplest case of filling factors $\nu = n/(np+1)$, (n and p are integers > 0, p even) the exponent is $p+1$. However, experiments show substantial deviations. In a microscopic model of fractional quantum Hall liquids, we calculate the edge Greens function by exact diagonalization and obtain the exponent α. We consider the 1/3 and 2/3 states with the Coulomb interaction and a variety of edge confining potentials. We find that the form of the confinement, such as sharpness of the edge and/or the strength of the confining potential which could lead to edge reconstruction, may cause deviations from universality in the edge-tunneling I-V exponent. We study two types of edge potentials: a sharp edge induced by a cut-off of angular momentum beyond m_{max}) and one induced by a uniform neutralizing background charge (a distance d from the 2-d layer). Without the background charge, the exponent retains its universal value for soft edges (large m_{max}) but is non-universal for hard edges. In the presence of background charge and strong confinement (small d), the exponent is universal even for hard edges; for weak confinement and hard edges there is a deviation from the universal value while for soft edges there are finite-size corrections to α, consistent with the edge reconstruction scenario. The relation of these results to experiments will be discussed.

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