ESRF	**Experiment title:** Study of refraction phenomena during diffraction on V shaped longitudinal groove	**Experiment number**: MI-314
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Report:

The measurement of sagittal deviation of x-ray beam diffracted on inclined surface of Si(111) single crystal was performed on BM5 beamline at ESRF for λ = 0.1 nm and inclination angle $\beta = 70^0$. The measured value agrees with the theory developed in previous papers. The topographic picture of the longitudinal edge shows a structure, which is explained in terms of the properties of inclined diffraction.

In previous papers it was shown that the beam diffracted on an inclined surface with the inclination angle β is sagittally deviated from the diffraction plane by an angle $\delta = K \tan \beta$. The geometry of the Si(111) single crystal sample with W shaped longitudinal groove used in this experiment is shown in Fig. 1. For the experiment we have chosen the sagittal divergence of the beam such that the beam slightly overfilled the groove. The vertical divergence was 1 mm. The diffracted beam was detected on the high resolution x-ray film Kodak at the distance 2 m from the sample. Without any refraction effect ($\delta = 0$) the cross-section of the diffracted beam would follow the W shape of the groove. In real case ($\delta \neq 0$), however, we should observe a splitting at the central part of the picture and a half splitting on the lateral parts of the picture which correspond to the diffraction on the edge between inclined and symmetrical part of the crystal. It is not possible to see directly the splitting 2δ (at the central part of the picture) because of the finite value of diffraction region ω_δ (in sagittal direction) which is comparable with δ. However, it should be obviously possible to see the gap $w = 2\delta - \omega_\delta$ (visible gap). To maximize the splitting we used relatively high β. The measurement was performed on BM5 beamline at ESRF. To utilize an advantage of the small vertical size of the source (80 μm) we placed the crystal sample such that the diffracting (111) planes were vertical. The radiation was monochromatized by a channel-cut Si (111) crystal oriented in the same way as the sample and placed before the sample. The beam diffracted on the edge was registered at the distances of 2 m. The wavelength used was 0.1 nm. The measured inclination angle of **W** sample was $\beta = 70.25^\circ$.

The value of δ calculated for our experimental arrangement is $\delta = 1.096 \times 10^{-4}$. The expected value of the splitting is $w = 0.2143$ mm (visible gap). This value was drawn in the photographic picture (blue lines) taken at the distance of 2 m (fig. 2) and it is seen that the calculated and measured gaps coincide pretty well. The measured value of w is 0.21 ± 0.04 mm which gives the experimental value $\delta = (1.07 \pm 0.2) \times 10^{-4}$.

The existence of ω_δ introduces some uncertainty in the determination of δ because the splitting is not sharp enough and also the distance sample – film could not be in this experiment longer than 2 m. It is obvious that more precise measurement is needed. As follows from (Hrdý & Siddons, 1999) the sharpness of the splitting should be substantially increased by using 2 or 4 grooved crystals in the dispersive (-,+,+,-) arrangement. In this case the horizontal broadening of the diffracted beam due to ω_δ is canceled and the value of the splitting (visible gap) should be $4\delta l$ in case of 2 edges in dispersive position or 8δ in case of 4 edges in dispersive position.

The topographic picture consists of many almost horizontal lines creating the "Christmas-tree" like structure, which may be explained in terms of the inclined diffraction properties. It is interesting to note, that the neighboring points on the crystal along the edge create (almost) horizontal lines <u>which do not overlap</u> (they are arranged parallel). On the other hand the same points in the case of symmetrical diffraction would create vertical lines which would overlap. This means that the structure would represent for monochromatic radiation the kind of topographic image of the edge region (or corresponding part of the channel-cut monochromator located upstream) which would have higher resolution than is reachable with symmetrically cut crystal. On the other hand it is obvious that for neighboring points arranged perpendicularly to the edge the resolution should be much worse because of large ω_δ. This should be kept in mind when performing topographic pictures of crystals utilizing diffraction planes which are not parallel to the surface.

The magnification of the lateral part of Fig. 2 which shows the diffraction on the edge between symmetrical and inclined part of the crystal shows interference patterns along the edge. The most probable explanation is that these fringes are due to the interference on the edge of the slit which delimits the sagittal divergence of the radiation. The more precise explanation would need an additional experiment.

References

Hrdý, J. (1998). *J. Synchrotron Rad.* **5**, 1206-1210.

Hrdý, J., Siddons D. P. (1999). *J. Synchrotron Rad.* **6**, 973-978.

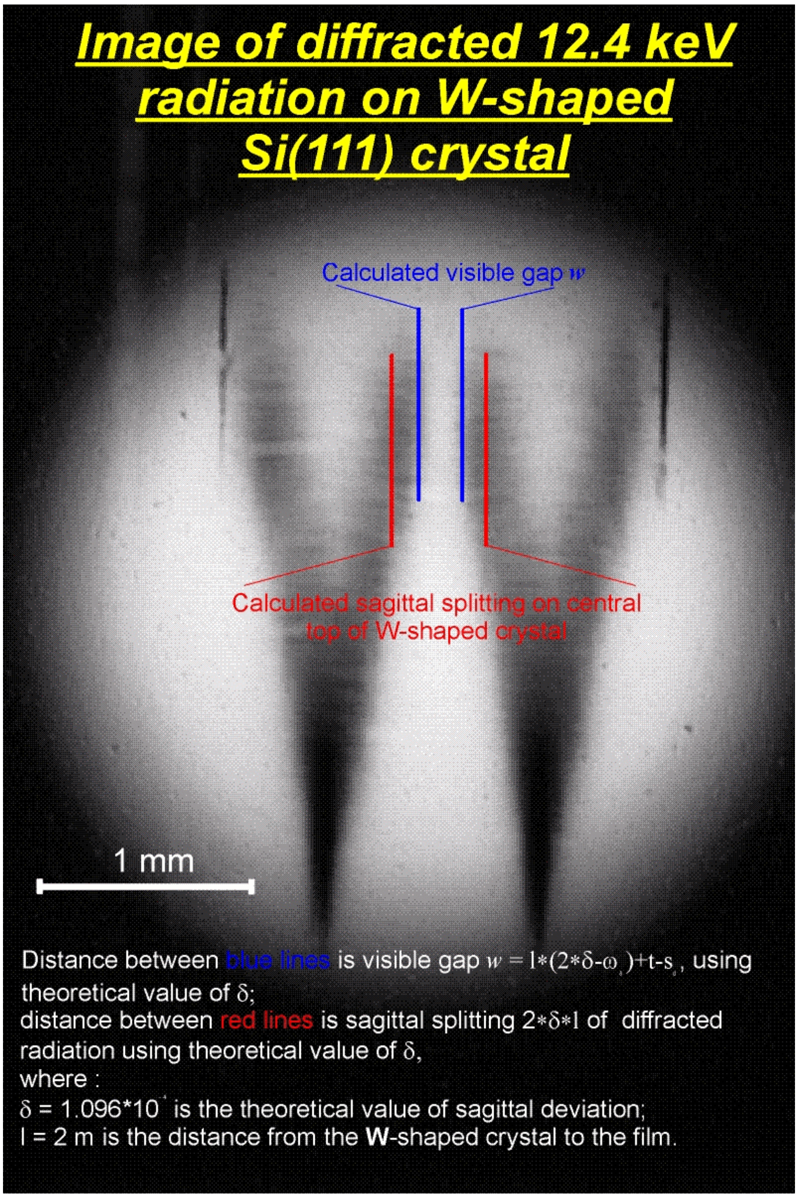

Fig.1.

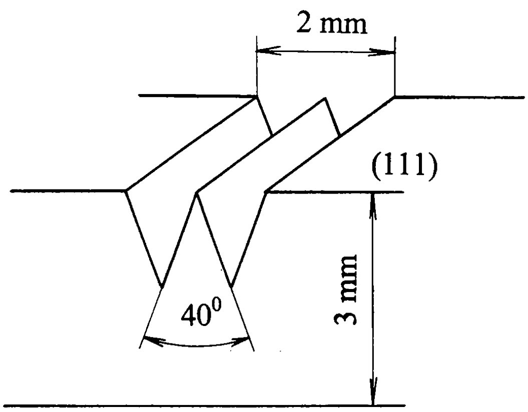

Fig.2.