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Photocurrent spectroscopy of 2D materials

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Confocal photocurrent measurements provide a powerful means of studying many aspects of the optoelectronic and electrical properties of a 2D device or material. At a diffraction-limited point they can provide a detailed absorption spectrum, and they can probe local symmetry, ultrafast relaxation rates and processes, electron-electron interaction strengths, and transport coefficients. We illustrate this with several examples, once being the photo-Nernst effect. In gapless 2D materials, such as graphene, in a perpendicular magnetic field a photocurrent antisymmetric in the field is generated near to the free edges, with opposite sign at opposite edges. Its origin is the transverse thermoelectric current associated with the laser-induced electron temperature gradient. This effect provides an unambiguous demonstration of the Shockley-Ramo nature of long-range photocurrent generation in gapless materials. It also provides a means of investigating quasiparticle properties. For example, in the case of graphene on hBN, it can be used to probe the Lifshitz transition that occurs due to the minibands formed by the Moire superlattice. We also observe and discuss photocurrent generated in other semimetallic (WTe_2) and semiconducting (WSe_2) monolayers. Work supported by DoE BES and NSF EFRI grants.