Imaging Macromolecules with X-ray laser pulses

Prof. Henry Chapman

Center for Free-Electron Laser Science, DESY and University of Hamburg

The short wavelength of X-rays allows us to image structures at the atomic scale, giving detailed pictures of biological macromolecules. However, X-ray radiation is energetic enough to ionize matter: the very act of measurement destroys the structure being investigated. Crystallography has been used to work around this limitation by spreading out the damage over billions of molecules, but it can often take years of trial and error to grow macromolecular crystals of sufficient quality. X-ray free-electron lasers produce pulses that are a billion times more brilliant than achievable at conventional sources, and which can be focused to intensities approaching conditions similar to stellar interiors. Nevertheless, pristine structural information can be obtained using pulses shorter than several femtoseconds. This concept of outrunning radiation damage has now been verified to atomic resolution by macromolecular “nanocrystallography” This ideas have been extended to disordered crystals where, by the removal of strict periodicity, the diffracted wavefield actually carries more information than obtainable from perfect crystals, giving a route to directly synthesis images of macromolecules.