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Spin and valley quantum Hall ferromagnetism in graphene on hexa-Boron nitride substrates ANDREA YOUNG, CORY DEAN, LEI WANG, HECHEN REN, PAUL CADDEN-ZIMANSKY, Columbia University, TAKASHI TANIGUCHI, KENJI WATANABE, NIMS, JIM HONE, KEN SHEPARD, PHILIP KIM, Columbia University — In graphene subjected to a quantizing magnetic field, the strong Coulomb interactions and fourfold combined spin/valley degeneracy lead to an approximate SU(4) isospin symmetry within individual Landau levels). At partial filling, exchange interactions can drive the ground state to polarize ferromagnetically within this expanded isospin space, manifesting experimentally as additional integer quantum Hall plateaus outside the normal sequence. Here we report the observation of a wide number of these quantum Hall isospin ferromagnetic states. Using tilted field magnetotransport, we classify the states appearing at different Landau Level filling factors by their real spin structure. We find evidence for real spin polarized states supporting Skyrmionic excitations, charge- or spin- density order, and valley textured excitations at different filling factors. We also observe unexpected reentrant behavior in tilted field in the higher Landau levels. Our results confirm graphene as a highly isotropic SU(4) ferromagnet, in which symmetry breaking is dictated by the interplay between the Zeeman effect, lattice scale interactions, and disorder.

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