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Ultrafast Extreme-UV ARPES Studies of Electron and Exciton Dynamics in the Transition-Metal Dichalcogenide $MoSe_2$ JAN H. BUSS, FREDERIC JOUCKEN, YIMING XU, JULIAN MAKLAR, HE WANG, MSD, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, USA, CHANGHYUN KO, Dept. of Materials Science and Engineering, University of California, Berkeley, CA, 94720, USA, SEFAATTIN TONGAY, School for Engineering of Matter, Transport and Energy, Arizona State University, Tempe, AZ, 85287, USA, JINQIAO WU, Dept. of Materials Science and Engineering, University of California, Berkeley, CA, 94720, USA, ROBERT A. KAINDL, MSD, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, USA — Semiconducting transition-metal dichalcogenides exhibit intriguing physical properties, including a large spin-orbit splitting, strong Coulomb interactions, and optical access to the valley degree of freedom. Important insight into the fundamental microscopic interactions can be obtained via studies of the momentum-resolved non-equilibrium carrier dynamics. Here, we present time-resolved ARPES investigations of $MoSe_2$ crystals using high-repetition-rate extreme-UV femtosecond pulses, enabling us to track the electron dynamics within the full Brillouin zone with high sensitivity. After resonantly driving excitons at the K-point, the transient ARPES signals reveal a rapid time evolution governed by inter-valley scattering to the conduction band minimum on a 70-fs time scale. We will discuss the momentum-space dynamics as well as distinct temporal and spectral features that provide evidence for the first observation of excitons via angle-resolved photoemission spectroscopy.

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