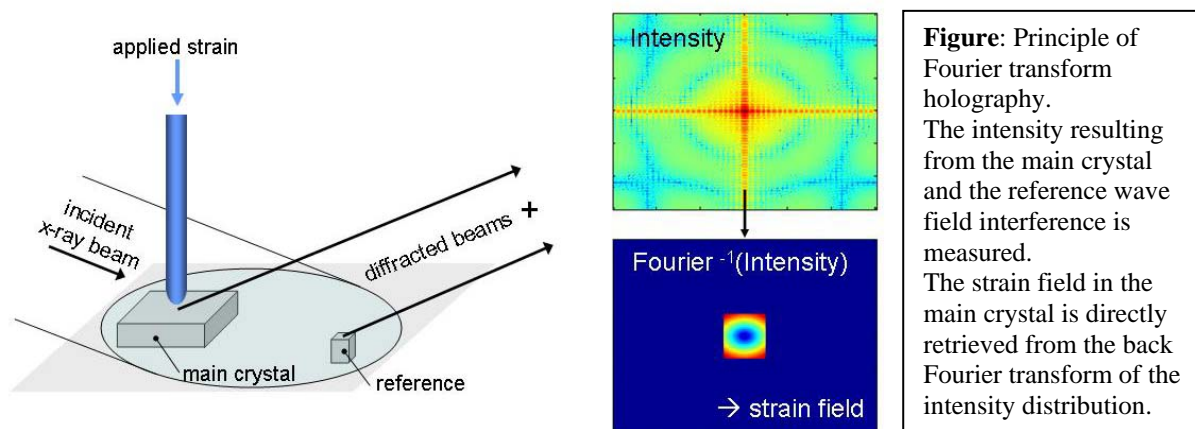


## PhD project : Determination of local strain using x-ray diffraction holography

The nanoworld has opened up new and attractive physical properties of materials as well as first applications resulting from the nanostructuration. At this scale, the detailed knowledge of the nanostructure is of major relevance to understand and monitor the physical properties. The question of the internal strain field distribution remains especially challenging. It requires not only a high sensitivity for atomic positions with nanometer resolution but also the capability to analyze as many as  $10^4$ - $10^{10}$  atoms to address crystal structure in the 10-1000 nm range. Although the electron based diffraction techniques present an excellent resolution, a great advantage of diffraction with x-rays results from the weak interaction of x-rays with matter, leading to non-destructive investigations of bulk materials. However, due to the lack of x-ray lenses for direct imaging, the x-ray diffraction analysis is strongly model dependant. In this context, the recent development of lens-less imaging techniques with coherent x-rays is promising as it combines the sensitivity of x-rays with a model free analysis and the expected atomic resolution.

Lens-less imaging techniques using coherent x-rays offer the newest solution to the century-old problem of phase retrieval. The use of a coherent beam ensures the possibility to encode the phase information in the reciprocal space *speckle* pattern. Instead of lenses, computer based methods are used for the image reconstruction. [1-3]. An alternative way is to reconstruct an image by experimentally encoding the speckle pattern by a reference wave in the so-called Fourier Transform Holography (FTH). Here the real space image is obtained by a simple inverse Fourier transform (see figure below) [4]. While the first experimental realization was already obtained in 1965 with visible light, one had to wait until the early 90's to further push the method in the x-ray regime, which is mandatory for nanoscale applications in order to overcome the micrometric diffraction-limited spatial resolution of conventional lasers. Several demonstrations using soft x-rays were obtained using synchrotron sources [5]. With the development of highly brilliant third generation synchrotron sources, such experiments become now possible in the hard x-ray regime, opening up the possibility for local strain investigation by FTH.

**The aim of this 3-year PhD project is to demonstrate the possibility of strain imaging using FTH in the Bragg condition. Investigated crystals will be model systems such as simple metals (Au, Cu) or semi-conductors (Si, Ge). The project results from a collaboration between the ESRF (A. Madsen, T. H. Metzger, Grenoble) and the IM2NP (V. Chamard and O. Thomas, Marseille). Hence, the PhD student will be located for one year in Grenoble and two years in Marseille. Additional experiments will be scheduled at the APS (Argonne, USA). The candidate should hold a degree in Physics allowing enrolment for a PhD, such as an MSc, Master 2 de Recherche, Laurea or equivalent. He/she should develop both experimental and computing skills. Please note that English is the working language at ESRF. The PhD grant will be co-financed by the French CNRS and ESRF. Applications will be accepted until June 2008.**



[1] J. Miao *et al.*, Nature **400**, 342 (1999); [2] M. A. Pfeifer *et al.*, Nature **442**, 63 (2006); [3] A. Minkevich *et al.*, Phys. Rev. B **76**, 104106 (2007); [4] G. W. Stroke and D. Falconer, Phys. Lett. **13**, 306 (1964); [5] S. Eisebitt *et al.*, Nature **432**, 885 (2004)

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