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The formation of the X-ray phase contrast under the diffraction focusing of the spherical wave

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The study of the inner structure of the weak-absorbing noncrystalline materials as well as the biological objects is carried out by the method of the X-ray phase contrast which at present is substantially in progress.

In the present work the possibility of reconstructing the inner structure of the one-dimensional phase objects under the diffraction focusing of the X-ray spherical wave is reported.The fact that with the incidence of the monochromatic X-ray spherical wave on the crystal in Laue geometry the diffracted radiation is focused inside the crystal is used. The focal line is perpendicular to the diffraction plane. Before entering the crystal the radiation is supposed to pass through the phase object where the inhomogeneities have one-dimensional distribution along the perpendicular diffraction plane. With the wave transmission trough the phase object the conditions of the focusing are broken: because of the refraction on the inhomogeneities the X-rays change their directions and the wave front is deformed. The intensity distribution analysis in the image diffracted from a strong-absorbing wedge-like crystal with rib parallel to the diffraction vector shows that the focusing is possible for every point of the phase object if one compensates the deviation from Bragg condition along the diffraction vector and the wave front deformation along the perpendicular diffraction plane. The focusing is possible if the source-crystal distance is smaller than the ratio of the inhomogeneity size and the difference of the index of refraction from the unit.

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Birefringence in multiple X-ray scatterings deduced from the alternative theory of Pendelloesung beat

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As well-known, the basic property of dynamical theory of X-ray diffraction is the phenomenon of dispersion, namely variation of the refraction index with direction of wave vectors. This is described by dispersion surface [2]. Here, birefringence is shown by the alternative theory of Pendelloesung beat [1]. By using it, paths of the diffracted photons (DP) and transmitted ones (TP) in the Bormann triangle (BT) are counted by the alternatives of the diffraction (d) and transmission (t). Both DP and TP in n multiple scatterings are developed from the convolution of the binomial distribution, *i.e.,*

$$(d+t)^n = \sum_{r=0}^{n} {}_nC_r d^{n-r} t^r = 1 \ , \quad (1)$$

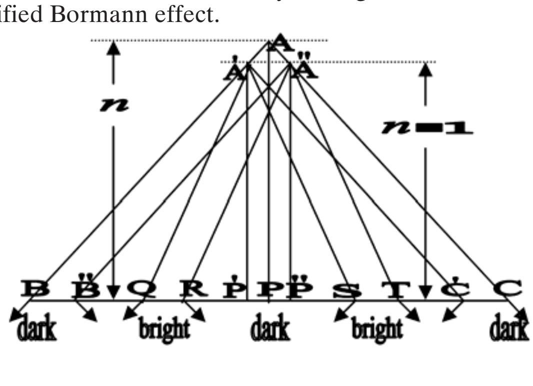
where $d=t=1/2$ ($d+t=1$). Both DP and TP are fixed by odd exponents of $d^{odd\ numbers}$ and even ones of $d^{even\ ones}$ in eq. (1), respectively [1]. Only *numbers* of both DP and TP can be separately counted by the following formula of

$$\sum_{r=0}^{n} {}_nC_r = \sum_{r=0}^{[n/2]} {}_nC_{2r} + \sum_{r=0}^{[(n-1)/2]} {}_nC_{2r+1} \ ,$$

but their *distribution* is unknown. (Here, [ ] is Gauss' notation.) Both distributions are separately shown in an example of $n=3$ as 1+3+3+1= (1+2+1+0)+(0+1+2+1) [1] from the formula of

$$\sum_{r=0}^{n} {}_nC_r = \sum_{r=0}^{n} \left({}_{n-1}C_r + {}_{n-1}C_{r-1} \right). \quad (2)$$

Here, ${}_nC_r = 0$, ($n<r$ or $r<0$). In the right side in eq (2), the 1st term corresponds to DP and the 2nd one to TP. Eq. (2) means that BT with index n could be split into two BT with index n-1 in the figure shown in figures in ref. [2]. Since the medians of AP, A'P' and A''P'' and both sides of AB, AC, A''B'' and A'C' in each BT have the highest exponent of n of d and t, respectively, these binomial coefficients are almost all zero [1], which means the darkness in X-ray. The maximum probability takes at n-$r \cong r$, *i.e.*, $r \cong n/2$, which lies A'Q and A'S of DP and A''R and A''T of TP that are medians of the four right-angled triangles in figure. The emitted photons from the vicinity of these form two highly concentrated photon beams due to birefringence from the binomial distribution. In symmetric Laue case with the scattering angle less than 90°, the angles of ∠ QA'S and RA''T are less than 45°. This ray tracing seems to be the new modified Bormann effect.



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