Leveraging Electric Fields to Investigate Protein Biophysics through Time-Resolved Crystallography

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Incoherent diffractive imaging (IDI) is a novel imaging technique which uses the transient coherence of X-ray fluorescence to image the structure of the emitting atoms to nanometer resolution. By employing second-order spatial intensity correlations akin to Hanbury Brown and Twiss's stellar intensity interferometry, IDI retrieves the spatial distribution of the underlying emitters, facilitating high-resolution characterization of heterogeneous nanoparticles with element specificity. We present recent results from our single-particle IDI experiments at European XFEL, showing for the first time the feasibility of 3D imaging of nanoparticles using IDI. Building upon the concept of IDI, we introduce Spectral Incoherent Diffractive Imaging (SIDI), a novel method for achieving dark-field imaging of nanostructures with heterogeneous oxidation states. With SIDI, shifts in photoemission profiles can be spatially resolved, enabling the independent imaging of the underlying emitter distributions contributing to each spectral line. In the X-ray domain, this approach offers unique insights beyond the conventional combination of diffraction and X-ray Emission Spectroscopy (XES). Our proposed method opens avenues for timeresolved, element specific and oxidation state-specific imaging of electron transfer in 3d-transition metal compounds or to study heterogeneous catalysts and battery materials where the nanoscale spatial distribution of elemental oxidation states is crucial for understanding function.