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Dirac semimetal state in black phosphorus

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Two-dimensional (2D) semiconductors have emerged as a class of materials that may impact our future electronics technologies. A key issue is controlling their electronic band structure widely to overcome the limit of natural properties. In this talk, I will introduce our recent angle-resolved photoemission spectroscopy studies on the widely tunable band gap in a 2D semiconductor, black phosphorus. We found that the in situ deposition of alkali-metal atoms modulates the band gap in the surface phosphorene layers of bulk black phosphorus by the giant Stark effect, resulting in the transition from a narrow-gap semiconductor to a 2D Dirac semimetal with a pair of Dirac cones. At the critical point of this transition, black phosphorus is a zero-gap semimetal, whose band dispersion is highly anisotropic, linear in armchair and quadratic in zigzag directions.