# Program Refra (Refraction parameters)

V. G. Kohn, 21-04-2020, kohnvict@yandex.ru

*NRC Kurchatov Institute, 123182 Moscow, Russia*

This paper presents a description of the program, i. e. how one can use it and a theoretical background, i. e. how the refraction parameters are calculated.

## 1. General information

The program calculates an energy dependence for an index of refraction Delta ($\delta$) and an index of absorption Beta ($\beta$), as well as the real and imaginary parts of the complex phase shift created by a slab of a thickness 1 $\mu$m. These data can be used in various estimations of several optical phenomena by means of analytical formulae. The input data have to be printed in the input windows of the program form. One example is shown at the beginning. The user must change numerical data and chemical formula according to the title of each input window.

The chemical formula contains the title of element (one capital symbol or one capital and one small symbol) followed by the index (number of atoms of definite kind) inside the round brackets. The index 1 may be omitted. There are the examples: Si, SiO(2), H(2)O, InSb. The user may edit the data each time and repeat the calculations. When the input data are ready, the user have to press the button [OK] and the results of calculation will be shown immediately in the special window. Simultaneously the results are saved to the file (refres.txt) in the program folder (s/vkRefra) relative to the folder of the main program vkACL.

## 2. Theoretical background

The complex refraction coefficient $n = 1 - \delta + i\beta$ allows to calculate how a phase of a plane wave of x rays is changed in matter compared to the vacuum (air). Let the phase of a plane wave in air be $kz$ where $k = 2\pi/\lambda$ is a wave vector and $z$ is a coordinate along the optical axis. Then the phase of a plane wave in matter will be $knz$. The phase shift of a plane wave in matter compared to air will be $\varphi = k(n-1)t$ where $t$ is a matter thickness. The phase has a real part $\varphi_r$ and an imaginary part $\varphi_i$. The imaginary part $\varphi_i = \mu t/2$ where $\mu$ is a linear absorption coefficient. The program presents the data for $\varphi_r$ and $\varphi_i$ in the case of $t = 1$ $\mu$m.

We note that $n = \chi_0/2$ where $\chi_0$ is a diffraction parameter for the case of scattering with the zero angle. One can read how to calculate $\chi_0$ in the article [1]. See the References section. The data for a calculation were taken from the internet.

## 3. Structure of the program

The program window has 5 buttons. The button [OK] allows user to run the program and to obtain the results. The button [Cancel] allows user to shut the program, i. e. to remove the window from the screen of display and to cancel the work with it. The user can choose another program or close the table of program icons.

There are 4 additional buttons which can be used if necessary. They play the role of additional service. The button [Help] allows to see this text. The button [Notes] opens the window of the internal editor to read from and write to the file (ref.txt). The user can create, save and restore some addition unformation about the program and variants of the input data.

The buttom [Save Var] allows user to save the current variant of input data in one of the 25 boxes of saving for the following use. The button [Choose Var] allows user to restore one of the 25 variants of the input data which was saved previously.

### References

[1] V. G. Kohn, Program for Calculating the Scattering Parameters Used in the X-ray Standing Wave Method, Crystallography Reports, 2006, **51**, N.6, 936-940. Click to read