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Supplementary information

Electrically tunable correlated and topological states in twisted monolayer–bilayer graphene

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Supplementary Information for:
Electrically tunable correlated and topological states in twisted monolayer-bilayer graphene

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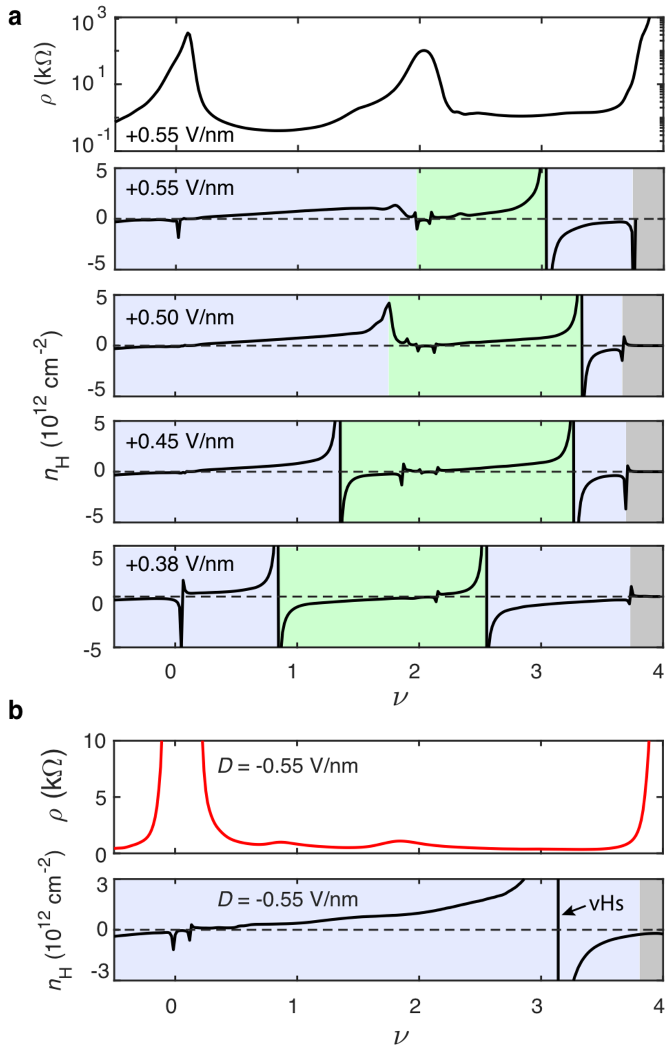

FIG. S1. **Additional transport in device D1.** **a**, ρ at $D = +0.55$ V/nm (top panels) and n_{H} at various $D > 0$ (bottom panels). Following the convention in the main text, green denotes regions in which spontaneous symmetry breaking renormalizes the Fermi surface. **b**, ρ (top) and n_{H} (bottom) at $D = -0.55$ V/nm. Signatures of correlated states are nearly absent at this D, and correspondingly n_{H} does not exhibit any abrupt sign changes or substantial deviations from a linear gate induced charge density, n. The sign change in n_{H} for ν just greater than 3 follows from a single particle model corresponding to a vHs, in which complete filling of a closed band requires an inversion of the sign of the charge carrier mass.

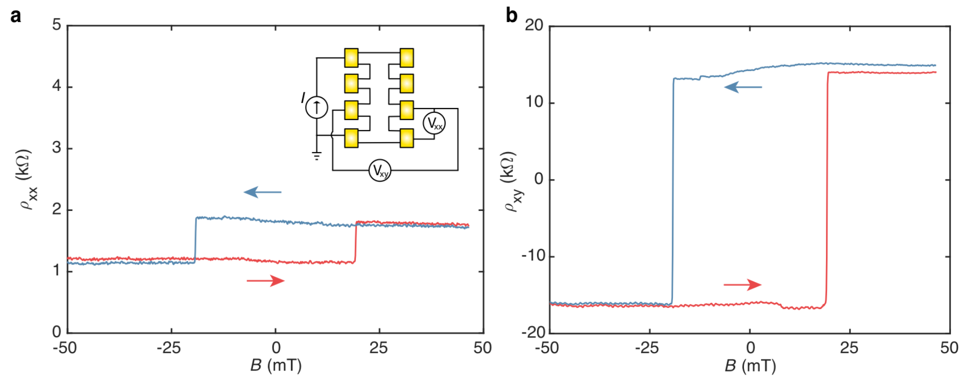

FIG. S2. **Raw data of the AHE in device D2 ($\theta = 0.89°$).** Data corresponds to Fig. 4b of the main text, however ρ_{xx} is not symmetrized in **a**, and ρ_{xy} not antisymmetrized in **b**. As a result, there is weak mixing between the two. The inset shows the measurement setup. Low frequency noise in ρ_{xy} for negative B does not appear in curves acquired at nearby values of n and D, and appears to be a measurement artifact.

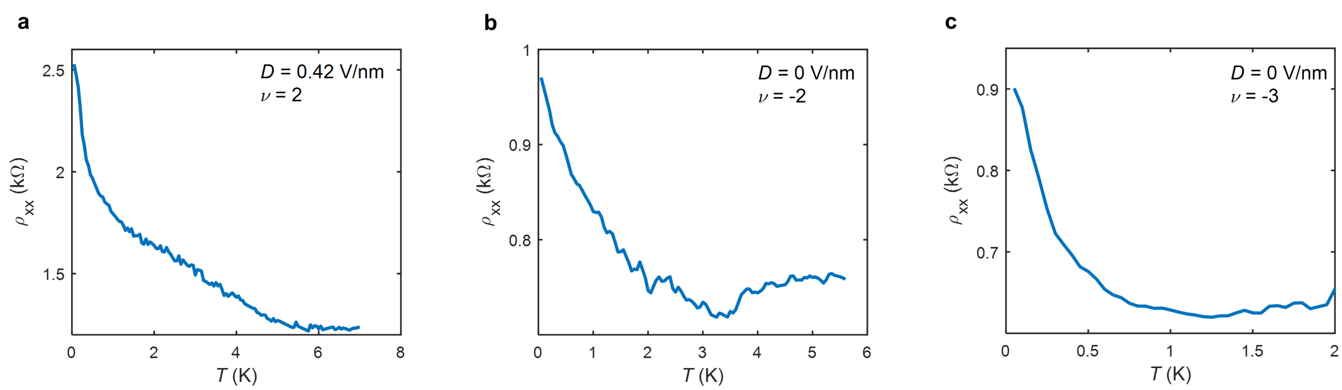

FIG. S3. **Transport of the CI states at $\nu = +2, -2, -3$ in device D2.** $\rho_{xx}(T)$ acquired at **a**, $\nu = 2$ and $D = 0.42$ V/nm, **b**, $\nu = -2$ and $D = 0$, and **c**, $\nu = -3$ and $D = 0$. All three states exhibit very weak insulating behavior at low T.

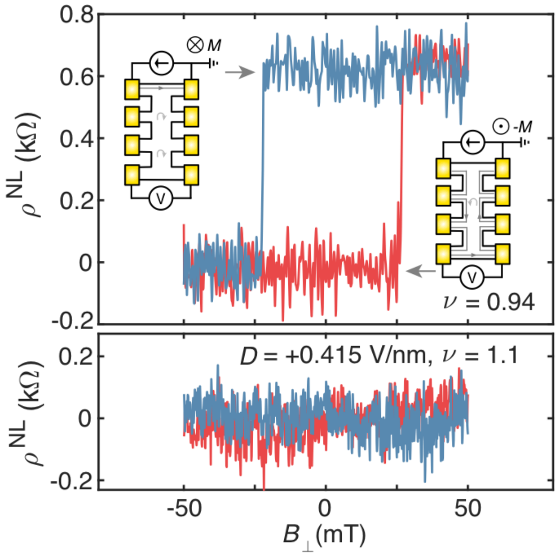

FIG. S4. **Non-local resistance measurements in device D2.** Non-local resistance, ρ^{NL}, acquired at $D = +0.415$ V/nm and $\nu = 0.94$ (top) and $\nu = 1.1$ (bottom). Schematics illustrate the contact configuration used for the measurement, as well as the corresponding chiral edge modes equilibrated to the source electrode. Outside the magnetic regime (bottom panel), vanishingly small ρ^{NL} is observed. In contrast, substantial ρ^{NL} is observed for a single sign of the magnetization. This has previously been understood to result from differences in equilibration between the nonlocal voltage probes depending on the chirality of the edge modes [1, 2], indicating the existent of these topological edge modes in our device.

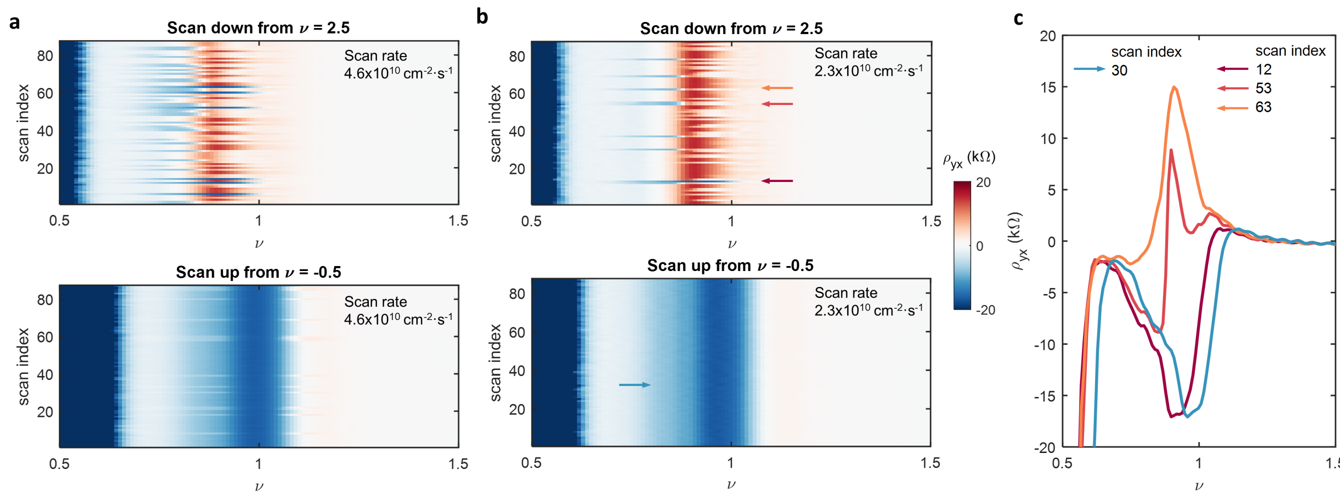

FIG. S5. **Stability of the doping-induced switching of the magnetic order in device D2.** **a**, ρ_{yx} as ν is swept down from $\nu = 2.5$ (top) and up from $\nu = -0.5$ (bottom). The sweep is repeated 87 times, denoted by the scan index. The offset of the features in ν between the two maps arise owing to fast sweeping of ν, as compared with the integration time of the lock-in amplifier. In the sweeps down from $\nu = 2.5$, the magnetic state is not successfully switched to the positive state (red) every time. **b**, Comparable measurement but with ν swept at half the rate as in **a**. The switching to the positive state (red) occurs in all but one sweep with this reduced sweeping rate. **c**, Selected line cuts corresponding to the arrows in **b**, showing various representative behaviors of ρ_{yx} as ν is swept. When sweeping up from $\nu = -0.5$, the magnetic state is negative every time, and closely resembles the blue curve (scan index 30). A wider range of behaviors is observed upon sweeping down from $\nu = 2.5$. Most frequently, the magnetic state closely resembles scan index 63, in which the positive state is observed. On occasion, the state appears to switch through various metastable configurations (scan index 53), corresponding to regions with trailing blue streaks in the top panel of **b**. Finally, in 1 of the 87 traces, we did not observe switching at all (scan index 12).

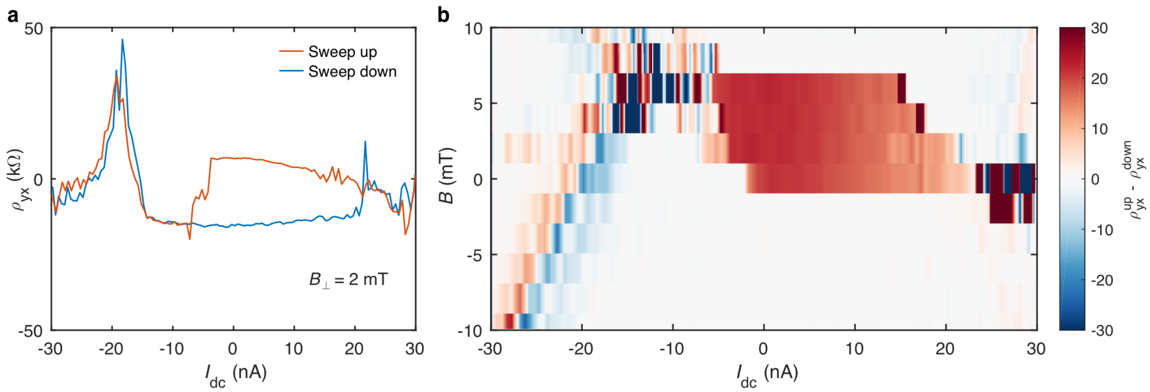

FIG. S6. **Switching the magnetic ordering with a direct current bias in device D2.** **a**, ρ_{yx} as the dc current, I_{dc}, is swept back and forth at $B_\perp = 2$ mT. The magnetic order can be switched with I_{dc}. Additional resistive states appear at larger I_{dc} and may be related to current melting of the magnetic ordering, however these features are not currently well understood. **b**, The difference between ρ_{yx} sweeping up and down as a function of $B_\perp$. The red region denotes the regime in which the magnetization can be switched with I_{dc}. At high field, the magnetization aligns with the external field and cannot be switched with I_{dc}.

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