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Electron-hole asymmetry in the integer and fractional quantum Hall effect in bilayer graphene

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The nature of fractional quantum Hall (FQH) states is determined by the interplay between the Coulomb interaction and the symmetries of the system. The unique combination of spin, valley, and orbital degeneracies in bilayer graphene is predicted to produce an unusual and tunable sequence of FQH states. In this talk, I will present local electronic compressibility measurements of the lowest Landau level in bilayer graphene performed using a scanning single-electron transistor. In the integer quantum Hall regime, we find that the background compressibility between filling factors breaks particle-hole symmetry and instead obeys a $\nu \rightarrow \nu + 2$ symmetry. We also find the above-mentioned $\nu \rightarrow \nu + 2$ symmetry in the FQH regime; we observe incompressible FQH states at filling factors $\nu = 2p + 2/3$ with hints of additional states appearing at $\nu = 2p + 3/5$, where p = -2, -1, 0 and 1. These observations highlight the importance of the orbital degeneracy for many-body states in bilayer graphene.