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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Testing of a hard x-ray sheaing interferometer for differential phase contrast imaging microfocusing	**Experiment number**: MI 521
Beamline: BM5	**Date of experiment**: from: Nov. 21st 2001 to: Nov. 26th 2001	**Date of report**:
Shifts: 15	**Local contact(s)**: E. Ziegler	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Name(s): Dr. Christian David*
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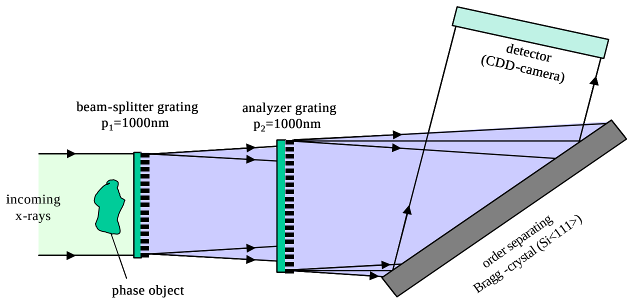
Report: The improved quality of modern synchrotron sources has led to a greatly increased coherence of the produced x-rays. On one hand this opens up the possibility to perform a large number of completely new scientific experiments. On the other hand the problem to maintain the quality of the generated radiation throughout all optical components of a beam line arises. The most sensitive method to measure the distortion of a wave front relies on the use of interferometers. A set-up for a Mach-Zehnder type interferometer for hard x-rays was introduced by Bonse and Hart [1]. It consists of three partially transmitting Bragg crystals used as beam splitter and recombining elements. The main technical difficulty of the Bonse-Hart set-up lies in the extreme demands with respect to the mechanical stability of the optical components. We have developed a different kind of set-up, which is known from visible light optics as shearing interferometer. Here, the incoming plane light wave is not split into two completely separated branches but merely sheared by a small angle. For this purpose we fabricated Silicon diffractive optics with high aspect ratio structures by electron-beam lithography and wet chemical etching. Similar to previous experiments with linear Fresnel lenses, the



'***Fig. 1:*** *Schematic view of the shearing interferometer set-up consisting of two gratings and a Bragg-crystal.*

effective structure height of the phase gratings was tuned to optimum by tilting the devices with respect to the beam [2].

We successfully tested this interferometer for photon energies 12.4, 15 and 24.8 keV. The basic set-up is depicted in Fig. 1. The first grating splits the incoming wave into the +1st and –1st diffraction orders. The interference of these two wave-fronts results in a pattern of interference lines, which is analyzed by the second diffraction grating. The relative phase of the two beams determines how the incoming intensity will

be distributed over the analyzer's diffraction orders. We used a Si>111> Bragg crystal to separate the zeroth diffraction order. By a slight angular misalignment of the two gratings we obtained an interferogram of Moiré-lines with excellent visibility. The set-up was not sensitive to mechanical drift or vibrations.
We used 100 and 200 µm diameter poly-styrene spheres as well defined phase objects to investigate the possibilities of differential phase imaging. A change of the orientation of the Moiré-lines is observed, which is directly linked to the difference in phase of two beam separated some tens of micons (depending on the grating pitches, separation, and the x-ray wavelength). A large number of interferograms for different experimental settings (energy, alignment, etc...) were recorded with a FRELON camera. Figure 2 shows a series of interferograms taken with different degrees of misalignment of the gratings orientation.

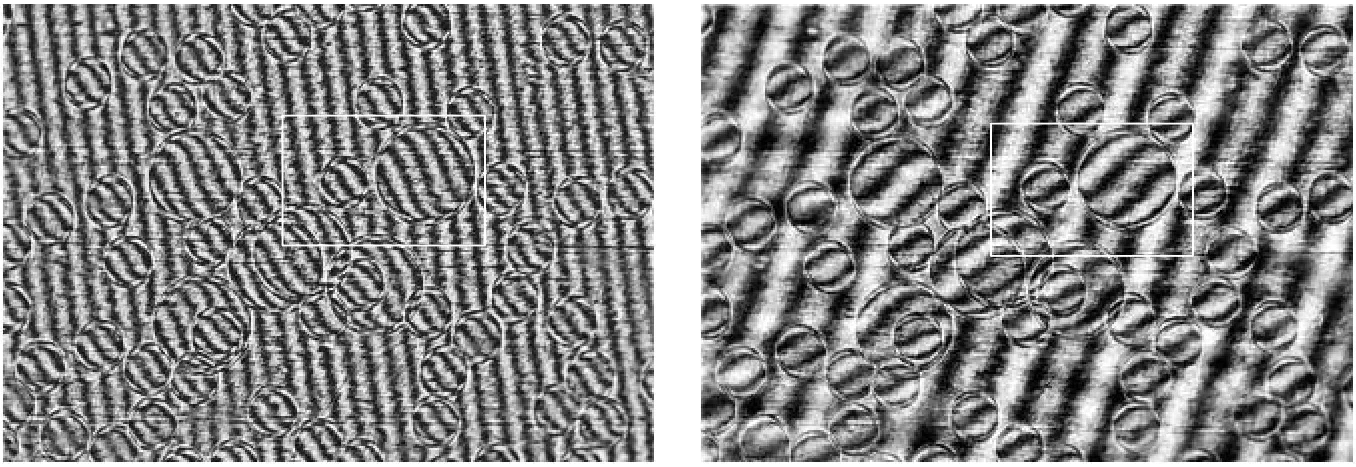


Fig. 2: *Shearing interferograms of 100 and 200 mm diameter poly-styrene spheres taken at 12.4 keV.*

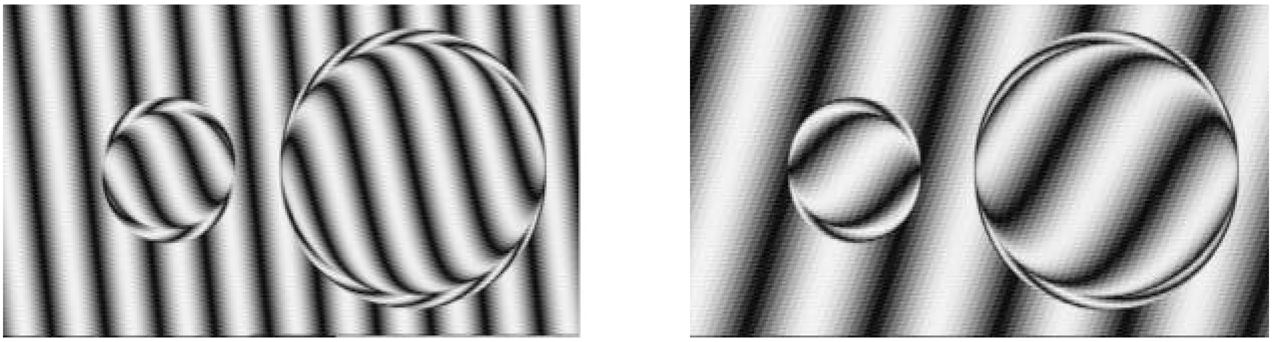


Fig. 3: *Numerically simulated interferograms corresponding to the marked regions in Figure 2.*

The obtained interferograms are in excellent agreement with numerical simulations (see Figure 3). This shows, that a reconstruction of unknown phase objects from such images could be possible. Our method may therefore open up a new possibility visualize an object with enhanced contrast, which could help to reduce the applied doses in x-ray micro-radiography. Another application is to analyze the wave front distortions caused by reflective x-ray optics.

A publication on these experiments to be submitted to Applied Physics Letters is presently under preparation. Future work will address two problems: 1) the Bragg analyzer used in this experiment made the aligment of the set-up very complicated and caused a great loss in intensity as only one diffracion order was used for image formation. We intend to make it obsolete by taking a highly absorbing second grating. 2) The flux at the used bending magnet was by far too low to do the alignment of the set-up using live images. The use of insertion device radiation will be necessary for future work.

We gratefully acknowledge the help of beamline scientist Eric Ziegler in this experiment.

REFERENCE

[1] U. Bonse and M. Hart, Appl. Phys. Lett. **6** 155 (1965)

[2] C. David, B. Nöhammer, E. Ziegler: Appl. Phys. Lett. **79** 1088 (2001)