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Resolving structural dynamics at multiple length and time scales with the Cornell high-brightness, ultrafast electron microdiffraction apparatus

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The out-of-equilibrium dynamics of engineered nanoscale systems, such as moiré materials, is an important domain for ultrafast science. Ultrafast electron diffraction (with high-angular magnification) is especially suited to investigating spatially coherent normal modes of oscillation in these systems, collective motion that could hold the key to novel device functionality. Nanometer and longer periodicities can appear as fine details in reciprocal space, only resolvable by a highly coherent (low momentum spread) probe. In the conjugate dimension, small probe spots are needed to obtain data from micron-sized material samples. To satisfy these two requirements simultaneously — high coherence and small probe size — requires a high-brightness electron beam. I describe early results of the kiloelectron-volt ultrafast electron diffraction apparatus at Cornell, and show with reference to an experimental case study in moiré materials that this machine meets demanding size and coherence requirements, thanks to a low emittance semiconductor photocathode source.

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