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Angle-Resolved Light-Matter Interaction in Anisotropic Layered Black Phosphorus SHENGXI HUANG, XI LING, MIT, EDDWI HASDEO, Tohoku University, LIANGBO LIANG, RPI,ORNL, WILLIAM PARKIN, UPenn, YUKI TATSUMI, AHMAD NUGRAHA, Tohoku University, ALEXANDER PURETZKY, ORNL, PAUL DAS, UPenn, BOBBY SUMPTER, DAVID GEOHEGAN, ORNL, JING KONG, MIT, RIICHIRO SAITO, Tohoku University, MARIJA DRNDIC, UPenn, VINCENT MEUNIER, RPI, MILDRED DRESSELHAUS, MIT — Orthorhombic black phosphorus (BP) and other layered materials, such as gallium telluride and tin selenide, stand out among two-dimensional (2D) materials owing to their anisotropic in-plane structure. This anisotropy adds a new dimension to the properties of 2D materials and stimulates the development of angle-resolved photonics and electronics. However, understanding the effect of anisotropy has remained unsatisfactory to-date, as shown by a number of inconsistencies in the recent literature. We use angle-resolved absorption and Raman spectroscopies to investigate the role of anisotropy on the electron-photon and electron-phonon interactions in BP. We highlight, both experimentally and theoretically, a non-trivial dependence between anisotropies and flake thickness, photon and phonon energies. We show that the anisotropic optical absorption is a reliable and simple way to identify the crystalline orientation of BP, which cannot be determined from Raman spectroscopy without the explicit consideration of excitation wavelength and flake thickness.

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