Energy gap evolution of the $\nu_{\rm tot} = 1$ quantum Hall state in an electron-electron bilayer system measured by single electron transistors

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One intriguing property of the $\nu_{\rm tot} = 1$ quantum Hall state hosted in a bilayer two-dimensional electron system (2DES) is its tolerance to electron density imbalance between the layers. Previous activation experiments in a small range of density imbalance have revealed a counter-intuitive asymmetric behavior of the energy gap at $\nu_{\rm tot} = 1$ depending on the layer index[1]. Here we extend the imbalance study to the extreme case by tuning the system from a single 2DES to a bilayer 2DES with a back gate. We observed a continuous evolution of the $\nu_{\rm tot} = 1$ state. Of particular interest is the significant enhancement of the quantum Hall state in the transition region from $\nu = 1$ to $\nu_{\rm tot} = 1$. Transport studies are complemented with measurements of the local compressibility using a single electron transistor (SET). It allows addressing compressibility issues[2], but also analyzing the evolution of the energy gap.

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[2]J. Martin, S. Ilani, B. Verdene, J. Smet, V. Umansky, D. Mahalu, D. Schuh, G. Abstreiter, and A. Yacoby. Science **305**, 980 (2004).