AFC 2008 Rennes

(www.afc2008.univ-rennes1.fr)

Colloque I : Révolutions technologiques (méthodes, sources, détection)

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Is there a role for coherent x-rays in biological structure determination ?

In this presentation we review the meaning of coherence and its practical realization in present-day synchrotron x-ray sources. We define x-ray coherence quantitatively in terms of the phase-space concept and use this to show how different measurement tasks in crystallography and other fields can be matched to beams of an appropriate degree of partial or full coherence.

Coherent x-rays are already being used for imaging experiments on non-periodic samples and high-resolution (10 nm) three-dimensional images have been produced. We review the principles, history and current practice of this technique known as coherent x-ray diffraction imaging (CXDI). Although CXDI has not so far produced a high-resolution three-dimensional image of a frozen-hydrated biological sample, this is the goal of much current development work and we report on progress.

Radiation damage is often an issue in biological imaging and we report results of calculations that show where the damage limit to resolution is likely to be for simple CXDI of natural biological material. We suggest that the damage limit may be circumvented in some interesting special cases by the use of prior knowledge and suggest some experimental approaches.

Finally we report on two further techniques that have been conceived to circumvent damage in x-ray imaging : (i) The "diffraction before destruction" approach in which a fast free-electron-laser x-ray pulse is used and (ii) the so-called "serial crystallography" in which the molecules in a molecular beam are oriented by elliptically-polarized laser light before being imaged by CXDI methods. Both these schemes have been the subject of much study and some important steps have been made experimentally. Nevertheless, the fruits of these projects have to be regarded as some years away.