IMAGING NANOSCALE OBJECTS BY FEMTOSECOND X-RAY DIFFRACTION WITH A SOFT-X-RAY FREE ELECTRON LASER

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The construction and commissioning of several VUV and X-Ray Free Electron Lasers (FELs) around the world presents exciting new opportunities to study phenomena that are far beyond the reach of current experimental capabilities. The broad scope of the proposed research at these facilities also provides excellent chances for enriching interdisciplinary collaborations between the physical, chemical, material and biological sciences. For instance, the high brightness and the ultra-short time structure of the FEL radiation allows time-resolved experiments on the femtosecond scale that follow (bio-)chemical reactions or probe the dynamics of fundamental processes in atomic, molecular and condensed matter physics.

Of particular interest is the so-called femtosecond diffractive imaging of nanometer- to micrometer-sized objects [1]. With this technique, a single diffraction pattern can be recorded from a large macromolecule, a virus or a cell before the sample explodes [2].

In this talk, I will review the basics of the femtosecond diffractive imaging technique and present results obtained using the first soft-X-ray FEL in the world, the FLASH facility at DESY in Hamburg. Using intense VUV radiation between 7 and 32 nm, diffraction images were obtained for various physical and biological targets ranging from van-der-Waals clusters to DNA molecules [3] and small living organisms. These experiments demonstrate the capability of single-shot imaging of nanoscale objects and represent an important step towards imaging uncrystalized biomolecules with sub- nanometer resolution.

Within a few years, several new FELs, which are currently under construction around the world, will allow extending the single particle imaging technique to the hard x-ray regime. An outlook on these planned experiments will be provided and the accompanying challenges will be discussed.

References

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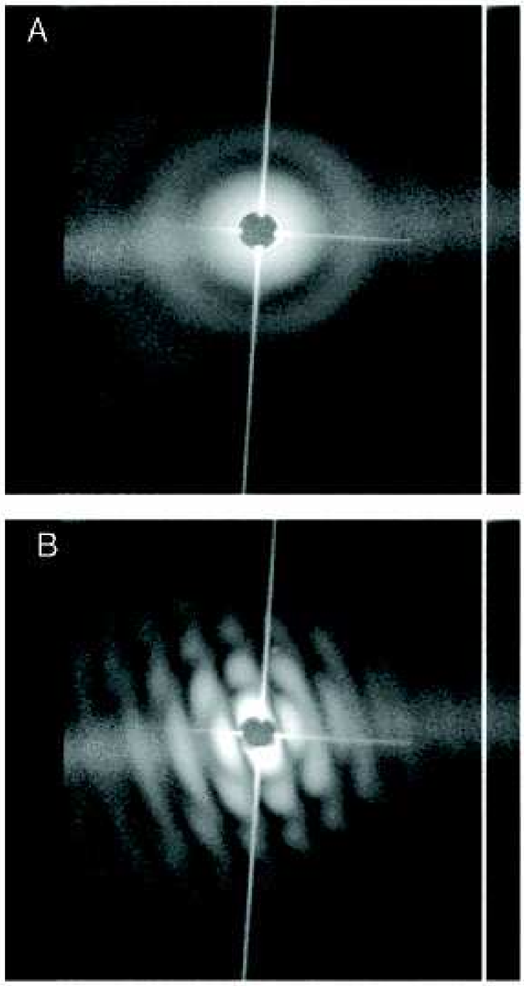

Figure 1. FLASH X-ray coherent diffraction patterns of (A) a single particle and (B) two particles [3].