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Watching and clocking electrons in condensed matter with visible light

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The wavelength of visible light is often assumed to impose fundamental frontiers in optical microscopies and time-resolved spectroscopies. In optical microscopies, it limits the spatial resolution to the nanometer scale while in time-resolved techniques it restricts the temporal resolution to the scale of femtoseconds. I will discuss how recent efforts allow us to push these frontiers. We show that precisely measured and controlled optical fields allow imaging of valence electrons in solids with sub-Angstrom resolution. This enables the establishment of a new kind of optical tomography of solids with a spatial resolution 104 times beyond the abbe limit. Optical fields also provide the required temporal resolution for observing how electronic relaxation occurs deep inside matter with attosecond precision. When used to nonlinearly release and probe free electrons from nanostructures controlled optical fields provide new routes to optical nanoelectronics and light-controlled electron diffraction techniques.

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