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Study of the polarization and inversion of spin and valley in graphene at nanoscale

Control of the spin and valley at the nano scale is a hot topic in condensed matter physics and materials science, which may have potential applications in spintronics and valleytronics in the near future. In our work, we systematically studied spin and valley polarization and inversion in graphene, realizing the control of spin and valley at the nanoscale and single electron level. Pristine graphene is diamagnetic. In our work, we introduce single carbon vacancy, to generate local magnetic moments in graphene. We realize the manipulation of magnetism of individual single-carbon vacancy in graphene by using a scanning tunneling microscopy (STM) tip. For the valley pseudospin degree of freedom, we demonstrate experimentally that a valley magnet can switch valley polarization and valley inversion in graphene. The valley magnet is realized by using both strain-induced pseudomagnetic fields and real magnetic fields. The pseudomagnetic fields, which are quite different from real magnetic fields, pointing in opposite directions at the two distinct valleys of graphene. Therefore, the coexistence of the pseudomagnetic fields and the real magnetic fields leads to imbalanced effective magnetic fields at the two distinct valleys of graphene. This allows us to control the valley in graphene as convenient as the electron spin by using the valley magnet. Our results highlight a pathway to valleytronics in strained graphene-based platforms.

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