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**The Nature of Quantum Hall States near the Charge Neutral Dirac Point in Graphene**[1] ZHIGANG JIANG, Columbia Univ./NHMFL, YUANBO ZHANG, YANWEN TAN, Columbia Univ., HORST STORMER, Columbia Univ./Bell Labs, PHILIP KIM, Columbia Univ. — We investigate the quantum Hall (QH) states near the charge neutral Dirac point of a high mobility graphene sample in high magnetic fields ($B$). We find that the QH states at filling factors $\nu = \pm 2$ show thermally activated behavior with an energy gap as large as $\sim$ 890 K at $B = 45$ T. This large energy gap between the $n = 0$ Landau level (LL) and the $n = 1$ LL, enables us to observe a well-defined QH effect in graphene over a wide temperature range and even up to room temperature. In addition, the data reveal an activation energy gap at filling factor $\nu = 1$, which is considerably larger than the previous studied spin states at $\nu = \pm 4$ and shows a square root dependence on $B$, suggesting a many-body origin of this state. Such an origin is further supported by tilted field measurements, in which the $\nu = \pm 1$ gaps are found to depend only on the normal component of the field with respect to the graphene plane. We therefore propose that the $\nu = \pm 1$ states arise from the lifting of the sublattice degeneracy of the $n = 0$ LL.

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