ESRF	**Experiment title:** **Strain effects in order-disorder fluctuations**	**Experiment number**: HS-1549
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Report:

In the past we have successfully implemented new methods for the time-averged measurement of diffuse short-range order patterns from various binary alloy systems [1]. For the analysis of this data we applied novel reciprocal space methods which have been developed within our department [2]. The results deduced from these investigations imply that short-range order fluctuations are strongly affected by the resulting strain in the system. Therefore, the aim of the current series of experiments is to perform time-resolved studies of the short range order fluctuations by XIFS. For many years, intensity fluctuation spectroscopy (IFS) has been a very useful tool to study fluctuation phenomena by using coherent visible light. With the advent of modern synchrotron sources like ESRF, it becomes more and more feasible to apply this technique in the X-ray regime (XIFS). Although in principle a chaotic light source, the beam of modern undulator sources can be remarkably coherent. Its large transverse coherence length results from the small source size (seen from the sample's point of view), and the narrow energy bandwidth yields an acceptable longitudinal coherence. In order to improve the coherence properties of the beam and reduce higher harmonics (the mirrors at ID1 were not operative at the time) the first harmonic of the undulator was used. This reduced the K-factor and minimized the effective source size, which was <u>not</u> further reduced by slits or pinholes. Since coherent experiments are a rather new technique at ID01, we studied the coherence properties of the beam and their stability by monitoring the Fraunhofer diffraction pattern from the sample aperture, a slit assembled from a set of polished molybdenum cylinders.
The coherence properties of the beam at ID01 exceeded our expectations by far, since we observed diffraction patterns for a slit gap up to 30μm and more. In order to resolve the diffraction pattern the diffractometer was not moved, but only the more precise offset position of the detector slit. The gap of the detector slit was set to 1μm. The visibility of the fringes allows to determine the coherence function. Our estimations taking into account the expected coherence lengths indicate, that the resolution limitations due to the 1 μm detector slit gap can be neglected.

Fig. 1 shows the diffraction pattern of a 6.7 µm wide horizontal slit gap. The asymmetry of the fringes is due to a displacement of the cylinders of 3mm with respect to each other. Partial coherence limits the visibility of the fringes, the calculated curve takes into account a gaussian coherence function with a FWHM of 25 µm. In fig. 2 the intensity from a 25.5 µm wide slit is compared with a calculation taking into account a coherence function with a FWHM of 23.3 µm.

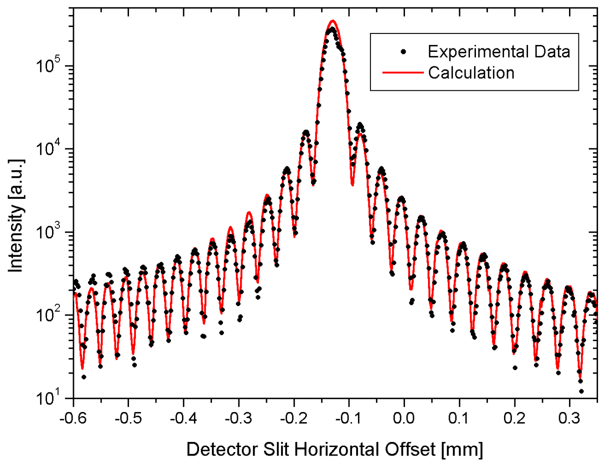

Fig. 1

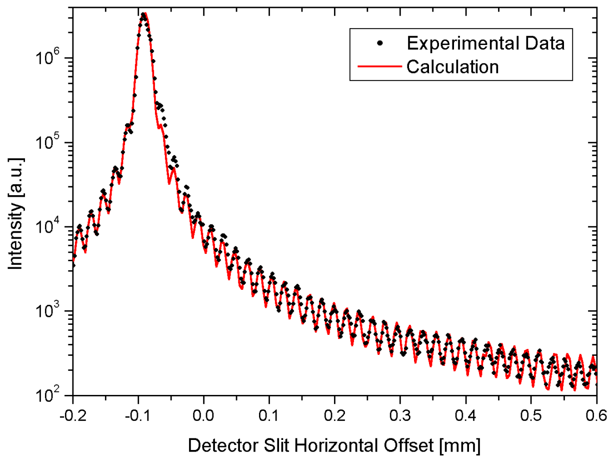

Fig. 2

One experimental problem was, that the coherence changed as a function of time and was lost sometimes almost completely within an hour. This was caused by two adverse effects: on one hand, the monochromator crystal had imperfections. Therefore, the coherence of the beam was dependent on the position of the beam on the crystal. On the other hand, the piezo device adjusting the monochromator tilt was subject to a certain drift. Both effects together led to instabilities of intensity and coherence. This problem is taken care of in the meantime and will not cause problems in future experiments. Nevertheless, the measurements stress an important point: coherent scattering experiments for the investigation of fluctuations require a simultaneous test of the degree of coherence independently from the signal itself.

The sample was of a 0.3 mm thick Cu_3Pd bulk crystal electrochemically thinned by well established techniques for the preparation of HRTEM samples. The thickness increases gradually from a hole in the center of the sample to the full 0.3mm at the rim. The diffraction experiment was carried out in transmission geometry at a 4.5µm thick spot on the sample, which is slightly smaller than the attenuation length of the 7.5keV rays used. Unfortunately, the crystal structure was damaged in this area, a fact that could not be noticed in the previously performed diffraction studies with our lab based sources. These studies were conducted using the beam from an X-ray tube with a much larger diameter than that of the coherent synchrotron beam, thus averaging over a larger portion of the predominantly intact sample.

Because of these problems the diffraction part of the experiment yielded no satisfactory data.

For future experiments, which we consider very promising with the highly coherent beam at ID01, the sample preparation will be refined and preliminary experiments will include X-ray diffraction with better collimated beams and electron microscopy techniques. In addition, we will modify the setup at ID01 in order to monitor the coherence properties of the beam in situ.

[1] H. Reichert, V.N. Bugaev, O. Shchyglo, A. Schöps, Y.Sikula, H. Dosch, Strain-induced nonanalytic short-range order in the spin glass $Cu_{83}Mn_{17}$, Phys. Rev. Lett. **87**, 236105 (2001).

[2] V.N. Bugaev, H. Reichert, O. Shchyglo, A. Udyansky, Y. Sikula, H. Dosch, q-space configurational energy and short-range order in alloys with atomic size mismatch, submitted to Phys. Rev. B.