Biological Coherent Diffraction Imaging - recent status in the ESRF and around the world

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When a coherent beam of X-rays illuminates a small sample (crystalline or not), the diffraction patterns become weak and continuous. Such a continuous pattern can be sampled at spacing finer than the Bragg peak frequency. Fourier transformation of diffraction patterns allows to extract both the phase and amplitude of the illuminated sample, i.e. to determine three-dimensional spatial arrangement of all scattering objects in the sample. The diffraction pattern contains detailed information on the structure of the sample, limited by the extent to which the full angular range of the diffraction patterns can be collected. Spatial resolution has essentially no limit, being limited by $\Delta\lambda/\lambda$ and weak signals at large angles. In the field of biological specimens, the specimen ability to withstand a highly intense X-ray exposure, sets the resolution limit of the technique, to around 10 nm.

The potential of Coherent Diffraction Imaging (CDI) in biological X-ray imaging has been demonstrated with dried samples [1,2]. Sample preparation in the frozen-hydrated state has the further advantage of preserving biological samples as close as possible to their natural state [3,4].

No technique at present can provide three-dimensional imaging at nanometer resolution of the interior of non-crystalline particles in the micron size range. In life-sciences such technique is needed to determine the internal structure of assemblies of macromolecules, protein complexes and virus particles at a resolution sufficient to recognize known proteins and determine their relationships to each other. CDI can potentially fills this gap, however should overcome various experimental difficulties as well to improve the phase retrieval algorithm. An overview of recent achievements in the ESRF and around the world in this technique will be given.

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