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Flash diffractive imaging.

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Theoretical studies and simulations predict that with a very short and very intense coherent X-ray pulse a single diffraction pattern may be recorded from a large macromolecule, a virus, or a cell without the need for crystalline periodicity (1). A three-dimensional data set could be assembled from such patterns when copies of a reproducible sample are exposed to the beam one by one (2). The over-sampled diffraction pattern permits phase retrieval and hence structure determination (3,4). The challenges in carrying out such an experiment are formidable, and engage an interdisciplinary approach drawing upon structural biology, atomic and plasma physics, mathematics, statistics, and X-ray laser physics. Here we report the first experimental results in flash diffractive imaging at the first soft X-ray laser in the world, the FLASH facility at DESY in Hamburg, Germany. The results indicate that an interpretable diffraction pattern can be obtained before the sample turns into a plasma as a consequence of an exposure to an intense femtosecond photon pulse. A second exposure shows scattering from a hole that was left behind where the sample used to be during the first exposure (5). Results on imaging live picoplankton will also be presented. The results provide the first experimental evidence for the basic principle of flash imaging, and show that one can get an interpretable diffraction pattern before sample explosion. The results have implication for imaging non-periodic molecular structures in biology and in any other area of science and technology where structural information on the nanoscale is valuable.

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