Excitation of evanescent wave by parametric X-ray radiation

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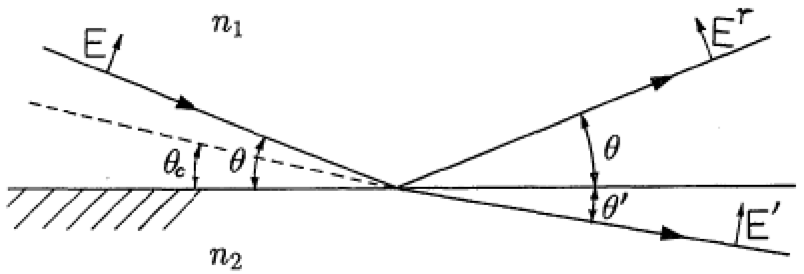
Compton first found that the refractive index is n<1 for X-rays in the medium and demonstrated experimentally the external reflection of X-rays.
A.H. Compton, Phil. Mag. 45 (1925) 1121.

The critical angle for transparent medium at frequencies exceeding the atomic frequencies is $\theta_c = \frac{\omega_p}{\omega}$,

that is just relation of plasma frequency to X-ray frequency.

Now the external reflection is used in different kinds X-ray optics, including e.g. experimental X-ray space astronomy.



Shozo INO
Journal of the Physical Society of Japan
Vol. 65, No. 10, October, 1996, pp. 3248-3253

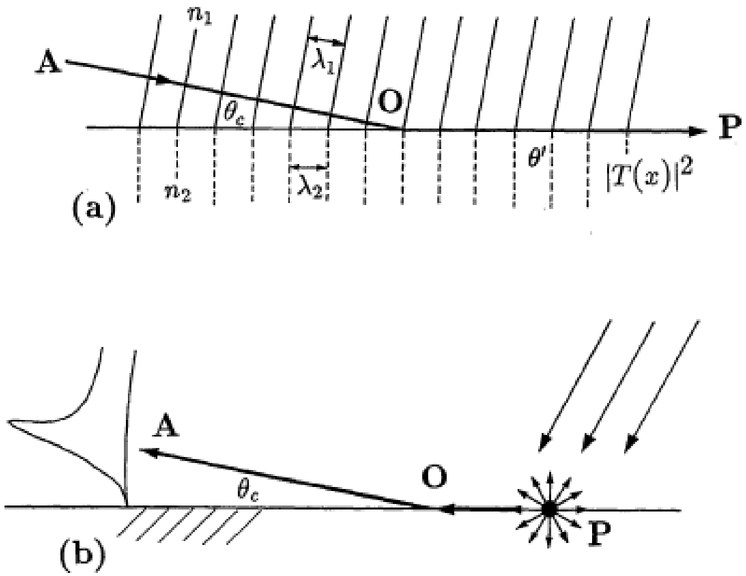


Fig. 2. Formation of the evanescent wave for grazing incidence of X-ray and it's observation. (a) Formation of evanescent wave at the surface. (b) X-ray excitation by an electron beam and it's observation. According to the reciprocity theorem, the X-rays emitted parallel to the surface create the same angular intensity distribution with $|T(x)|^2$.

Observation of the evanescent wave of characteristic X-rays, excited by 15 keV electron beam

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VOL. 24, NO. 6, JUNE, 1985 pp. L387–L390

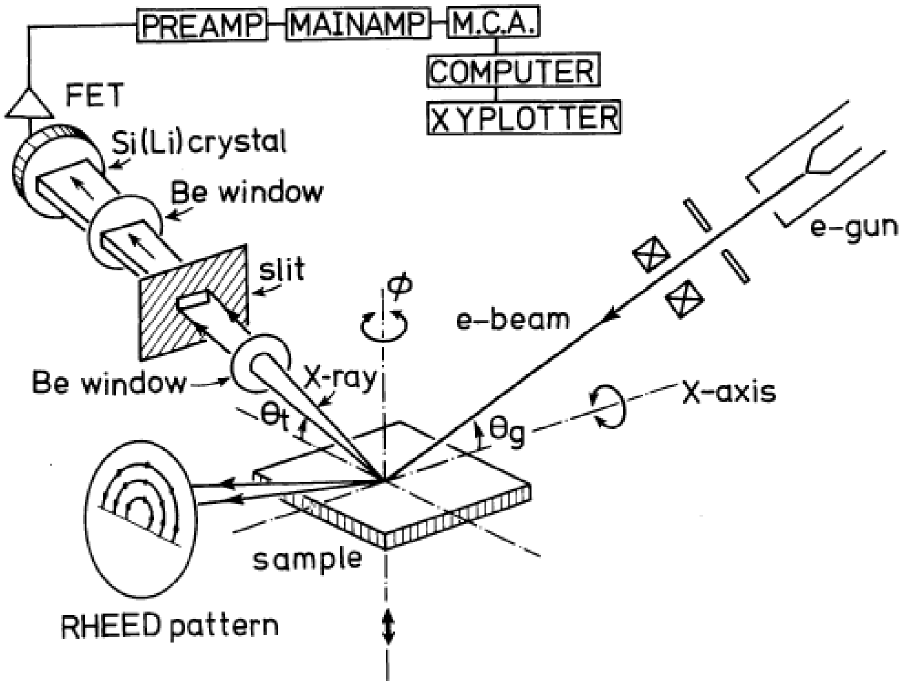


Fig. 1. Schematic illustration of the apparatus used for total-reflection-angle X-ray spectroscopy in RHEED experiments (RHEED-TRAXS).

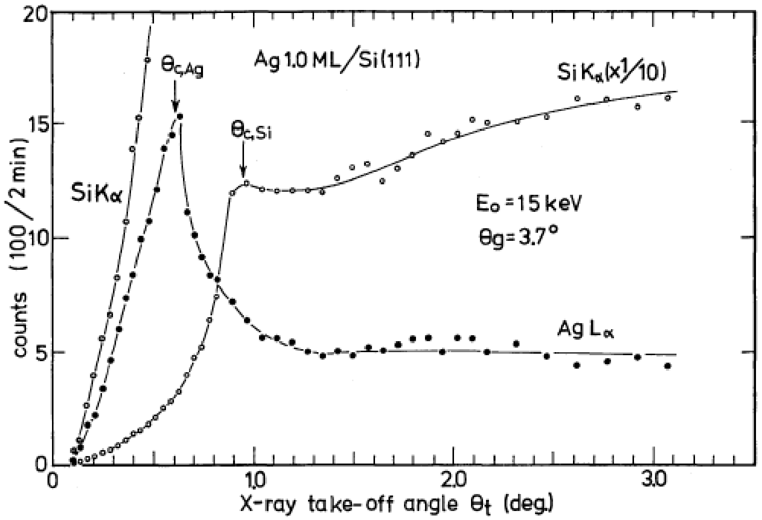


Fig. 3. Depedences of the absolute intensities (peak heights) of the characteristic X-rays on the X-ray take-off angle θ_t. The spectra were taken from the clean Si(111) surface after Ag deposition of 1.0 monolayer. Arrows show the critical angles for total reflection of each characteristic X-ray by silicon.

Experiment with characteristic X-rays, excited by 0.5 MeV proton beam

V.P. Petukhov / Nucl. Instr. and Meth. in Phys. Res. B 150 (1999) 46–49

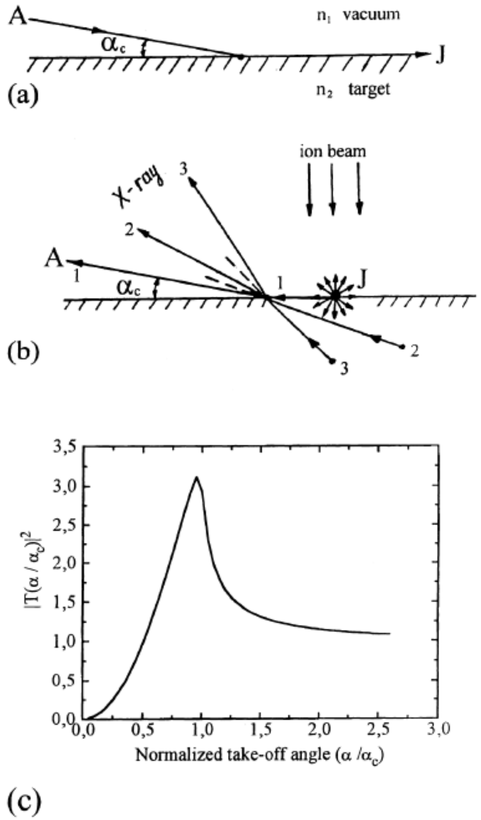


Fig. 1. A schematic illustration of the evanescent wave formation. (a) Formation of the evanescent wave at a surface for grazing incidence of X-ray. (b) X-rays excitation by an ion beam and propagation of X-rays emitted from a points in the target. (c) Angular intensity distribution of the evanescent wave.

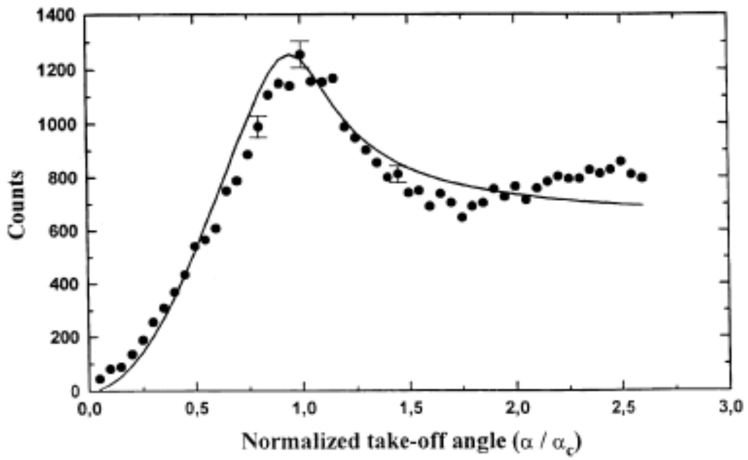
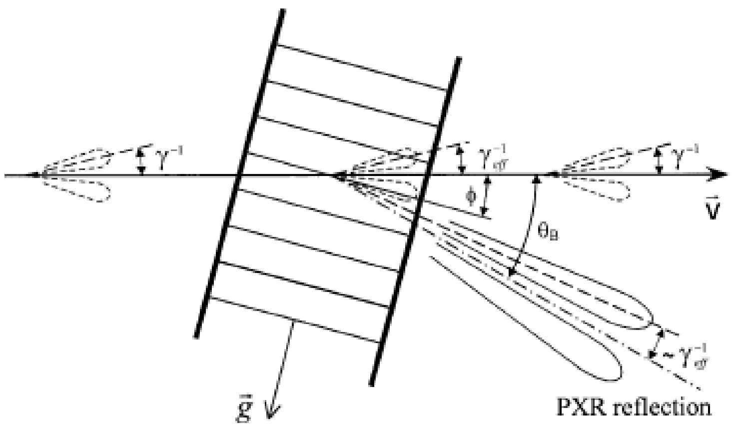


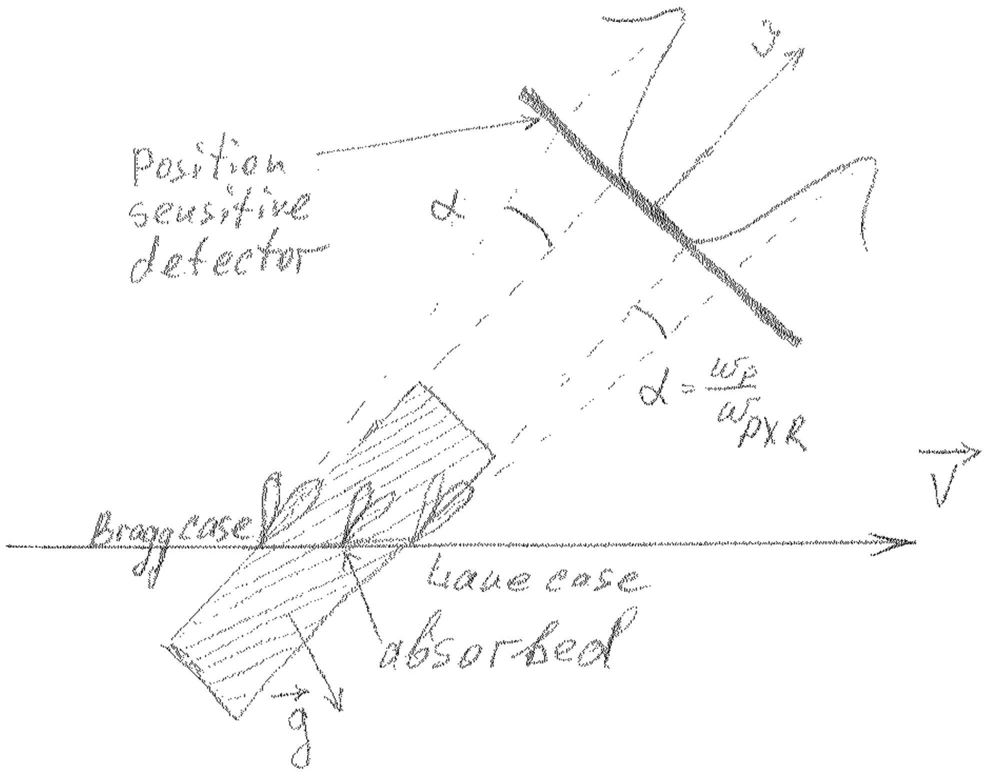
Fig. 2. Dependence of the intensity of K_α line emitted from C atoms on the X-ray take-off angle. Solid line presents the calculation of transmissivity $|T(\alpha/\alpha_c)|^2$ for Si with $\beta/\delta = 0.3$.

We will not discuss asymmetric diffraction schemes here

Before, the characteristic X-ray radiation was used as a source of radiation for excitation and observation of the evanescent wave.
The characteristic X-rays are quasi-monochromatic, and isotropic radiation.
We propose to use the PXR as a source of radiation for excitation and observation of the evanescent wave.
The PXR is tunable by direction, frequency and polarization.
The PXR is produced **inside** of the medium.



How to excite the evanescent wave by the PXR in Bragg and Laue geometries and how to observe it



Experiment at SAGA LS, Japan, target - 20mkm Si crystal, Observation angle 32.2°, 255 MeV electron beam

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Observation of parametric X-ray radiation by an imaging plate

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ABSTRACT

We have demonstrated experimentally the application of an imaging plate for registering the an tribution of parametric X-ray radiation. The imaging plate was used as a two-dimensional posi sitive X-ray detector. High-quality images of the fine structure in the angular distributions of around the reflection of the parametric X-ray radiation produced in a silicon crystal by a 255-M tron beam from a linear accelerator have been observed in the Laue geometry. A fairly good a between results of measurements and calculations by the kinematic theory of parametric X-ray is shown. Applications of the imaging plates for the observation of the angular distribution of X- duced by accelerated particles in a crystal are also discussed.

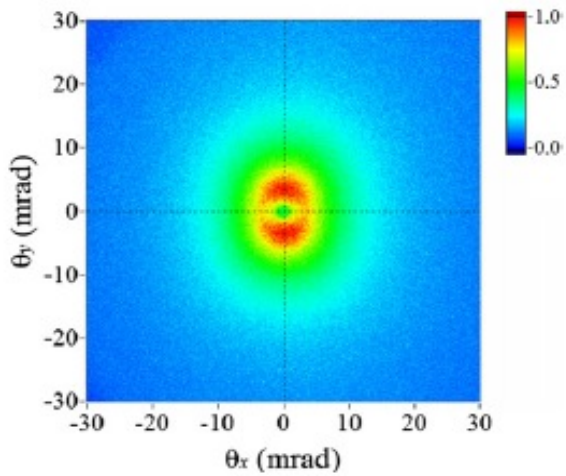


Fig. 2. Two-dimensional angular distribution in the PXR reflection observed with the imaging plate. The center of the PXR reflection (Bragg direction) is at $\theta_{x,y} = 0$.

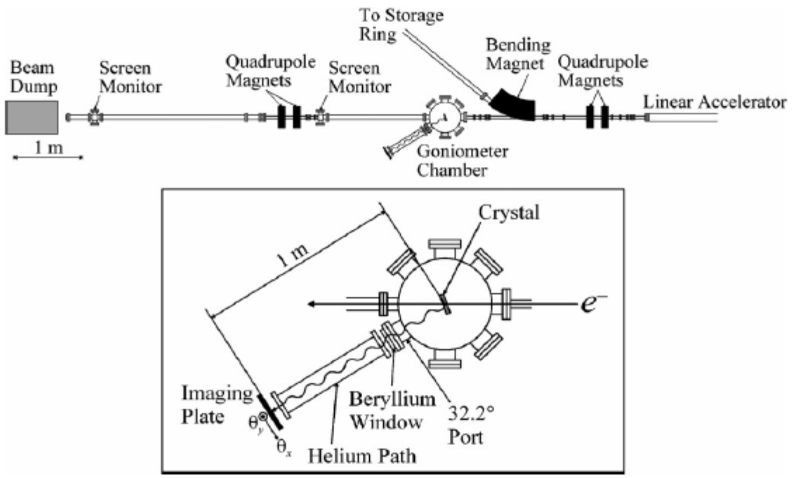


Fig. 1. Scheme of the experimental setup (top view). The inset shows an enlargement of the setup around the goniometer chamber. A duct filled with helium gas was placed between the chamber and IP in order to reduce the attenuation of X-rays in air.

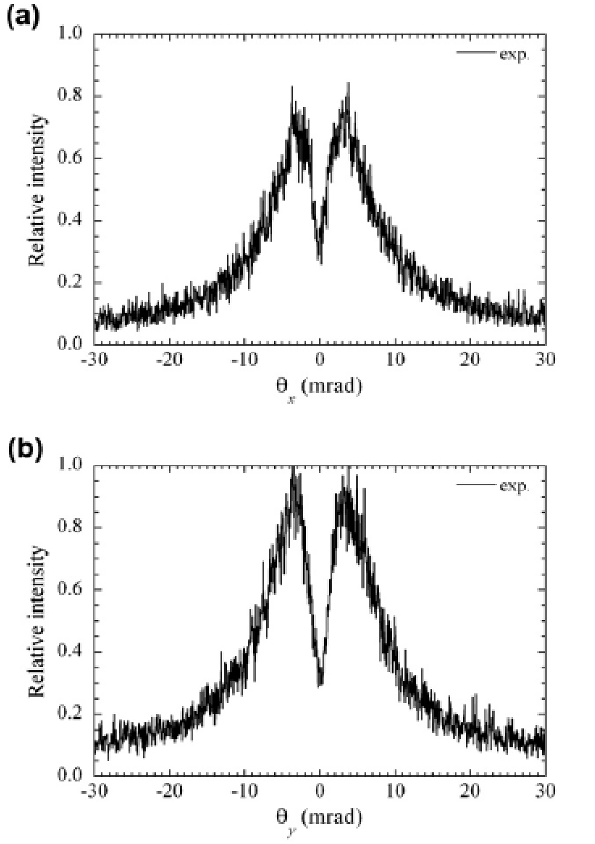


Fig. 3. (a) Horizontal and (b) vertical cross-sectional profiles. The positions of the cross sections are indicated by the dotted lines in Fig. 2. These one-dimensional data were extracted from single pixel (50 × 50 μm) rows from the two-dimensional data presented in Fig. 2.

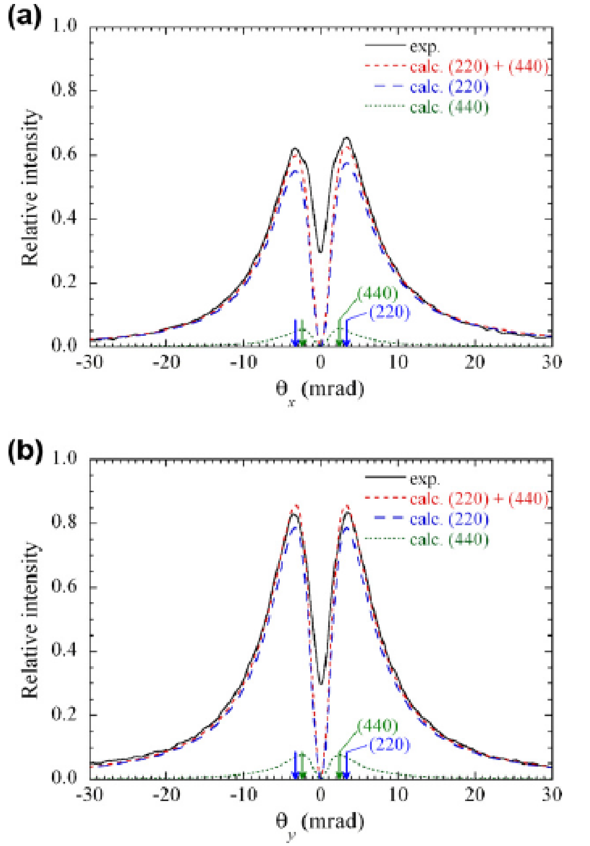


Fig. 4. (a) Horizontal and (b) vertical cross-sectional profiles. Data from Fig. 2 were averaged over an area of 1 × 1 mm (1 × 1 mrad) on the IP. Black line: experiment, red line: calculation by Eq. (3), blue line: contribution of the (220) PXR reflection, green line: contribution of the (440) PXR reflection. The angular sizes calculated by Eq. (2) for the (220) and (440) PXR reflections are indicated by the blue and green arrows, respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

straggling of the data reflects the restricted number of quanta reg

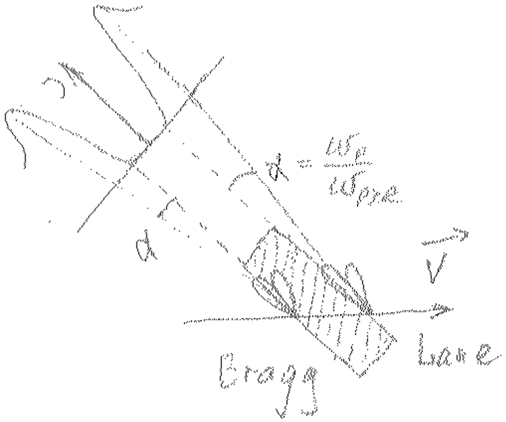
Agreement with PXR kinematic theory by Ter-Mikaelian is with accuracy about or less then 5% (out of the reflection center).

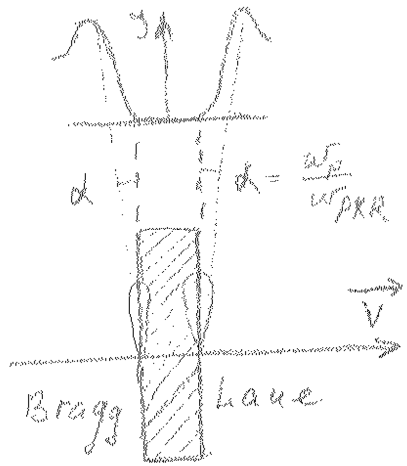
This may be e.g. due to irregularity of the background.

Other schemes:

Excitation of the evanescent wave in backward hemisphere and at the right angle to the particle beam.

At the right angle the take-off angle is 4.6 mrad for Si(220) at the experimental angular resolution about 1 mrad (FWHM)





Thus, experimental possibility for observation of the evanescent wave excited by the PXR exists in SAGA-LS.

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Thank you for yours attention