How to use Wsb : Electromagnetic field simulator by BPM

1. Preparation before use and use conditions
2. Input/output and relationships between other software
3. Contents of output files
4. Execution method
5. Method of drawing calculation results
6. Input rules for input file (wsb06.dat)
7. Contents of wsb.dat (wsb01.dat)
8. Contents of wsb.dat (wsb02.dat)
9. Contents of wsb.dat (wsb03.dat)
10. Contents of wsb.dat (wsb04.dat)
11. Contents of wsb.dat (wsb05.dat)
12. Contents of wsb.dat (wsb06.dat)
13. Contents of nk.dat
14. Procedure for defining optical structures
15. Contents of wsb.dat (wsb07.dat)
16. Contents of wsb.dat (wsb08.dat)
17. Relationships (1) between kt and structures for kd=0
18. Relationships (2) between kt and structures for kd=0
19. Relationships (3) between kt and structures for kd=0
20. Relationships (4) between kt and structures for kd=0
21. Reference to sub.dat for kd=1 (sub.dat)
22. Contents of wsb.dat (wsb09.dat)
23. Method of forming a lens shape (wsb10.dat)
24. Method of converting AFM data by afm.exe (afm01.dat)
25. Pasting converted data of AFM (wsb11.dat)
26. Calculation example (wsb12.dat)
27. Notes (wsb13.dat)

1. Preparation before use and use conditions

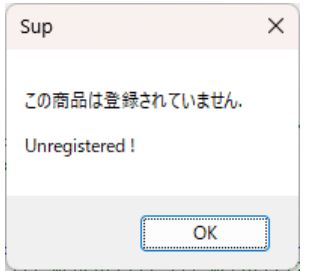
1. Operating environment (supported OS): Windows 64bit 7,8,10,11 Edition
2. Status at the time of distribution

		Included files
Ws_soft	Wsems	Wsems.exe, HScrollListbox.dll, Wsbch.exe, Wscnt.exe, Sup.exe(1) Wsf.exe, Wsr.exe, Wsb.exe, Afm.exe, Ems.exe nk.dat, sub.dat
	Picture	1_a1.png etc.
	Text	wsb_j.txt, wsf_j.txt, wsr_j.txt , wsb_e.txt, wsf_e.txt, wsr_e.txt
	Install	w_ifort_runtime_p_2022.2.0.3790.exe
	Samples	220401-cnt&mnt — i_xz.out, i_xz_t.out, i_xy.out, m_xz.out, m_xy.out, i_far.out
		220401-wsb — wsb01.dat～wsb13.dat
		220401-wsf — wsf01.dat～wsf14.dat
		220401-wsr — wsr01.dat～wsr17.dat
		Comparison — 230208-wsb — wsb_1.dat～wsb_9.dat
		230208-wsf — wsf_1.dat～wsf_9.dat
		230208-wsr — wsr_1.dat～wsr_9.dat
		nk_data.xlsx, sub_data.xlsx, nk.dat, sub.dat
		Wsems.exe_shortcut, ReadMe.txt

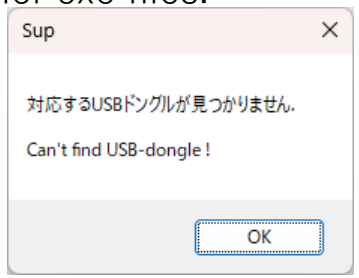
(note 1) Sup.exe is a file for determining registration, which should be stored in the same folder Wsems as other exe files.

3. Installation Procedure
   3.1 Copy the folder Ws_soft to a drive (e.g., drive D).
   3.2 Click on w_ifort_runtime_p_2022.2.0.3790.exe to install the runtime.
4. Uninstallation procedure
   Delete the folder Ws_soft.
5. Restriction on use
   - If a registered USB dongle is connected (or MAC address is registered) and the corresponding sup.exe is installed in the folder “Wsems”, calculation starts without any function restrictions.
   - If the sup.exe included in the folder “Wsems” does not correspond to the registered USD dongle or registered MAC address, the message ① is displayed for 5 seconds. If the USB dongle is not connected, the message ② is displayed for 5 seconds. Air and two optical materials limit applies. However, to the extent that use is within the limit, the calculation continues.

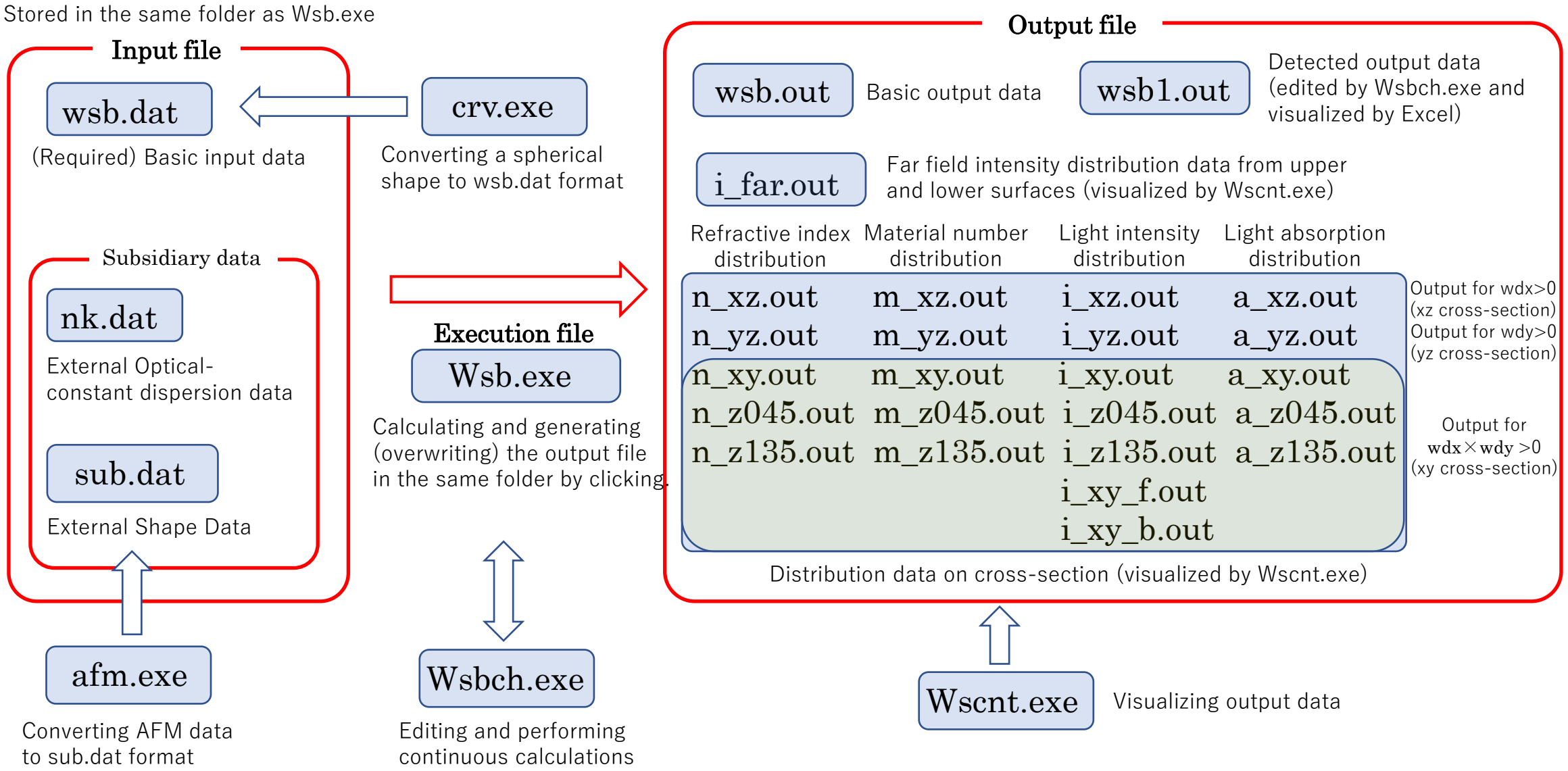
①



②



2. Input/output and relationships between other software



3. Contents of output files

wsb.out : Main calculation results. Step (number of grid steps), Layer (component layer number), z (step position number), neff (effective refractive index of propagating light), pk/pk0 (maximum of intensity ratio), Transmitted (transmissive light amount), Reflected (reflective light amount), Absorbed (absorbed light amount), Scattered (scattered light amount), Total (sum of the previous four), Compens (compensating rate for energy conservation), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount), Inflow_M01_-x(light amount flowing in from -x boundary of specified material 01). Outlow_M01_+x(light amount flowing out from +x boundary of specified material 01). Inflow_M01_-z(light amount flowing in from -z boundary of specified material 01). Outlow_M01_+z(light amount flowing out from +z boundary of specified material 01).

wsb1.out : Extracted calculation results. Transmitted (light amount flowing out from +z boundary surface of the analysis area), Reflected (light amount flowing out from -z boundary surface), Absorbed (absorbed light amount of the analysis area), Total (sum of the previous three), Inflow_M01_-x(light amount flowing in from -x boundary of specified material 01). Outlow_M01_+x(light amount flowing out from +x boundary of specified material 01). Inflow_M01_-z(light amount flowing in from -z boundary of specified material 01). Outlow_M01_+z(light amount flowing out from +z boundary of specified material 01).

m_xy.out : xy cross-sectional distribution of material numbers. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **m_xz.out** : xz cross-sectional (y = csy) distribution of material numbers. **m_yz.out** : yz cross-sectional (x = csx) distribution of material numbers. **m_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for material numbers. **m_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for material numbers. These images can be displayed by Wscnt.

n_xy.out : xy cross-sectional distribution of refractive indexes. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **n_xz.out** : xz cross-sectional (y = csy) distribution of refractive indexes. **n_yz.out** : yz cross-sectional (x = csx) distribution of refractive indexes. **n_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for refractive indexes. **n_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for refractive indexes. These images can be displayed by Wscnt.

k_xy.out : xy cross-sectional distribution of extinction coefficients. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **k_xz.out** : xz cross-sectional (y = csy) distribution of extinction coefficients. **k_yz.out** : yz cross-sectional (x = csx) distribution of extinction coefficients. **k_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for extinction coefficients. **k_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for extinction coefficients. These images can be displayed by Wscnt.

i_xy.out : xy cross-sectional distributions of light intensity (i. e., electric & magnetic field intensity ※). The round-trip distributions are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xy_f.out** : xy cross-sectional distributions of total light intensity for forward path (ncy>=3). The distributions for forward-path light are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xy_b.out** : xy cross-sectional distributions of total light intensity for backward path (ncy>=4). The distributions for backward-path light are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xz.out** : xz cross-sectional (y=csy) distributions of light intensity. In case of ity=0, the results for forward path, backward path, 2nd forward path, etc., and the last total are superimposed. In case of ity>0, accumulated intensity distributions are output separately for forward or backward path, and the distribution for overall paths is added on to the end (the same applies hereafter). **i_yz.out** : yz cross-sectional (x=csx) distributions of light intensity. **i_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for light intensity. **i_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for light intensity. These images can be displayed by Wscnt.

a_xy.out : xy cross-sectional distributions of absorption. The round-trip distributions are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **a_xz.out** : xz cross-sectional (y=csy) distributions of absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_yz.out** : yz cross-sectional (x=csx) distributions of absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. These images can be displayed by Wscnt.

i_far.out : Far-field intensity distributions (-z side and +z side in the order). The image can be displayed by Wscnt.

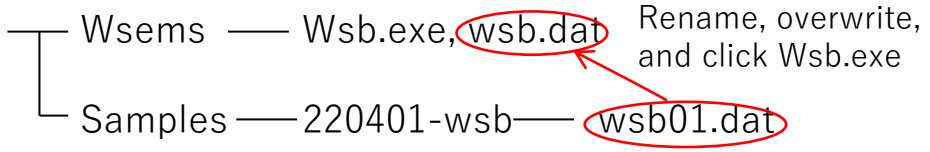
※ ity=0 : For a round-trip calculation(ncy>1), intensity distributions are defined by incoherent light. The interference between forward and backward light is neglected and overlapped light is treated as intensity sum of them. ity=1 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for an electric and magnetic field. ity=2 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for an electric field. ity=3 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for a magnetic field.

4. Execution method

Among the three methods, we strongly recommend (1) because it allows setting numerical data without worrying about input rules.

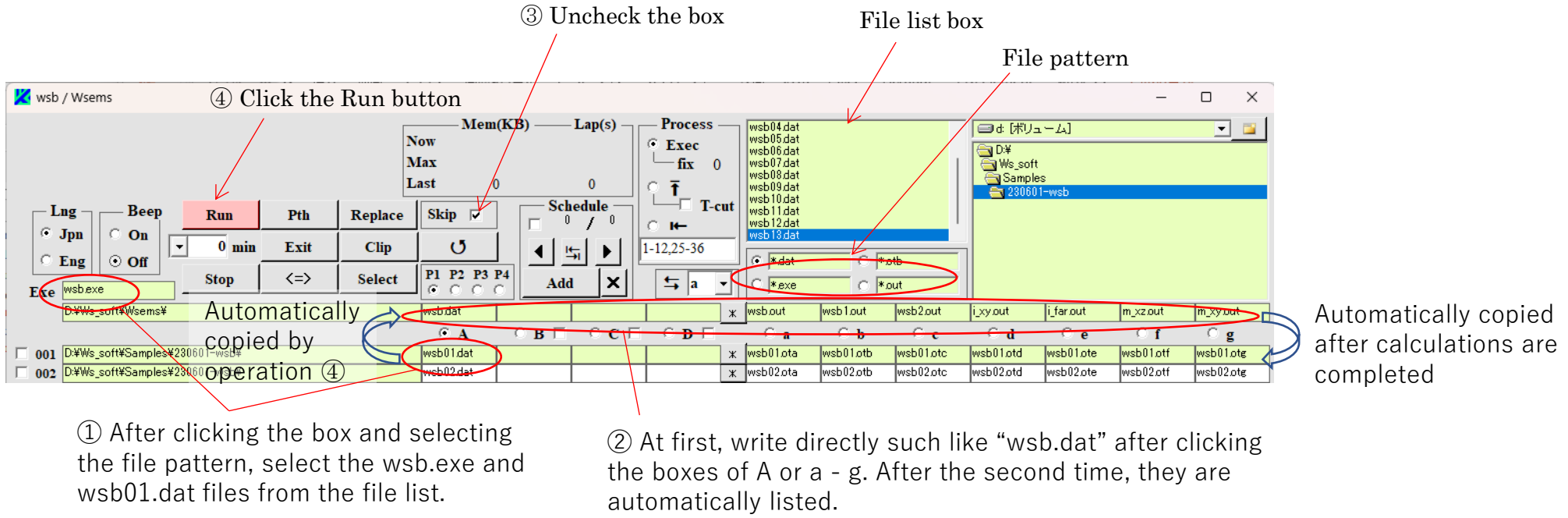
(1) Method by using wsems.exe (most recommended). In detaile, see “How to use Wsems”.

(2) Method by clicking wsb.exe directly



The vertical alignment of wsb.dat is easier to be edited if the font is set to Courier New in Notepad. However, note that it is not possible to distinguish between full-width and half-width spaces.

(3) Method using wsbch.exe (steps ① to ④ below)



5. Method of drawing calculation results

During the calculation, wscnt in the same folder start in linkage with the execution of wsb.exe, and the calculation results of i_xz.out or i_yz.out are displayed in real time.

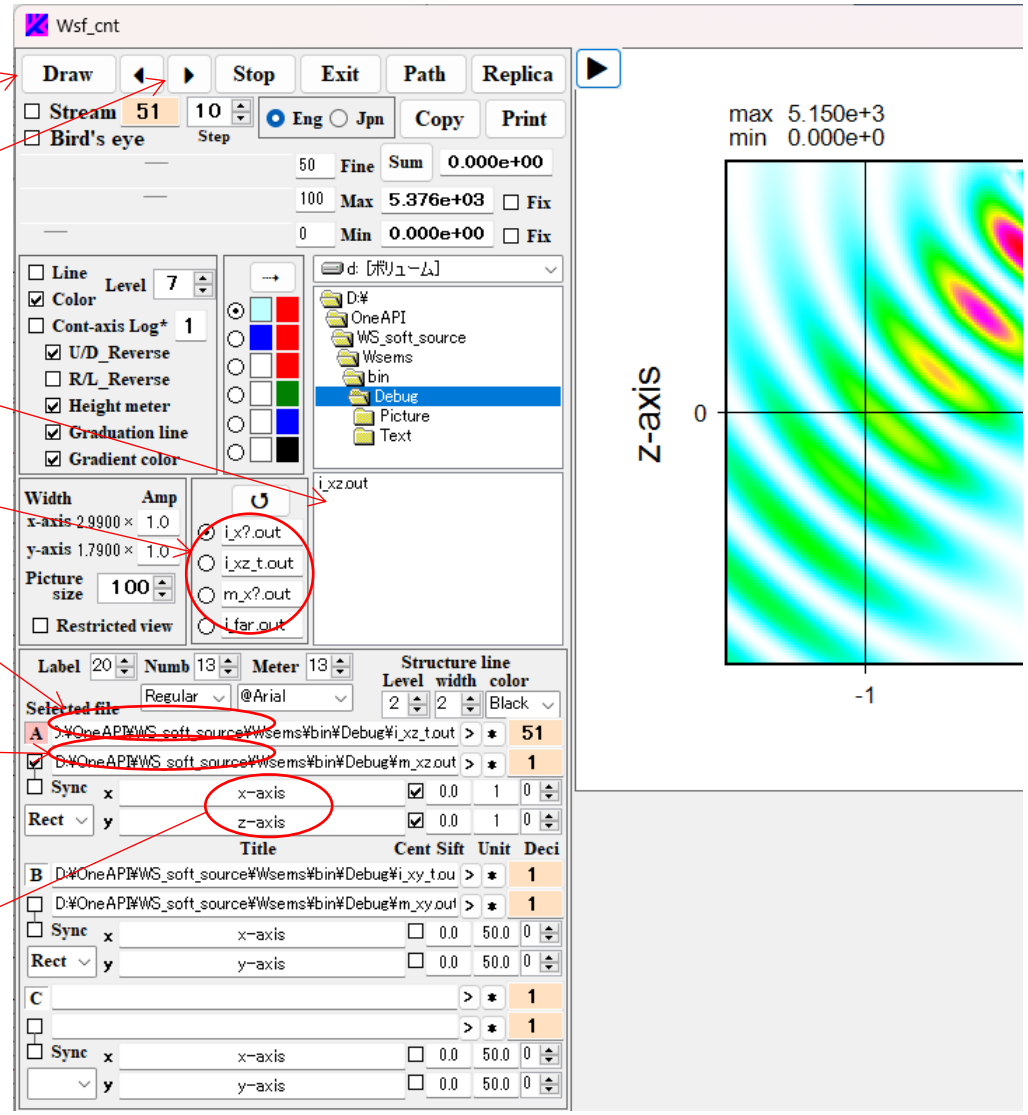
Output data generated in ¥Ws_soft¥Wsems can be visualized by wscnt.exe in the steps ①~⑤. If registered, limitation of file patterns is removed and “ot?” files generated by wsbch can also be visualized.

④Click Draw button to start drawing.
⑤Click ▶ button to advance frame.

File list box

File pattern

①After click the box, select a file pattern, and choose the file from the file list box.
② To add a structure line, check the checkbox and click the box on the right and select the file from the file list box.
③ Click on the box and type in directly.



6. Input rules for input file (wsb06.dat)

The following pages can be ignored when using Wsems.

Numeric data input rules

- Input numbers must be one-byte numbers. A space is a half-width space, and Tab code is not acceptable.
- The right end of the input numerals should be aligned with the vertical line on the right end of the variable label (or the * mark) above.
- The number without a decimal point is an integer type, and that with a decimal point (5 or less digits) is a real number type.

```
Digit 1        10        20        30        40        50
** wsb.dat
①
*        ncy(>0)      wb(um)     kfl(0,1)    kot         ms         ity
               2       0.500            0      0          0           0
②
*        wdx(um)     wdy(um)     dxy(um)      dz(um)
           3.000       0.000       0.020    0.020
*        Lam(um)      th(deg)     fi(deg)    kps
           0.940        0.00        0.00      0
*        wx0(um)     wy0(um)     xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
           2.500       2.500        0.00       0.00      0.000      0.000      0.000      0
*        stx(um)     sty(um)     csx(um)    csy(um)
           0.500       0.000       0.000      0.000
③
* km    *       Name   ko          an        ab          ak
   1           Ta205    1      1.0000      0.00      0.0000
   2             -Al    1      2.0000      0.00      0.0000    Digit60    70    80    90    100    110
* kr         * kd    kt      ps(deg)   px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#          0     4          0.0     1.50       1.50      0.500       0.50       0.00       0.00     0.0
* kf    km    kr kd    kt      ps(deg)   px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp      xq
   1     1     0  0     2          0.0     0.00       0.00       0.50       0.50      0.000       0.00     0.0     0.0
   2     2     0  0    -2          0.0     0.00       0.00       0.60       0.60      0.000       0.00     1.0     0.0
④
* kb  kl  km  kp          tk    kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *   **
   1   0   0   0        0.40     0    0
   2   0   0   0        0.50     1    0
   3   0   0   0        0.10     1    2
   4   0   0   0        0.50     1    0
```

Examples of incorrect input.

①
```
*        ncy(>0)      wb(um)     kfl(0,1)
               2       0.500            0
```
Full-width digit. A full-width space is contained.

②
```
*        wdx(um)     wdy(um)     dxy(um)
           1.500       1.500       0.020
```
The right edge of the input number deviates from the right of the variable label above.

③
```
* km    *       Name   ko          an
   1    Ta205          1.0          1
```
Beyond the 8-column range. Real number type is put into integer type. Integer type is put into real number type.

④
```
* kb  kl  km  kp          tk    kf    *
   1   0   0   0        0.40     0    0
   2   0   0   0        0.50     1    0
   3   0   0   0        0.10     1     2
   4   0   0   0        0.50     1    0
```
The right edge of the input number deviates from position of the * mark above.

```
* kb  kl  km  kp          tk    kf    *
   1   0   0   0        0.40     0    0
   2   0   0   0        0.50     1    0
   3   0   0   0        0.10     1    2
c
   4   0   0   0        0.50     1    0
```

To interrupt a calculation in the middle of layers, insert a line leading "C“ at the interruption position.

Compute time

7. Contents of wsb.dat (wsb01.dat), 2.0s

```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot          ms         ity
              2         1.0           0     0           0           0
*       wdx(um)    wdy(um)    dxy(um)    dz(um)
           10.0         0.0        0.02       0.02
*       Lam(um)     th(deg)    fi(deg)    kps
              0.5      -45.0         0.0        0
*       wx0(um)    wy0(um)    xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
              9.0        9.0         0.0        0.0        2.0        0.0        0.0        0
*       stx(um)    sty(um)    csx(um)    csy(um)
              0.0        0.0         0.0        0.0
* km   *     Name  ko        an         ab         ak
    1        -SiO2   1    2.0000       0.00     0.0000
    2#        -Al    1    2.0000       0.00     0.0000
* kr   *    kd   kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#         0    4           0.0       1.50       1.50      0.500       0.50       0.00       0.00      0.0
* kf   km   kr  kd   kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
    1#    1    0   0    1           0.0       1.00      1.000       0.50       0.50     -0.000       0.00      0.0      0.0
    2#    2    0   0    4           0.0       2.00      2.000       1.00       1.00      0.000       0.00      0.0      0.0
* kb   kl   km   kp        tk    kf     *     *     *     *     *     *     *     *     *     *     *     *     *     *     *
    1    0    1    0      5.00     0     0
    2    0    0    0      5.00     0     0
```

Digit60 70 80 90 100 110

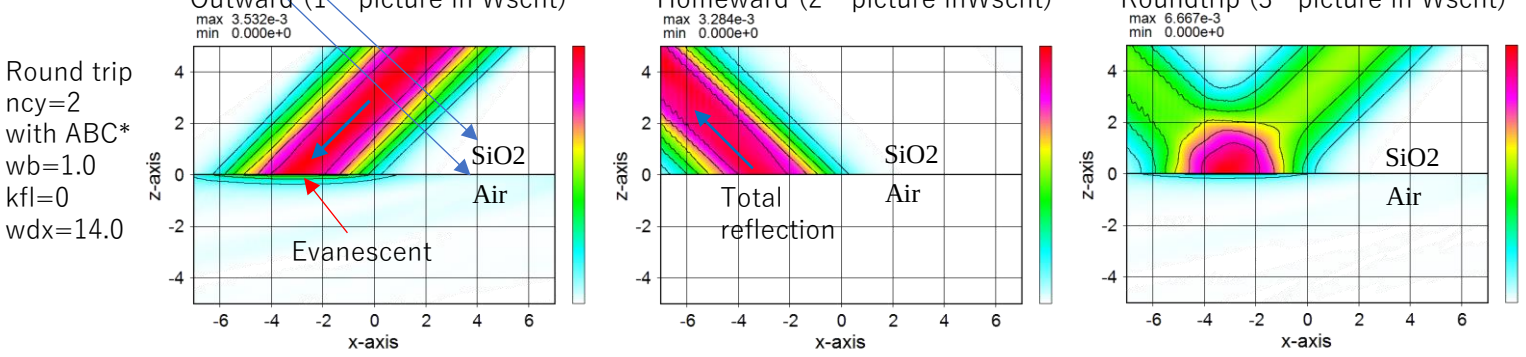
ncy Number of propagation iterations. |ncy|=1 : forward.
=2 : forward + backward. >2 : forward + backward + 2nd forward...
wb Absorbing boundary width (um).
=0 is for no absorbing boundaries. The larger the value, the more non-reflective the boundaries are, but the amount of calculation increases .
kfl =0: Drawing without absorbing boundaries.
=1: Drawing with absorbing boundaries.
kot Intensity distributions are represented in a maximum of (kot+4) digits.
ms Drawing point number in x/y directions is compressed to 1/2^ms.
ity Definition of intensity distribution for a round trip calculation.
=0 : for incoherent light The interference between forward and backward light is neglected and overlapped light is treated as intensity sum of them. =1 : electric & magnetic fielf intensity,
=2 : electric fielf intensity, =3 : magnetic fielf intensity.

Sequential numbers must be assigned from 1 (no more than 3 digits)

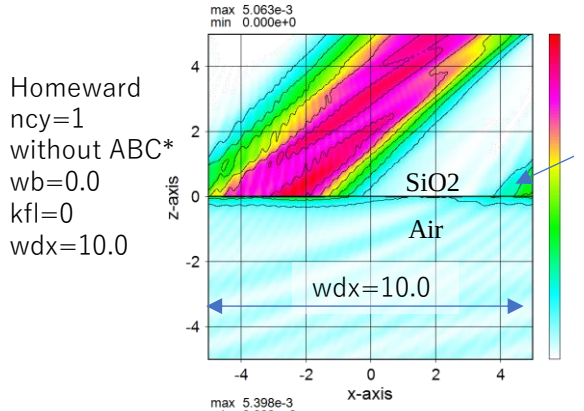
Outward (1st picture in Wscnt)

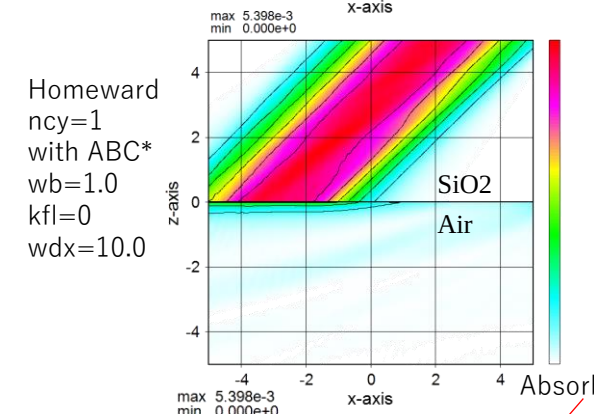
Homeward (2nd picture inWscnt)

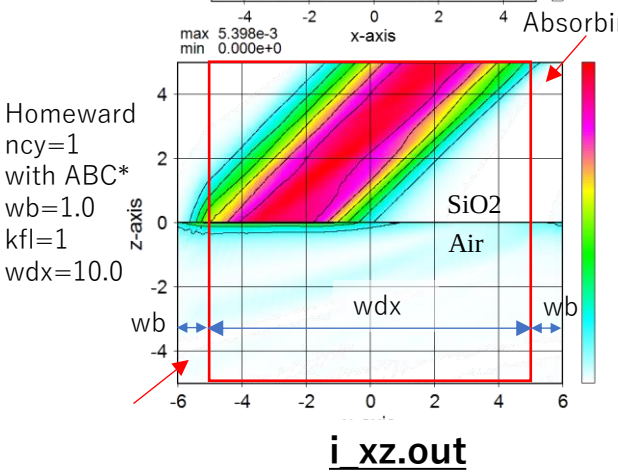
Roundtrip (3rd picture in Wscnt)



i_xz.out







i_xz.out

(*) ABC=Absorbing Boundary Condition

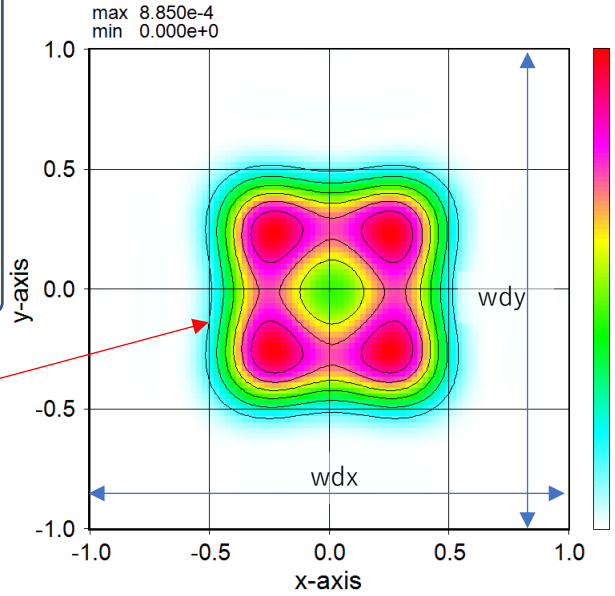
8. Contents of wsb.dat (wsb02.dat), 0.9s

```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)    kot          ms         ity
              1       0.500           0      0           0           0
*       wdx(um)    wdy(um)    dxy(um)     dz(um)
          2.000      2.000       0.020      0.020
*       Lam(um)     th(deg)     fi(deg)    kps
          0.500        0.00        0.00      0
*       wx0(um)    wy0(um)     xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
          1.000      1.000         1.00       1.00      0.000      0.000      0.000      0
*       stx(um)    sty(um)     csx(um)    csy(um)
          0.000      0.000       0.000      0.000
* km    *     Name   ko          an         ab         ak
    1         -SiO2    1     2.0000       0.00     0.0000
    2#          -Al    1     2.0000       0.00     0.0000
* kr           * kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#              0     4           0.0       1.50       1.50      0.500       0.50       0.00       0.00      0.0
* kf    km    kr  kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
    1#     1     0   0     1           0.0       1.00      1.000       0.50       0.50     -0.000       0.00      0.0        0.0
    2#     2     0   0     4           0.0       2.00       2.00       1.00       1.00      0.000       0.00      0.0        0.0
* kb   kl   km   kp          tk    kf    *
    1    0    0    0        0.60     0    0
    2    0    0    0        0.60     0    0
    3    0    0    0        0.60     0    0
```

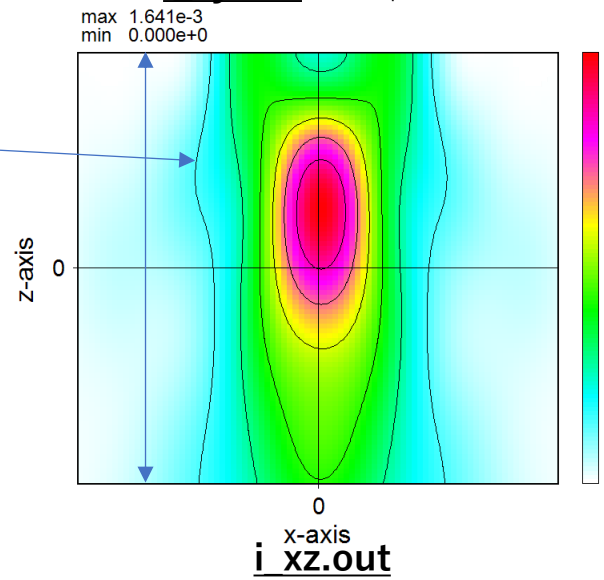
Digit60 70 80 90 100 110

wdx Analysis width in the x direction (um).
wdx=0 becomes a 2-dimensional problem. The center of the width is the positional basis for the light source and structures.
wdx Analysis width in the y direction (um).
wdy=0 becomes a 2-dimensional problem. The center of the width is the positional basis for the light source and structures.
dxy Rough grid interval in x/y-direction (um). The actual interval is optimized to be close to that and displayed in wsb.out. The actual value should be less than 1/10 of the wavelength.
dz Grid interval in z-direction (um). For layers where the layer thickness tk divided by dz is not an integer, the grid interval becomes tk divided by an integer obtained by rounding up tk/dz.

Intensity distribution at the light-source position. Since high-frequency components are cut off, the distribution deviates from the uniform one defined in the light-source.



i_xy.out 1st picture in Wscnt



i_xz.out

Base layers

Up to 10000 lines can be input as far as the last line or the line starting from "c" appears. Optical constants above the top layer or below the bottom layer is the same ones as the top or the bottom layer, respectively, and then no boundary reflections from there.

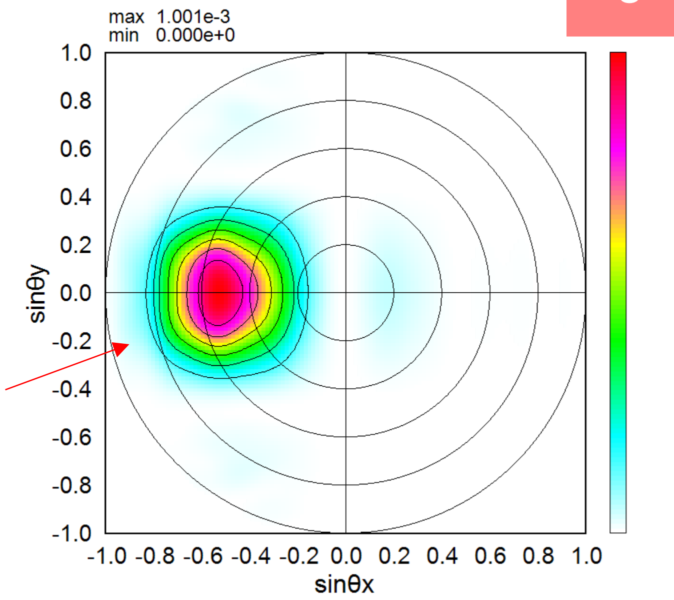
kl Not operated (operated in wsf and wsr).
km Construction material number refered in km designation field. km=0 means vacuum (n=1.0).
kp =0: Automatic setting by definition of dz
>0: The layer thickness tk is divided by kp. In case of homogeneous configuration, setting of kp=1 enables skip calculation.
tk Layer thickness (um)
kf =0: No reference
>0: Structure shape number refered in kf designation field. The refered shape structures are overwritten on the layer.
This numbers are represented by four digits, up to 100 set per line.

9. Contents of wsb.dat (wsb03.dat), 4.3s

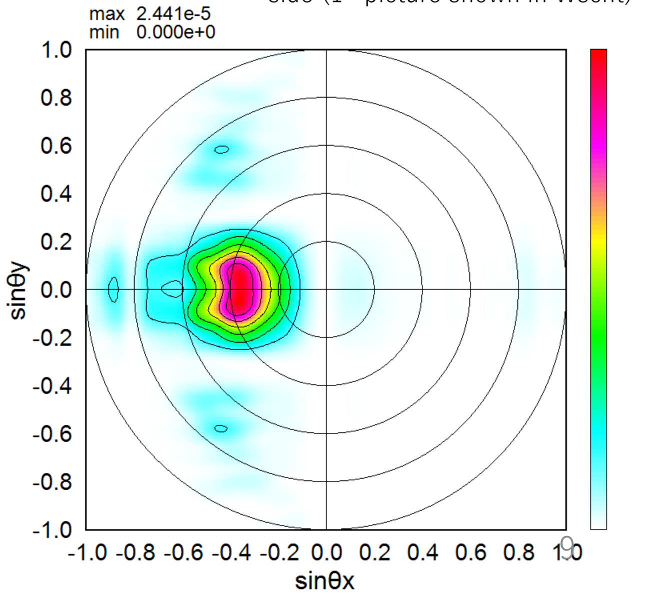
```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)   kfl(0,1)    kot         ms        ity
              2       0.500          0          0          0          0
*       wdx(um)     wdy(um)    dxy(um)     dz(um)
          3.000       3.000      0.020      0.020
*       Lam(um)     th(deg)    fi(deg)     kps
          0.500     -20.00       0.00          0
*       wx0(um)     wy0(um)   xrm(rim)   yrm(rim)    sx0(um)    sy0(um)    dfc(um)    kap
          1.000       1.000       1.00       1.00      0.500      0.000      0.000          0
*       stx(um)     sty(um)    csx(um)    csy(um)
          0.000       0.000      0.000      0.000
* km    *    Name  ko        an         ab         ak
   1        -SiO2   1    2.0000       0.00     0.0000
   2#         -Al   1    2.0000       0.00     0.0000   Digit60     70     80     90     100     110
* kr          * kd   kt     ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
   1#            0    4         0.0      1.50       1.50      0.500       0.50       0.00       0.00      0.0
* kf    km    kr kd  kt     ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp     xq
   1#    1     0  0   1         0.0      1.00      1.000       0.50       0.50     -0.000       0.00      0.0    0.0
   2#    2     0  0   4         0.0      2.00       2.00       1.00       1.00      0.000       0.00      0.0    0.0
* kb   kl   km  kp        tk     kf    *    *    *    *    *  桁数 *  70  *  * 80 *  * 90 *  *100 *  *110 **
   1    0    1   0      0.60      0    0
   2    0    1   0      0.60      0    0
   3    0    0   0      0.60      0    0
```

Lam Wavelength (um).
th Azimuth angle of incident light with z-axis (deg).
fi Argument angle of incident light with x-axis in xy-plane (deg).
kps Source polarization.
= 0 : random polarization. = 1 : p-polarization.
= 2 : s-polarization. = 3 : 45-degree polarization. = 4 : 135-degree polarization.

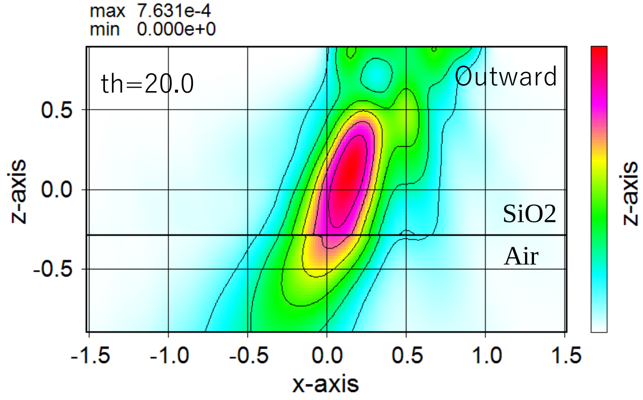
Since high-frequency components are cut off at the light-source position, the intensity distribution is broadened in the far-field.



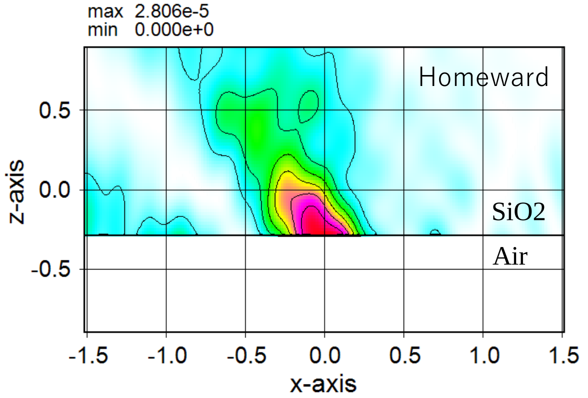
i_far.out Far-field distribution from the Air side (1st picture shown in Wscnt)



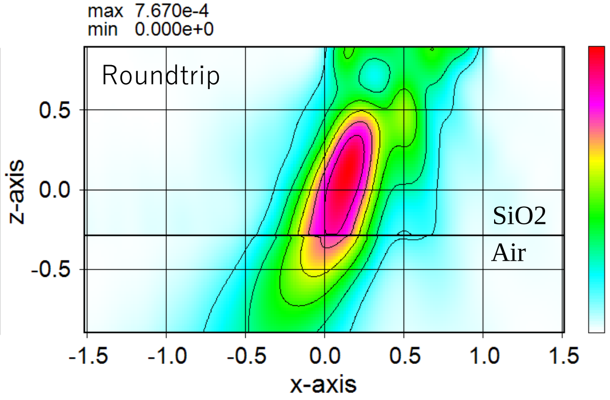
i_far.out Far-field distribution from the SiO2 side (2nd picture shown in Wscnt)



i_xz.out 1st picture in Wscnt



i_xz.out 2nd picture in Wscnt



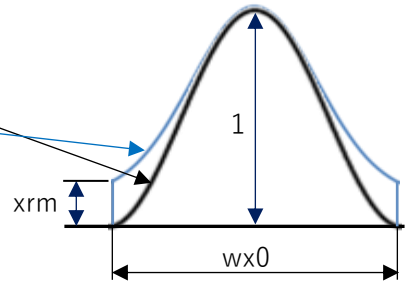
i_xz.out 3rd picture in Wscnt

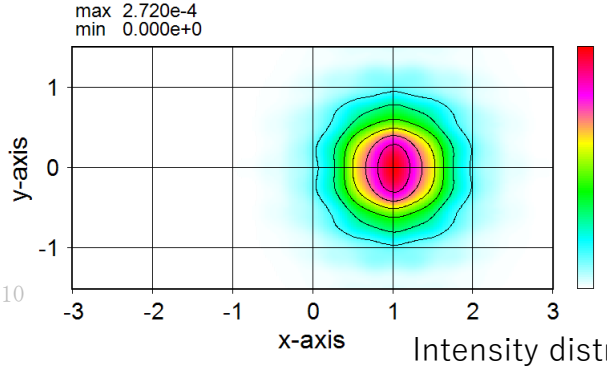
10. Contents of wsb.dat (wsb04.dat), 4.6s

```
Digit 1       10        20        30        40        50
      ** wsb.dat
      *       ncy(>0)      wb(um)    kfl(0,1)   kot          ms         ity
                1       0.500         0          0           0          0
      *       wdx(um)    wdy(um)    dxy(um)    dz(um)
            6.000       3.000      0.020      0.020
      *       Lam(um)     th(deg)    fi(deg)   kps
            0.500         0.00       0.00       0
      *       wx0(um)    wy0(um)    xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
            1.000       1.000      0.00       0.00       1.000      0.000      2.000      0
      *       stx(um)    sty(um)    csx(um)    csy(um)
            0.000       0.000      0.000      0.000
      * km   *    Name   ko         an         ab         ak
        1#        -SiO2   1      2.0000       0.00     0.0000
        2#          -Al   1      2.0000       0.00     0.0000
      * kr          * kd   kt       ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
        1#              0    4        0.0        1.50       1.50      0.500       0.50       0.00       0.00      0.0
      * kf   km   kr kd   kt       ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
        1#  1    0  0    1        0.0        1.00       1.000       0.50       0.50     -0.000       0.00      0.0        0.0
        2#  2    0  0    4        0.0        2.00        2.00       1.00       1.00      0.000       0.00      0.0        0.0
      * kb   kl   km   kp        tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
        1    0    0    0      2.00    0    0
        2    0    0    0      2.00    0    0
```

Digit60 70 80 90 100 110 / 術数 * 70 * * 80 * * 90 * * 100 * * 110 **

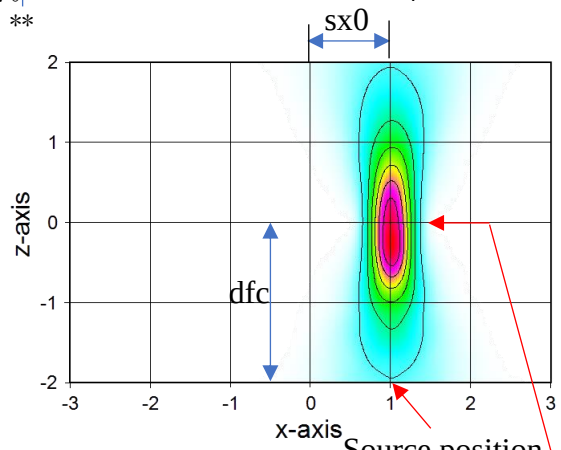
wx0 Light source spread in x-direction (um).
wy0 Light source spread in y-direction (um).
xrm =1 : uniform intensity in x-direction.
=0 : cos-intensity distribution, full width half maximum = wx0/2
=0～1 : rim intensity ratio of Gaussian distribution in x-direction.
yrm =1 : uniform intensity in y-direction.
=0 : cos-intensity distribution, full width half maximum = wy0/2.
=0～1 : rim intensity ratio of Gaussian distribution in y-direction.
sx0 Shift length of light source center in x-direction (um).
sy0 Shift length of light source center in y-direction (um).
dfc Defocus aberration of light source (um). If dfc>0, the focal point shifts to the lower side.
kap Apperture shape of light source. =0 : rectangular, =1 : elliptic shape.





i_xy.out

Intensity distribution at light-source position (1st picture in Wscnt)



i_xz.out

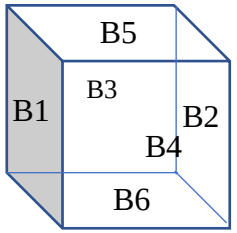
If dfc>0, the distribution defined in kap is reflected at this position

11. Contents of wsb.dat (wsb05.dat), 0.8s

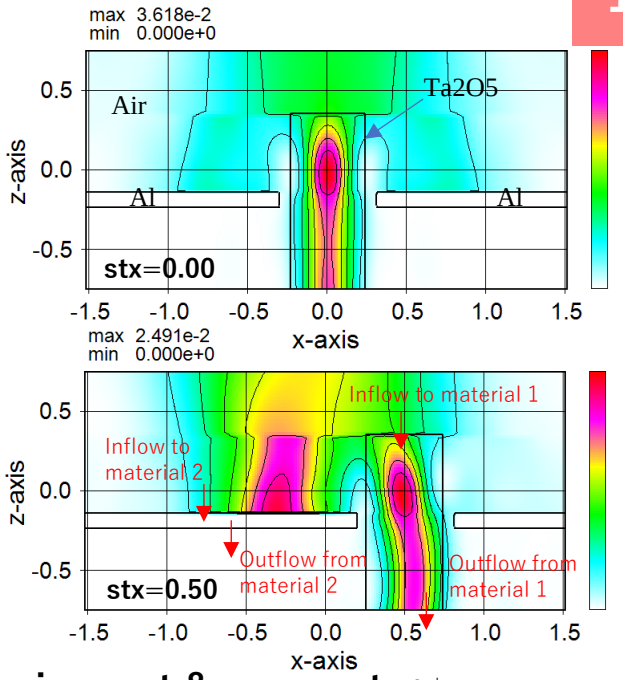
```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot          ms         ity
              2       0.500           0         0          0           0
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
          3.000       0.000       0.020      0.020
*       Lam(um)      th(deg)     fi(deg)    kps
          0.940        0.00        0.00          0
*       wx0(um)     wy0(um)     xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
          2.500       2.500        0.00       0.00      0.000      0.000      0.000          0
*       stx(um)     sty(um)     csx(um)    csy(um)
          0.500       0.000       0.000      0.000
* km  *     Name  ko        an         ab         ak
     1        Ta205   1   1.0000       0.00     0.0000
     2          -Al   1   2.0000       0.00     0.0000   Digit60        70         80         90        100        110
* kr          * kd   kt       ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#           0    4        0.0       1.50       1.50      0.500       0.50       0.00       0.00       0.0
* kf   km   kr kd   kt       ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
     1    1    0  0    2        0.0       0.00       0.00       0.50       0.50      0.000       0.00       0.0        0.0
     2    2    0  0   -2        0.0       0.00       0.00       0.60       0.60      0.000       0.00       1.0        0.0
* kb  kl  km  kp       tk   kf   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   **
     1   0   0   0     0.40    0   0
     2   0   0   0     0.50    1   0
     3   0   0   0     0.10    1   2
     4   0   0   0     0.50    1   0
```

Base layers

stx Shift length of overall structure center in x-direction (um). Not applicable for light source position.
sty Shift length of overall structure center in y-direction (um). Not applicable for light source position.
csx Cross sectional position of graphics in x-direction (um).
csy Cross sectional position of graphics in y-direction (um).



When up/down is set to a reversal mode in Wscnt, “up” is correspond to -z side and “down” is to +z side.



i_xz.out & m_xz.out 3rd picture in Wscnt

12. Contents of wsb.dat (wsb06.dat), 1.0s

```
Digit 1       10        20        30        40        50
** wsb.dat
*      ncy(>0)      wb(um)    kfl(0,1)   kot         ms        ity
           2       0.500          0         0          0          0
*      wdx(um)    wdy(um)    dxy(um)    dz(um)
       1.500      1.500       0.020      0.020
*      Lam(um)    th(deg)    fi(deg)    kps
       0.940       0.00       0.00          0
*      wx0(um)    wy0(um)    xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
       2.000      2.000       0.00       0.00       0.000      0.000      0.000          0
*      stx(um)    sty(um)    csx(um)    csy(um)
       0.000      0.000       0.000      0.000
* km   *     Name   ko        an         ab         ak
     1          Ta2O5   1    1.0000       0.00     0.0000
     2             Al   1    2.0000       0.00     0.0000
* kr          * kd   kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#           0    4         0.0        1.50       1.50      0.500       0.50       0.00       0.00      0.0
* kf   km   kr kd   kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
     1    1    0  0    2         0.0        0.00       0.00       0.50       0.50      0.000       0.00      0.0        0.0
     2    2    0  0   -2         0.0        0.00       0.00       0.60       0.60      0.000       0.00      1.0        0.0
* kb   kl   km   kp        tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    **
     1    0    0    0      0.40    0    0
     2    0    0    0      0.50    1    0
     3    0    0    0      0.10    1    2
     4    0    0    0      0.50    1    0
```

Digit60 70 80 90 100 110

Calculated as external data

If unregistered, only up to two lines can be read.

Calculated as internal data

Corner R is expressed by setting elliptic exponent index xp.

km designation field (for optical materials)

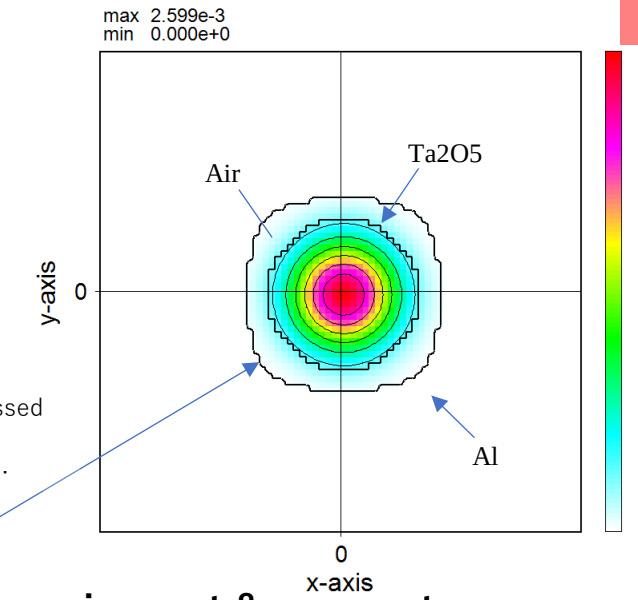
The first 3 digits are serial line numbers, up to 200 lines can be input. Name Material name (within 8 digits) SiO2, Ag, Al, Au, Be, Cr, Cu, Ni, Pd, Pt, Ti, W have internal data. For others, by entering the wavelength, refractive index, and extinction coefficient in the file of nk.dat as external data, the refractive index and extinction coefficient are automatically interpolated. If no data exists in nk.dat, the values defined by the right-side parameters of 'an' are given priority. nk.dat should be created by each user and stored in the same folder as wsb.exe.

ko Whether to output detected light amount to wsb1.out or not.
=0 : not output, =1 : output.

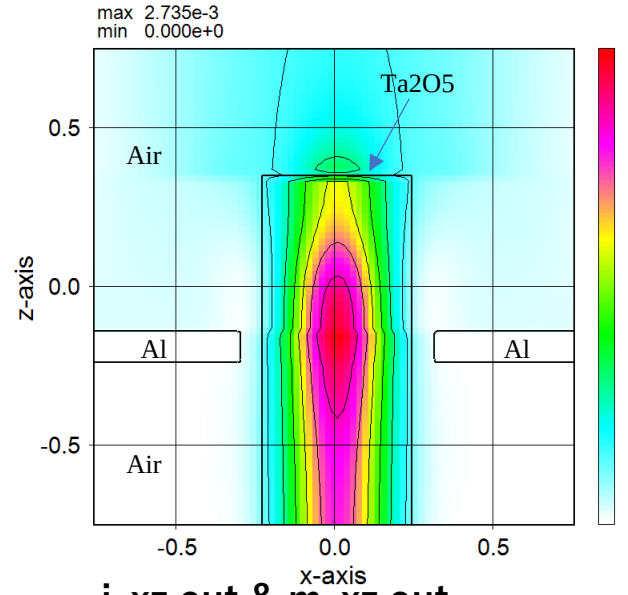
an Refractive index.

ab Abbe number, if =0, no dispersion (fixed to refractive index).

ak Extinction coefficient.



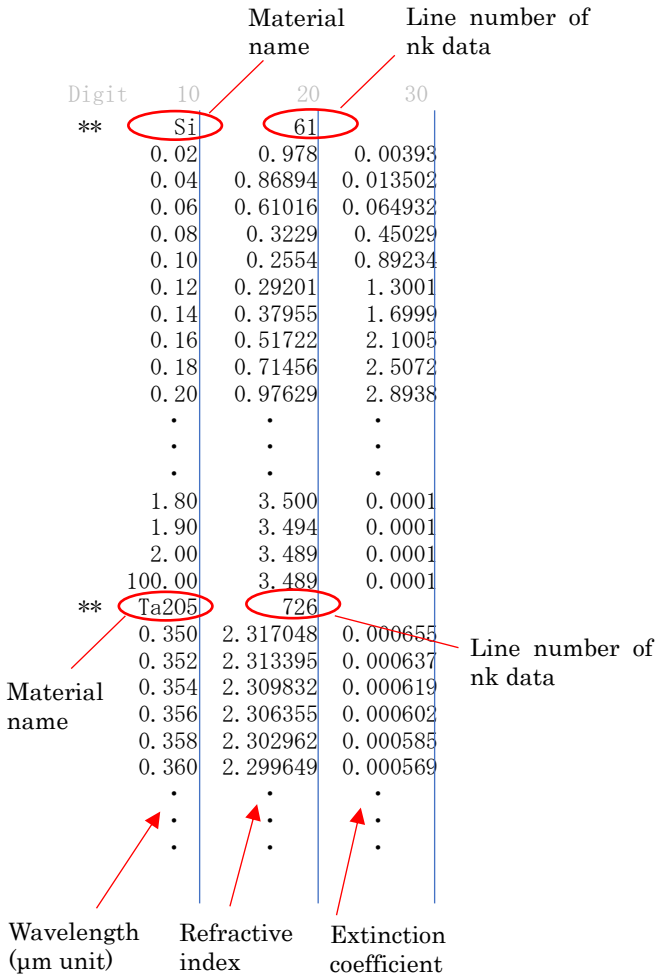
i_xy.out & m_xy.out (4th picture in Wscnt)



i_xz.out & m_xz.out

(3rd picture in Wscnt)

13. Contents of nk.dat



Excerpts from nk.dat

Numerical Data Input Rule

- After entering the delimiter mark (**) on the first line of the numerical data, write the material name (8 columns) and the number of lines of nk.dat (10 columns).
- Input numbers are half-width (Spaces should be half-width and Tab codes are not allowed).
- The right edge of the input digit must be aligned with a vertical line in 10-digit increments.
- Input numbers should be spaced by at least one half-width space.

The material data can be created by overlaying the actual measured values or literature values, etc. in the format shown above. The file name should be "nk.dat" and must be stored in the folder where wsb.exe is located. However, the material name must be other than -SiO2, -Ag, -Al, -Au, -Be, -Cr, -Cu, -Ni, -Pd, -Pt, -Ti, -W which are defined in internal materials. If there are duplicate material names, the first data takes priority.

References

https://refractiveindex.info/?shelf=main&book=Ta2O5&page=Bright-amorphous

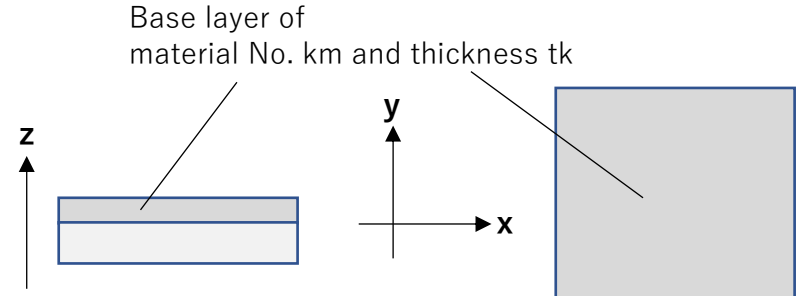
https://www.filmetricsinc.jp/refractive-index-database/Ta2O5

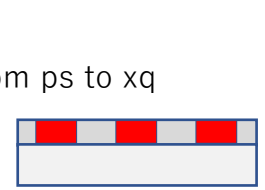
14. Procedure for defining optical structures

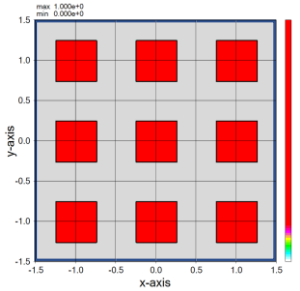
① Definition of a Base layer
1. setting km and tk
2. entering kf for reference

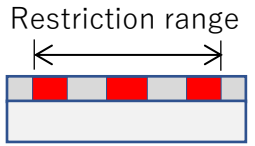
② Definition of periodic structures
on a Base layer at Kf specification field
1. setting km,kd,and kt
2. definition of structures by setting parameters from ps to xq
3. entering kr for reference

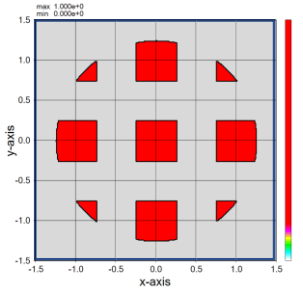
③ Restriction of periodic structures at Kr specified field
1. setting kd and kt
2. definition of the restriction shape by setting parameters from ps to xp












```
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot          ms          ity
          1       0.500           0          0           0           0
*       wdx(um)    wdy(um)    dxy(um)     dz(um)
        3.000      3.000      0.020       0.020
*       Lam(um)     th(deg)    fi(deg)    kps
        0.940       0.00       0.00          0
*       wx0(um)    wy0(um)    xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
        2.000      2.000       1.00       1.00       0.000      0.000      0.000          0
*       stx(um)    sty(um)    csx(um)    csy(um)
        0.000      0.000      0.000      0.000
* km    *     Name   ko         an          ab          ak
    1          -SiO2    1     2.0000        0.00      0.0000
    2#           -Al    1     2.0000        0.00      0.0000
* kr          * kd    kt      ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
    1#              0     2      0.0        0.00       0.00       2.50       2.50       0.00       0.00       0.0
* kf    km    kr  kd    kt      ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp          xq
    1     1     0   0     2      0.0        1.00       1.000      0.50       0.50      -0.000      0.00       0.0        0.0
    2#    2     0   0     4      0.0        2.00       2.00       1.00       1.00       0.000      0.00       0.0        0.0
* kb   kl   km   kp        tk     kf     *     *     *     *     *     *     *     *     *     *     *     *     *     *     **
    1    0    0    0       0.60     1     0
```

Kr field ③
Kf field ②
① Base layer

15. Contents of wsb.dat (wsb07.dat), 0.8s

```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot         ms        ity
             1       0.500           0         0          0          0
*       wdx(um)     wdy(um)    dxy(um)    dz(um)
         3.000       3.000       0.020      0.020
*       Lam(um)     th(deg)    fi(deg)    kps
         0.940        0.00        0.00          0
*       wx0(um)     wy0(um)    xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
         2.000       2.000       1.00       1.00       0.000      0.000      0.000          0
*       stx(um)     sty(um)    csx(um)    csy(um)
         0.000       0.000       0.000      0.000
* km    *    Name   ko          an         ab         ak
    1         -SiO2    1     2.0000       0.00     0.0000
   2#         -Al      1     2.0000       0.00     0.0000
* kr          * kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
   1#           0     2          0.0        0.00       0.00       2.50       2.50       0.00       0.00       0.0
* kf    km    kr    kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
    1     1     0     0     2          0.0        1.00       1.000      0.50       0.50      -0.000      0.00       0.0        0.0
   2#     2     0     0     4          0.0        2.00       2.00       1.00       1.00       0.000      0.00       0.0        0.0
* kb    kl    km    kp          tk    kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    **
    1     0     0     0        0.60     1     0
```

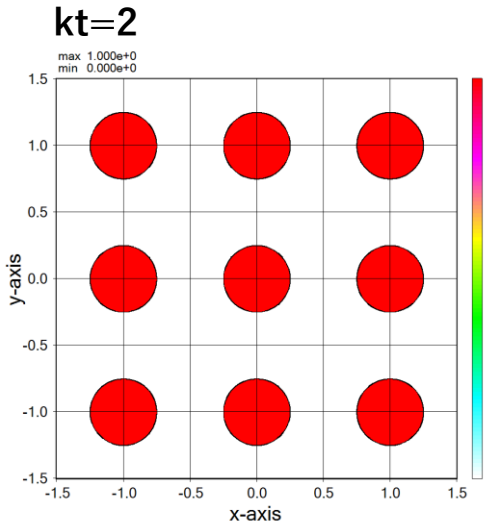
See the pages that follow for relationship with figures.

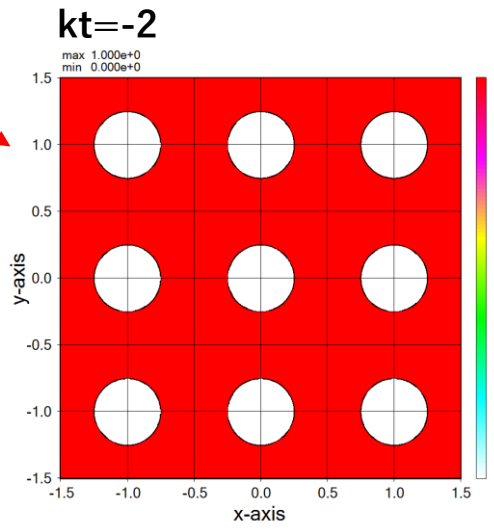
Referred

ps Rotation angle of all structures around the region center (deg).
px Structure period in x-direction (um). When =0, it is an isolated pattern.
py Structure period in y-direction (um). When =0, it is an isolated pattern.
wx Structure width in y-direction (um).
wy Structure width in y-direction (um).
sx Shift length of the structure center in x-direction (um).
sy Shift length of the structure center in y-direction (um).
xp Elliptic exponent index for kt=2. Lattice duty ratio for kt=10 to 17.
xq Starting point of lattice for kt=10 to 17.

Defined inside periodic circles

Defined outside periodic circles





m_xy.out

kf designation field (for foreground structures)

The first 4 digits are serial line numbers, up to 9999 lines can be input.

km Construction material number referred in km designation field. km=0 means vacuum (n=1.0).

kr Restriction shape number referred in kr designation field. kr=0 means restriction free.

kd How to input shape data of structures. =0: by internal definition. =1: by external data using sub.dat.
Applied to all except for wx and wy, sub.dat can be input up to 400 types (up to 1000 lines for each type).

kt Selection of shape type. (-kt shows an inverted shape for kt.)

When kd=1, kt=Pattern No. in sub.dat.

When kd=0,

kt=0 No area definition.

=1 Rectangular areas of width wx*wy centered on a square grid position of period px*py.

=2 Elliptic shape of width wx*wy and elliptic index xp centered on a square grid position of period px*py, where xp = -2.0 to -1.0 for star, = -1.0 for diamond, = 0.0 for ellipse, > 0.0 for square.

=3 Hexagons shape (top/bottom vertex angles) of width wx*wy centered on a square grid position of period px*py.

=4 Hexagon shape (left/right vertex angles) of width wx*wy centered on a square grid position of period px*py.

=5 Diamond shape of width wx*wy centered on a square grid position of period px*py.

=6 Right-angled triangular shape (diagonal 1st quadrant) of width wx*wy centered on a square grid position of period px*py.

=7 Right-angled triangular shape (diagonal 2nd quadrant) of width wx*wy centered on a square grid position of period px*py.

=8 Right-angled triangular shape (diagonal 3rd quadrant) of width wx*wy centered on a square grid position of period px*py.

=9 Right-angled triangular shape (diagonal 4th quadrant) of width wx*wy centered on a square grid position of period px*py.

=10 Linear lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.

=11 Concentrically elliptic lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square px*py of period px*py.

=12 Concentrically dodecagonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.

=13 15-degrees-rotated lattice for kt=12.

=14 Concentrically 18-corner polygonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.

=15 10-degrees-rotated lattice for kt=14.

=16 Concentrically hexagonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.

=17 30-degrees-rotated lattice for kt=16.

16. Contents of wsb.dat (wsb08.dat), 0.7s

```
Digit 1        10        20        30        40        50
** wsb.dat
*       ncy(>0)      wb(um)     kfl(0,1)   kot          ms         ity
             1       0.500            0     0           0           0
*       wdx(um)     wdy(um)     dxy(um)    dz(um)
        3.000       3.000       0.020      0.020
*       Lam(um)      th(deg)     fi(deg)    kps
        0.940        0.00        0.00       0
*       wx0(um)     wy0(um)     xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
        2.000       2.000       1.00       1.00       0.000      0.000      0.000      0
*       stx(um)     sty(um)     csx(um)    csy(um)
        0.000       0.000       0.000      0.000
* km    *    Name   ko          an         ab         ak
  1          -SiO2   1       2.0000       0.00     0.0000
  2#         -Al     1       2.0000       0.00     0.0000
Digit60        70        80        90        100       110
* kr          * kd    kt      ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
  1                0     2    0.0        0.00       0.00       2.50       2.50       0.00       0.00       0.0
* kf    km    kr kd    kt      ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
  1     1     1  0     1       0.0        1.00       1.000      0.50       0.50       -0.000     0.00       0.0        0.0
  2#    2     0  0     4       0.0        2.00       2.00       1.00       1.00       0.000      0.00       0.0        0.0
* kb    kl    km    kp        tk         kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    **
  1     0     0     0         0.60       1     0
```

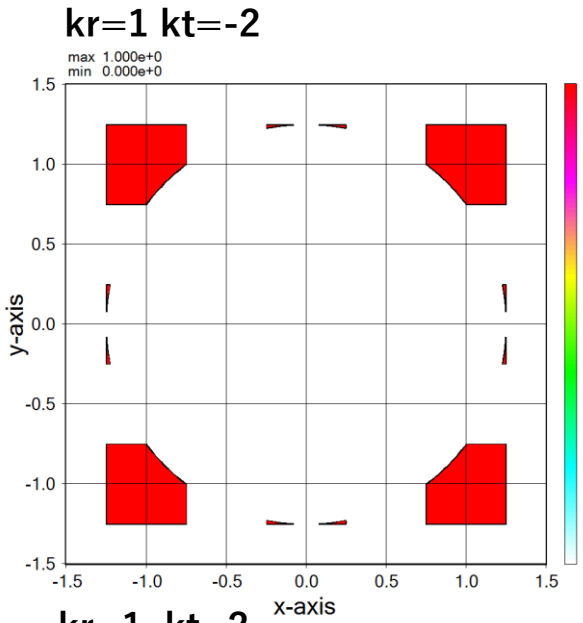
Referred

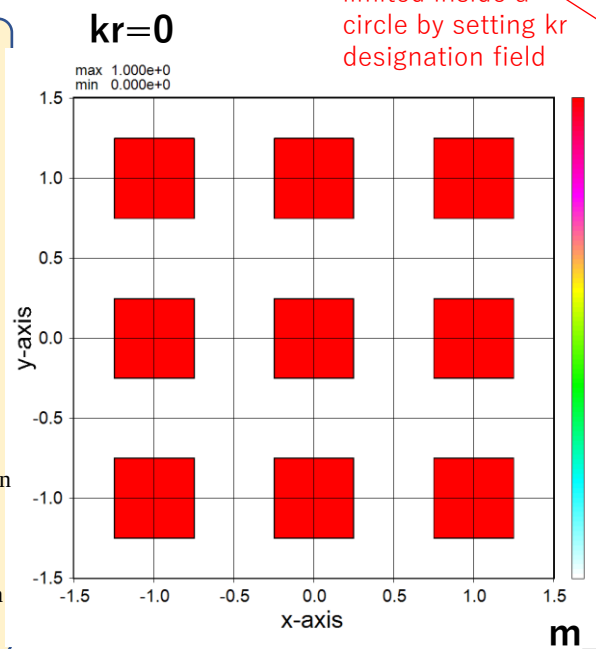
ps Rotation angle of all structures around the region center (deg).
px Structure period in x-direction (um). When =0, it is an isolated pattern.
py Structure period in y-direction (um). When =0, it is an isolated pattern.
wx Structure width in y-direction (um).
wy Structure width in y-direction (um).
sx Shift length of the structure center in x-direction (um).
sy Shift length of the structure center in y-direction (um).
xp Elliptic exponent index for kt=2. Lattice duty ratio for kt=10 to 17.

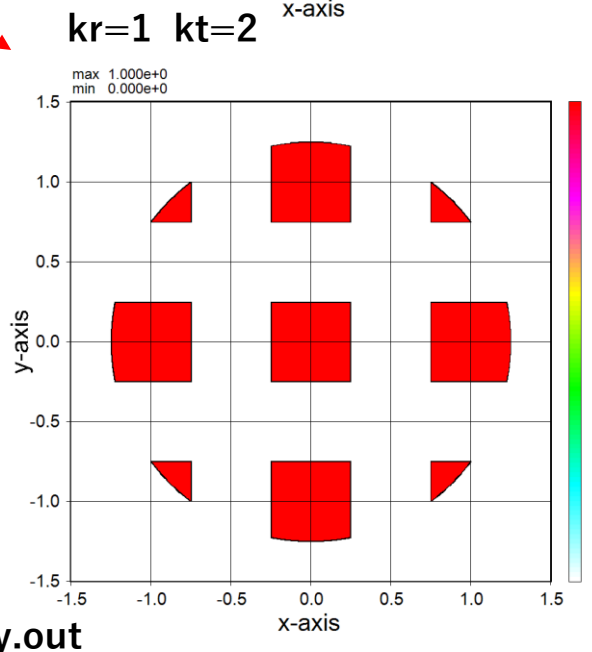
limited outside a circle by setting kr designation field

limited inside a circle by setting kr designation field

kr designation field (for restricting shapes)
The first 4 digits are serial line numbers, up to 1000 lines can be input.
kd How to input shape data of structures. =0: by internal definition. =1: by external data using sub.dat.
Applied to all except for wx and wy, sub.dat can be input up to 400 types (up to 1000 lines for each type).
kt Selection of shape type. (-kt shows an inverted shape for kt.)
When kd=1, kt=Pattern No. in sub.dat. When kd=0, kt=0 No area restriction.
=1 Restricted by rectangular areas of width wx*wy centered on a square grid position of period px*py.
=2 Restricted by elliptic shape of width wx*wy and elliptic index xp centered on a square grid position of period px*py, where xp = -2.0 to -1.0 for star, = -1.0 for diamond, = 0.0 for ellipse, > 0.0 for square.
=3 Restricted by hexagons shape (top/bottom vertex angles) of width wx*wy centered on a square grid position of period px*py.
=4 Restricted by hexagon shape (left/right vertex angles) of width wx*wy centered on a square grid position of period px*py.
=5 Restricted by diamond shape of width wx*wy centered on a square grid position of period px*py.
=6 Restricted by a right-angled triangular shape (diagonal fist quadrant) of width wx*wy centered on a square grid position of period px*py.
=7 Restricted by a right-angled triangular shape (diagonal second quadrant) of width wx*wy centered on a square grid position of period px*py.
=8 Restricted by a right-angled triangular shape (diagonal third quadrant) of width wx*wy centered on a square grid position of period px*py.
=9 Restricted by a right-angled triangular shape (diagonal fourth quadrant) of width wx*wy centered on a square grid position of period px*py.

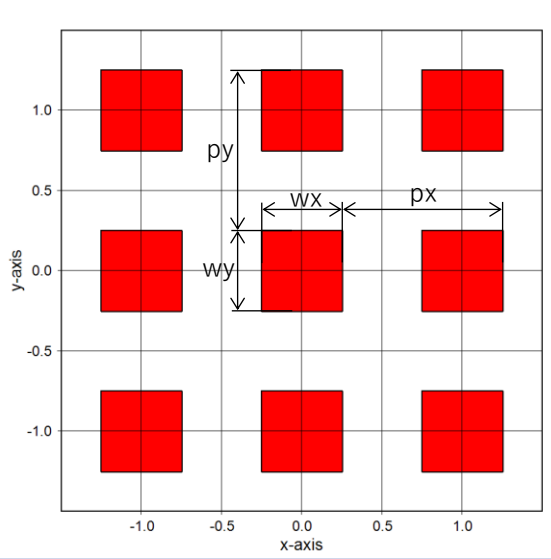
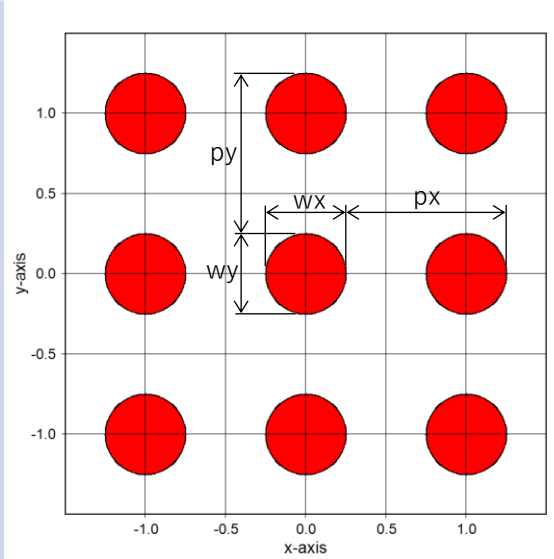
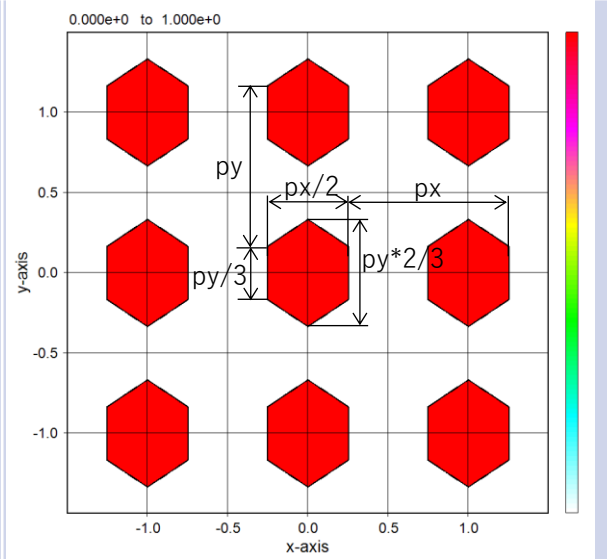


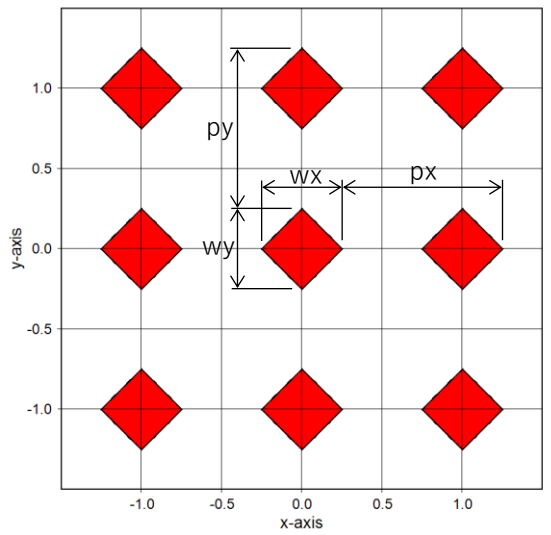
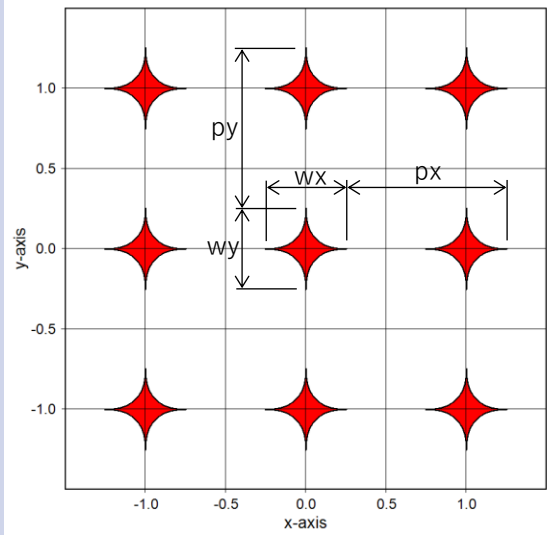
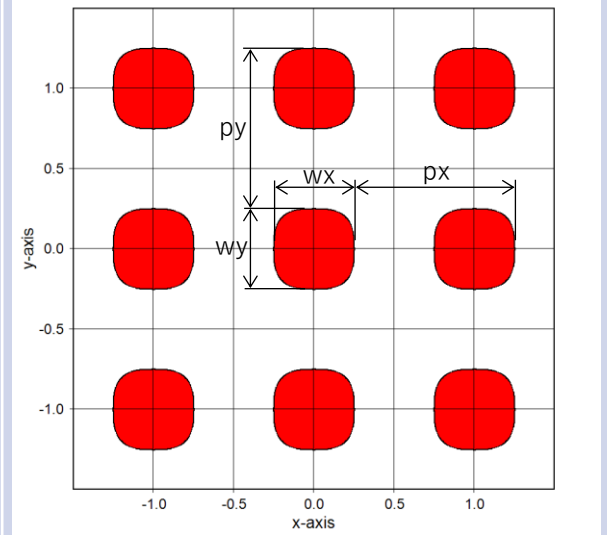




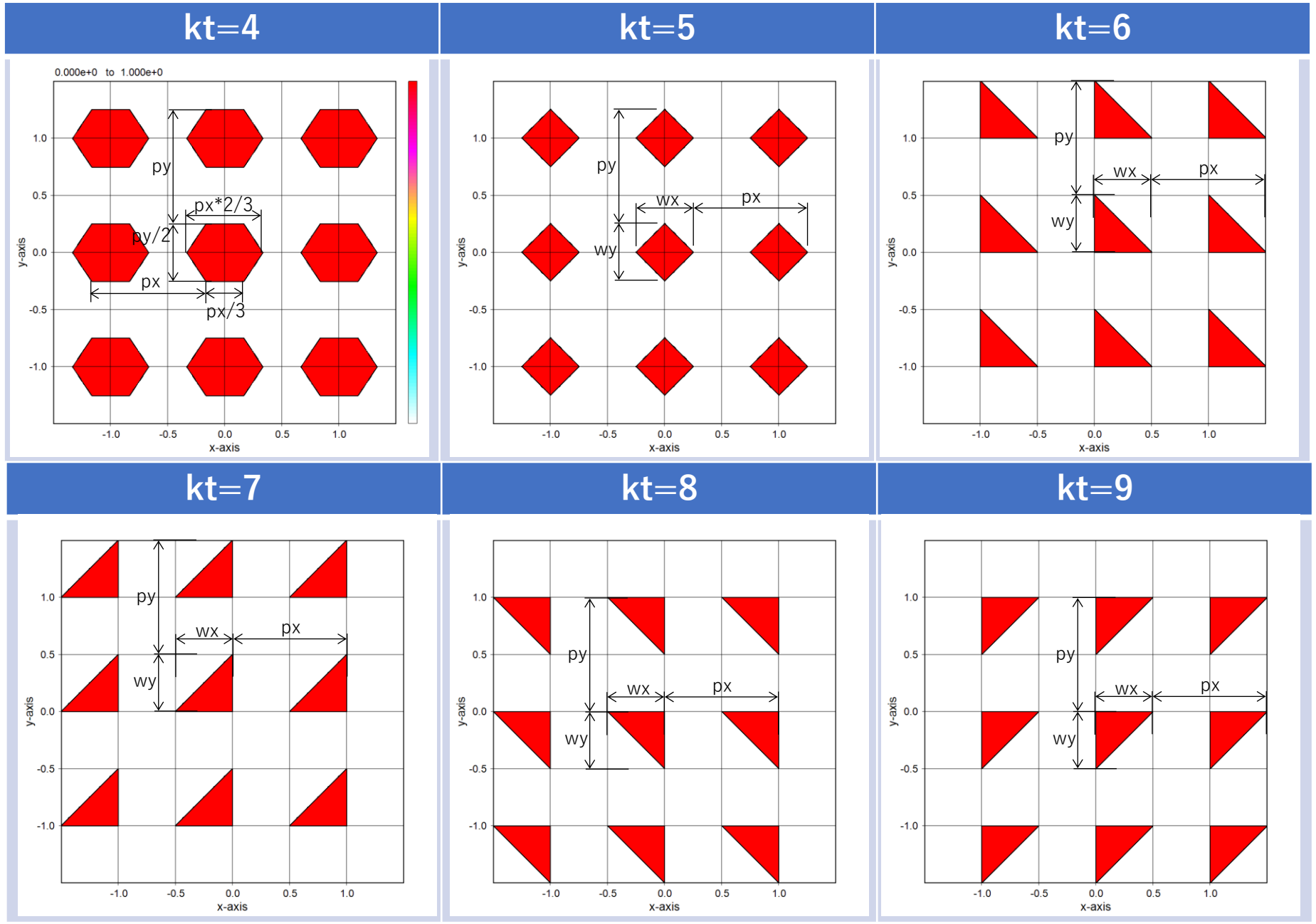
m_xy.out

17. Relationships (1) between kt and structures for kd=0

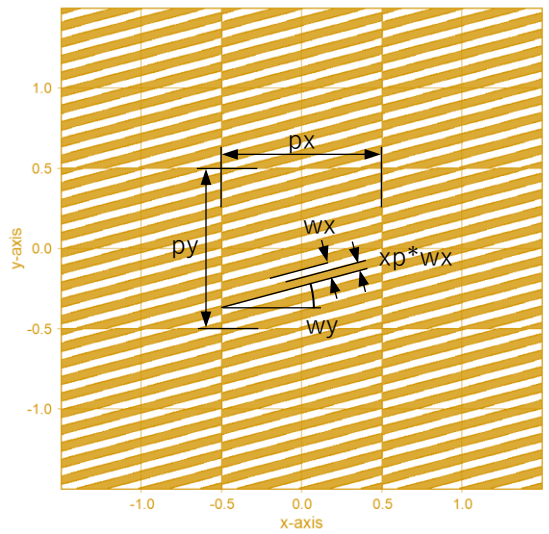
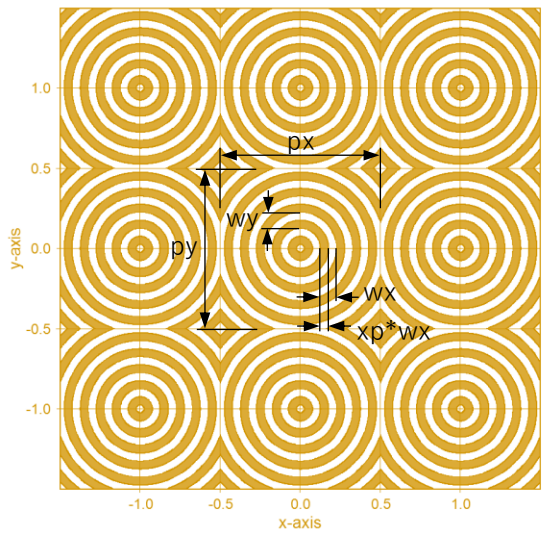
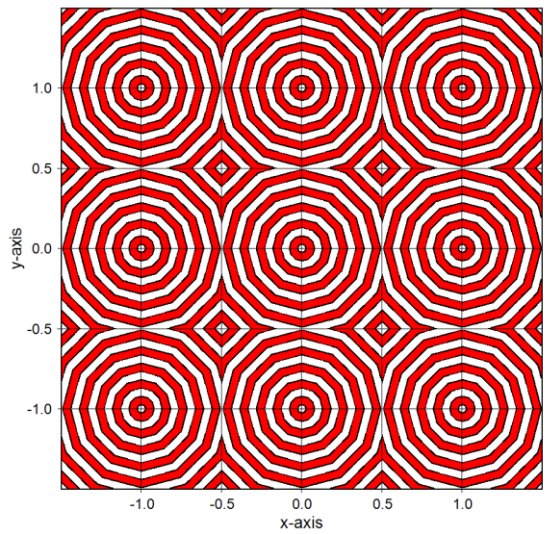
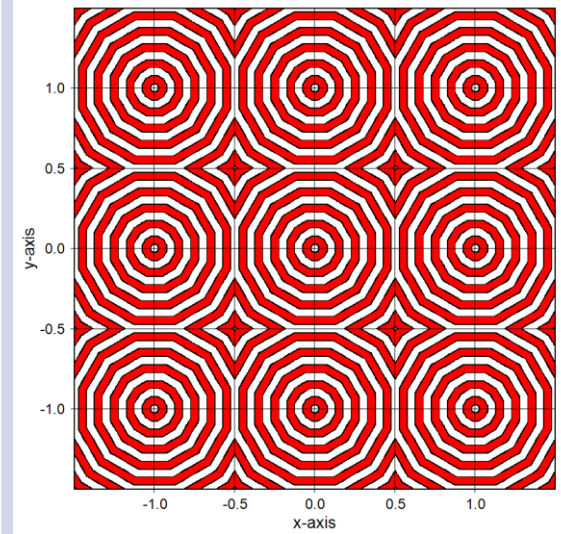
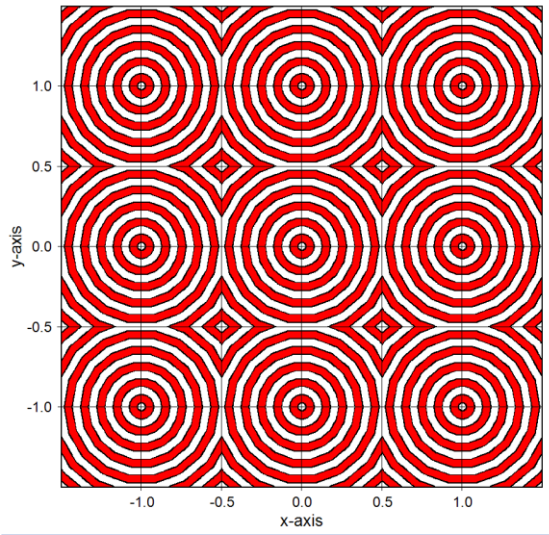
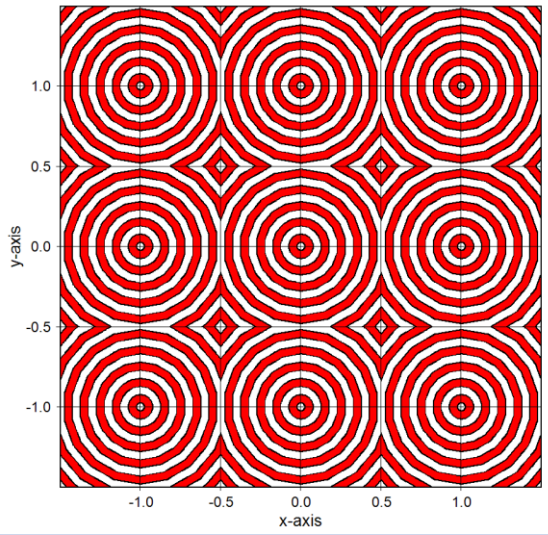
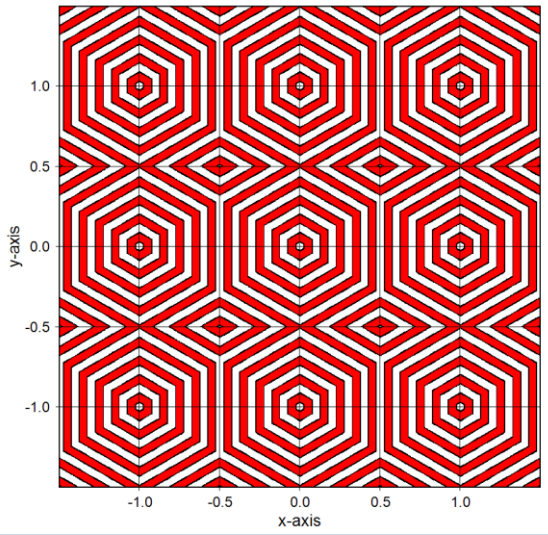
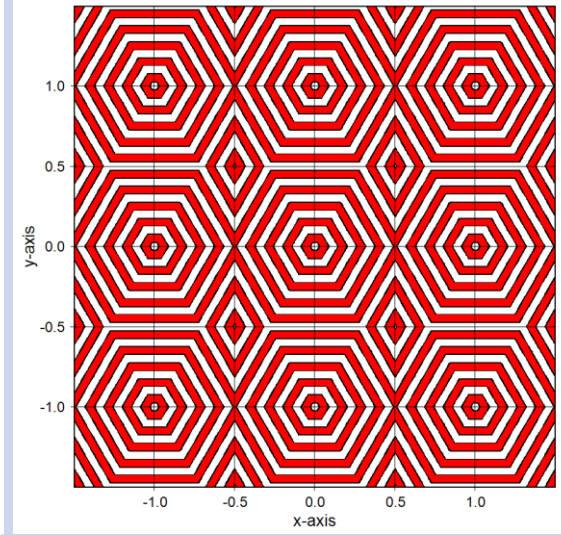
kt=1	kt=2	kt=3
		

kt=2,xp=-1.0	kt=2,xp=-1.5	kt=2,xp=1.0
		

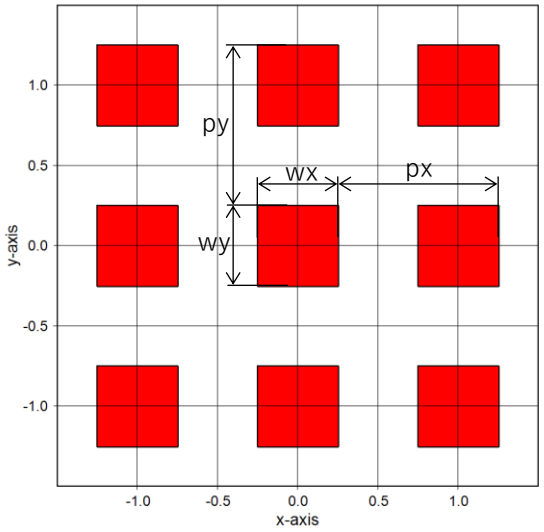
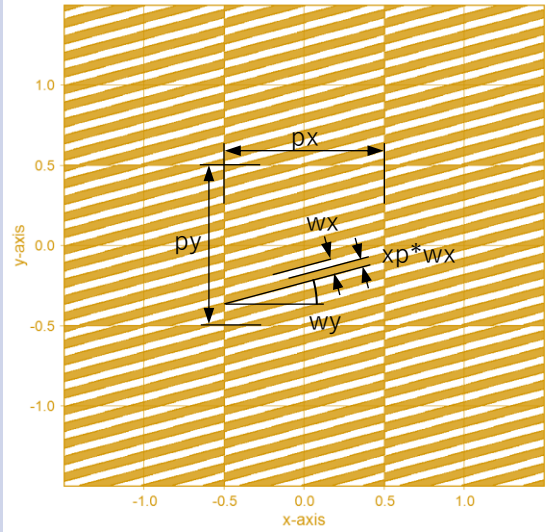
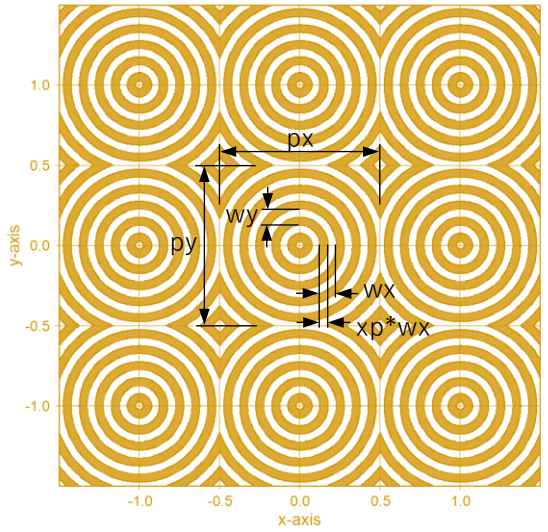
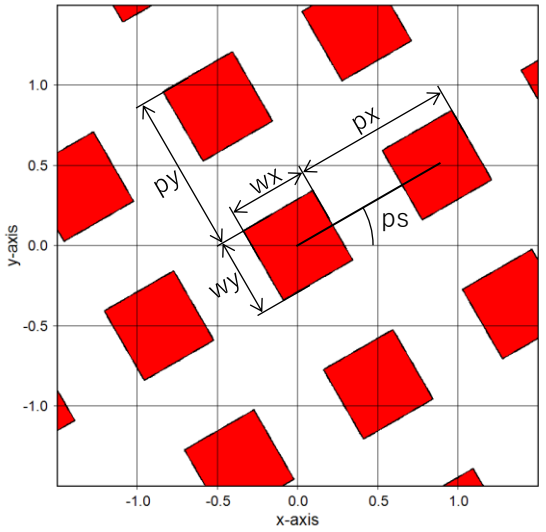
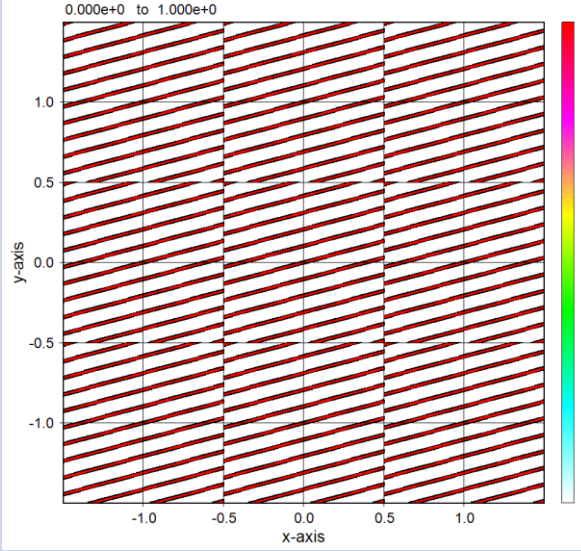
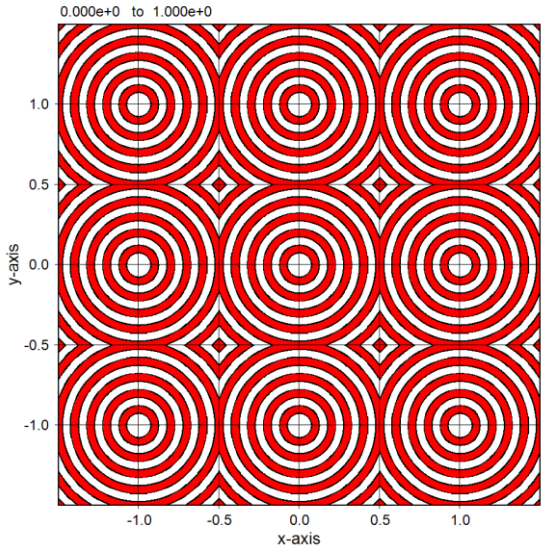
18. Relationships (2) between kt and structures for kd=0



19. Relationships (3) between kt and structures for kd=0

kt=10	kt=11	kt=12	kt=13
			
kt=14	**kt=15**	**kt=16**	**kt=17**
			

20. Relationships (4) between kt and structures for kd=0

kt=1,ps=0.0	kt=10,xp=0.5	kt=11,xq=0.0
		
kt=1,ps=30.0	**kt=10,xp=0.2**	**kt=11,xq=0.5**
		

21. Reference to sub.dat for kd=1 (sub.dat)

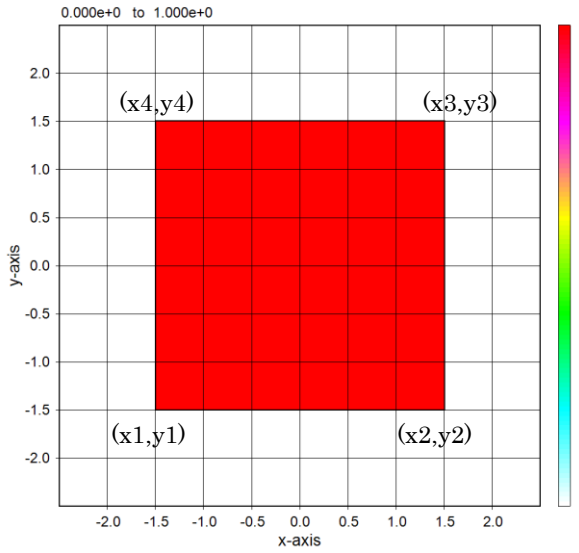
Copntents of sub.dat

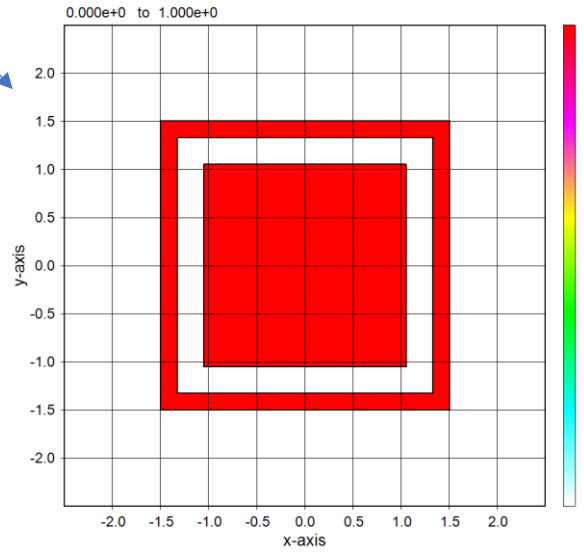
	x1	y1	x2	y2	x3	y3	x4	y4
Digit1	5	15	25	35	45	55	65	75	85
1	−1. 5000	−1. 5000	1. 5000	−1. 5000	1. 5000	1. 5000	−1. 5000	1. 5000
2	−1. 0500	−1. 0500	1. 0500	−1. 0500	1. 0500	1. 0500	−1. 0500	1. 0500
	−1. 5000	−1. 5000	1. 5000	−1. 5000	1. 5000	−1. 3250	−1. 5000	−1. 3250
	1. 3250	−1. 3250	1. 5000	−1. 3250	1. 5000	1. 3250	1. 3250	1. 3250
	1. 5000	1. 3250	1. 5000	1. 5000	−1. 5000	1. 5000	−1. 5000	1. 3250
	−1. 5000	−1. 3250	−1. 3250	−1. 3250	−1. 3250	1. 3250	−1. 5000	1. 3250

Corresponding to the values kt of wsb.dat. Duplication is prohibited.

Excerpt of sub.dat

The enclosing figures of four points (in μm) of (x1,y1), (x2,y2), (x3,y3), and (x4,y4) or their aggregate figures are lined up at a pitch of px, py and a shift amount of sx, sy.





Numeric data input rules

- Input numerals must be one-byte ones (full-width spaces are not allowed, nor are tab codes).
- The right end of the input numerals for each must be aligned with 10-digits increments after first 5-digits.
- Input numbers should be separated by at least one space.

22. Contents of wsb.dat (wsb09.dat), 4.9s⇒3.1s

If kp>0 in the homogeneous layer, the computation time can be reduced. However, the z-section is inaccurately displayed. If wb>0, the calculation results include some errors .

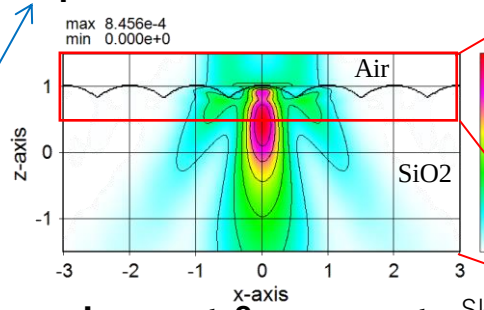
```
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)  kot         ms          ity
             1       0.500           0       0          0          0
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
        6.000       6.000       0.020       0.020
*       Lam(um)      th(deg)     fi(deg)    kps
        0.940        0.00        0.00          0
*       wx0(um)     wy0(um)     xrm(rim)    yrm(rim)    sx0(um)     sy0(um)     dfc(um)     kap
        2.000       2.000        1.00        1.00        0.000       0.000       0.000          0
*       stx(um)     sty(um)     csx(um)     csy(um)
        0.000       0.000       0.000       0.000
* km     *     Name   ko        an          ab          ak
   1#          Ta2O5    1     1.0000        0.00      0.0000
   2           -SiO2    1     1.4500        0.00      0.0000
* kr           * kd    kt       ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp
   1#             0     2        0.0         0.00        0.00        2.50        2.50        0.00        0.00        0.0
* kf    km    kr kd    kt       ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp          xq
    1     2     0  0     2        0.0       1.000       1.000       0.244       0.244       0.000       0.00        0.0         0.0
    2     2     0  0     2        0.0       1.000       1.000       0.420       0.420       0.000       0.00        0.0         0.0
    3     2     0  0     2        0.0       1.000       1.000       0.539       0.539       0.000       0.00        0.0         0.0
    4     2     0  0     2        0.0       1.000       1.000       0.633       0.633       0.000       0.00        0.0         0.0
    5     2     0  0     2        0.0       1.000       1.000       0.712       0.712       0.000       0.00        0.0         0.0
    6     2     0  0     2        0.0       1.000       1.000       0.782       0.782       0.000       0.00        0.0         0.0
    7     2     0  0     2        0.0       1.000       1.000       0.844       0.844       0.000       0.00        0.0         0.0
    8     2     0  0     2        0.0       1.000       1.000       0.900       0.900       0.000       0.00        0.0         0.0
    9     2     0  0     2        0.0       1.000       1.000       0.951       0.951       0.000       0.00        0.0         0.0
   10     2     0  0     2        0.0       1.000       1.000       0.998       0.998       0.000       0.00        0.0         0.0
   11     2     0  0     2        0.0       1.000       1.000       1.041       1.041       0.000       0.00        0.0         0.0
   12     2     0  0     2        0.0       1.000       1.000       1.081       1.081       0.000       0.00        0.0         0.0
   13     2     0  0     2        0.0       1.000       1.000       1.118       1.118       0.000       0.00        0.0         0.0
   14     2     0  0     2        0.0       1.000       1.000       1.153       1.153       0.000       0.00        0.0         0.0
   15     2     0  0     2        0.0       1.000       1.000       1.185       1.185       0.000       0.00        0.0         0.0
   16     2     0  0     2        0.0       1.000       1.000       1.215       1.215       0.000       0.00        0.0         0.0
   17     2     0  0     2        0.0       1.000       1.000       1.243       1.243       0.000       0.00        0.0         0.0
   18     2     0  0     2        0.0       1.000       1.000       1.269       1.269       0.000       0.00        0.0         0.0
   19     2     0  0     2        0.0       1.000       1.000       1.293       1.293       0.000       0.00        0.0         0.0
   20     2     0  0     2        0.0       1.000       1.000       1.316       1.316       0.000       0.00        0.0         0.0
   21     2     0  0     2        0.0       1.000       1.000       1.337       1.337       0.000       0.00        0.0         0.0
   22     2     0  0     2        0.0       1.000       1.000       1.357       1.357       0.000       0.00        0.0         0.0
   23     2     0  0     2        0.0       1.000       1.000       1.375       1.375       0.000       0.00        0.0         0.0
   24     2     0  0     2        0.0       1.000       1.000       1.392       1.392       0.000       0.00        0.0         0.0
   25     2     0  0     2        0.0       1.000       1.000       1.407       1.407       0.000       0.00        0.0         0.0
* kb   kl   km   kp        tk      kf      *     *     *     *     *     *     *     *     *     *     *     *     *     *     *     **
    1    0    0    0     0.500       0      0
    2    0    0    0     0.020       1      0
    3    0    0    0     0.020       2      0
    4    0    0    0     0.020       3      0
    5    0    0    0     0.020       4      0
    6    0    0    0     0.020       5      0
    7    0    0    0     0.020       6      0
    8    0    0    0     0.020       7      0
    9    0    0    0     0.020       8      0
   10    0    0    0     0.020       9      0
   11    0    0    0     0.020      10      0
   12    0    0    0     0.020      11      0
   13    0    0    0     0.020      12      0
   14    0    0    0     0.020      13      0
   15    0    0    0     0.020      14      0
   16    0    0    0     0.020      15      0
   17    0    0    0     0.020      16      0
```

Continued

```
   18    0    0    0     0.020      17      0
   19    0    0    0     0.020      18      0
   20    0    0    0     0.020      19      0
   21    0    0    0     0.020      20      0
   22    0    0    0     0.020      21      0
   23    0    0    0     0.020      22      0
   24    0    0    0     0.020      23      0
   25    0    0    0     0.020      24      0
   26    0    0    0     0.020      25      0
   27    0    2    0     2.000       0      0
```

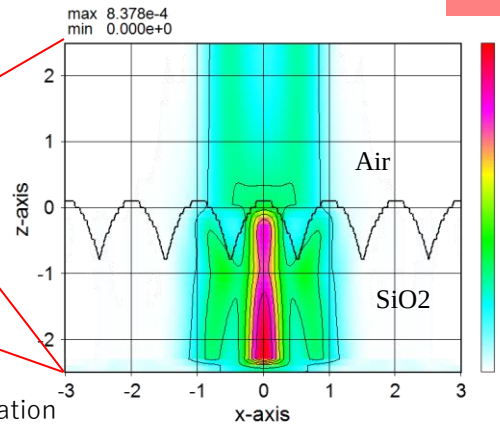
Insert a blank line starting with "c" at the breakpoint to abort reading

kp=0

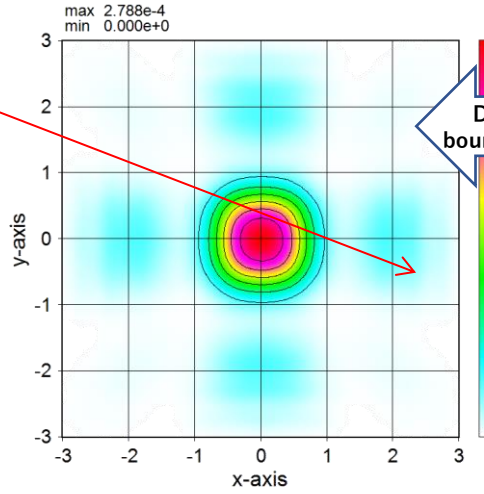


i_xz.out & m_xz.out

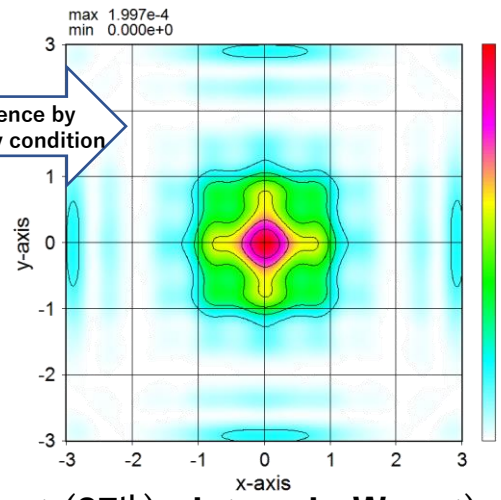
kp=1



Skip calculation



Difference by boundary condition



i_xy.out (last (27th) picture in Wscnt)

Base layers

Up to 10000 lines can be input as far as the last line or the line starting from "c" appears. Optical constants above the top layer or below the bottom layer is the same ones as the top or the bottom layer, respectively, and then no boundary reflections from there.

kl Not operated (operated in wsf and wsr).

km Construction material number referred in km designation field. km=0 means vacuum (n=1.0).

kp =0: Automatic setting by definition of dz. >0: The layer thickness tk is divided by kp.
In case of homogeneous configuration, setting of kp=1 enables skip calculation.

tk Layer thickness (um)

kf =0: No reference. >0: Structure shape number referred in kf designation field. The referred shape structures are overwritten on the layer. This numbers are represented by four digits, up to 100 set per line.

23. Method of forming a lens shape (wsb10.dat), 1.9s

	A	B	C	D	E
1					
2	a=radius	n=Layer No	y=a-n*dz	x=sqrt(a^2-y^2)	2x=Intercept width
3	0.75	1	0.740	0.122	0.244
4	dz=Grid interval	2	0.720	0.210	0.420
5	0.02	3	0.700	0.269	0.539
6	ht=height	4	0.680	0.316	0.633
7	0.5	5	0.660	0.356	0.712
8		6	0.640	0.391	0.782
9		7	0.620	0.422	0.844
10		8	0.600	0.450	0.900
11		9	0.580	0.475	0.951
12		10	0.560	0.499	0.998
13		11	0.540	0.520	1.041
14		12	0.520	0.540	1.081

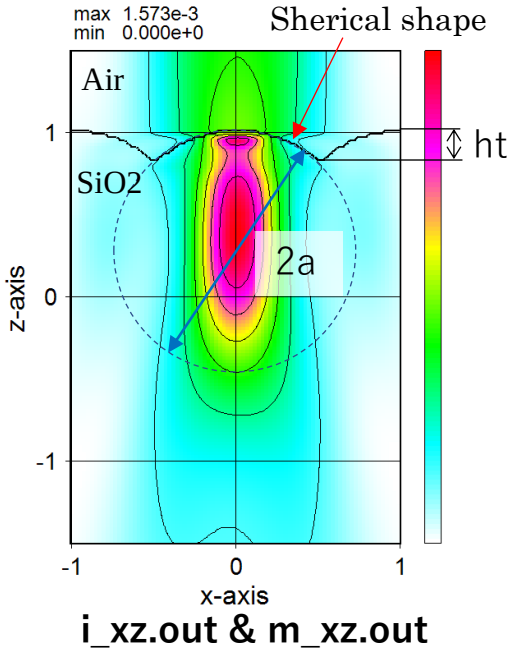
ht Structure height (μm)
a Radius for circular cross-section (μm)

wsems_data.xlsx

```
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot          ms          ity
            1       0.500           0          0           0           0
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
        2.000       2.000       0.020       0.020
*       Lam(um)      th(deg)     fi(deg)   kps
        0.750        0.00        0.00        0
*       wx0(um)     wy0(um)     xrm(rim)    yrm(rim)    sx0(um)     sy0(um)     dfc(um)     kap
        1.800       1.800       0.00        0.00        0.000       0.000       0.000         0
*       stx(um)     sty(um)     csx(um)     csy(um)
        0.000       0.000       0.000       0.000
* km    *     Name   ko          an          ab          ak
   1#          Ta205    1      1.0000        0.00      0.0000
   2           -Si02    1      1.4500        0.00      0.0000
* kr           * kd    kt        ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp
   1#           0      2         0.0         0.00        0.00        2.50        2.50        0.00        0.00        0.0
* kf    km    kr kd    kt        ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp          xq
    1     2     0  0     2         0.0       1.000       1.000       0.244       0.244       0.000       0.00        0.0         0.0
    2     2     0  0     2         0.0       1.000       1.000       0.420       0.420       0.000       0.00        0.0         0.0
    3     2     0  0     2         0.0       1.000       1.000       0.539       0.539       0.000       0.00        0.0         0.0
    4     2     0  0     2         0.0       1.000       1.000       0.633       0.633       0.000       0.00        0.0         0.0
    5     2     0  0     2         0.0       1.000       1.000       0.712       0.712       0.000       0.00        0.0         0.0
    6     2     0  0     2         0.0       1.000       1.000       0.782       0.782       0.000       0.00        0.0         0.0
    7     2     0  0     2         0.0       1.000       1.000       0.844       0.844       0.000       0.00        0.0         0.0
    8     2     0  0     2         0.0       1.000       1.000       0.900       0.900       0.000       0.00        0.0         0.0
    9     2     0  0     2         0.0       1.000       1.000       0.951       0.951       0.000       0.00        0.0         0.0
   10     2     0  0     2         0.0       1.000       1.000       0.998       0.998       0.000       0.00        0.0         0.0
   11     2     0  0     2         0.0       1.000       1.000       1.041       1.041       0.000       0.00        0.0         0.0
   12     2     0  0     2         0.0       1.000       1.000       1.081       1.081       0.000       0.00        0.0         0.0
   13     2     0  0     2         0.0       1.000       1.000       1.118       1.118       0.000       0.00        0.0         0.0
   14     2     0  0     2         0.0       1.000       1.000       1.153       1.153       0.000       0.00        0.0         0.0
   15     2     0  0     2         0.0       1.000       1.000       1.185       1.185       0.000       0.00        0.0         0.0
   16     2     0  0     2         0.0       1.000       1.000       1.215       1.215       0.000       0.00        0.0         0.0
   17     2     0  0     2         0.0       1.000       1.000       1.243       1.243       0.000       0.00        0.0         0.0
   18     2     0  0     2         0.0       1.000       1.000       1.269       1.269       0.000       0.00        0.0         0.0
   19     2     0  0     2         0.0       1.000       1.000       1.293       1.293       0.000       0.00        0.0         0.0
   20     2     0  0     2         0.0       1.000       1.000       1.316       1.316       0.000       0.00        0.0         0.0
   21     2     0  0     2         0.0       1.000       1.000       1.337       1.337       0.000       0.00        0.0         0.0
   22     2     0  0     2         0.0       1.000       1.000       1.357       1.357       0.000       0.00        0.0         0.0
   23     2     0  0     2         0.0       1.000       1.000       1.375       1.375       0.000       0.00        0.0         0.0
   24     2     0  0     2         0.0       1.000       1.000       1.392       1.392       0.000       0.00        0.0         0.0
   25     2     0  0     2         0.0       1.000       1.000       1.407       1.407       0.000       0.00        0.0         0.0
* kb   kl   km   kp          tk    kf    *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
   1    0    0    0        0.500   000   0
```

Continued

```
    2     0     0     0       0.020   001     0
    3     0     0     0       0.020   002     0
    4     0     0     0       0.020   003     0
    5     0     0     0       0.020   004     0
    6     0     0     0       0.020   005     0
    7     0     0     0       0.020   006     0
    8     0     0     0       0.020   007     0
    9     0     0     0       0.020   008     0
   10     0     0     0       0.020   009     0
   11     0     0     0       0.020   010     0
   12     0     0     0       0.020   011     0
   13     0     0     0       0.020   012     0
   14     0     0     0       0.020   013     0
   15     0     0     0       0.020   014     0
   16     0     0     0       0.020   015     0
   17     0     0     0       0.020   016     0
   18     0     0     0       0.020   017     0
   19     0     0     0       0.020   018     0
   20     0     0     0       0.020   019     0
   21     0     0     0       0.020   020     0
   22     0     0     0       0.020   021     0
   23     0     0     0       0.020   022     0
   24     0     0     0       0.020   023     0
   25     0     0     0       0.020   024     0
   26     0     0     0       0.020   025     0
   27     0     2     0       2.000   000     0
```



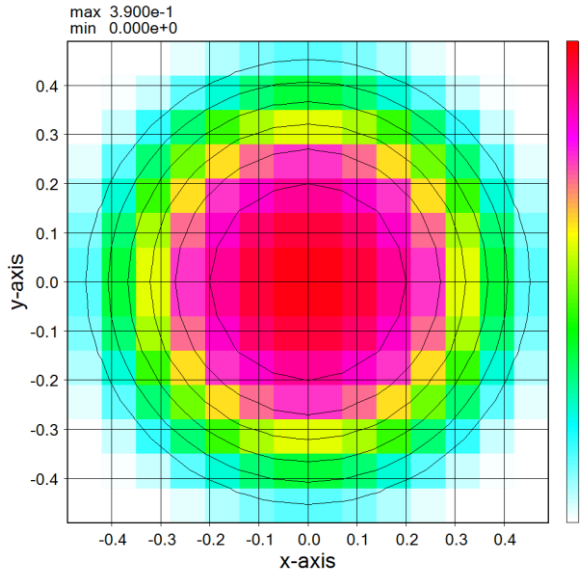
i_xz.out & m_xz.out

Rewritten　As it is　Rewritten　As it is　Rewritten

24. Method of converting AFM data by afm.exe (afm01.dat)

nx x-axis measurement point
ny y-axis measurement point
dx x-axis measurement increment (μm)
dy y-axis measurement increment (μm)
amp z-axis measurement amplification ratio
theta Azimuth angle of the plane normal with the z-axis (deg)
phi Angular angle of the plane normal around the z-axis (deg)
psi Rotation angle of the measured image around the plane normal (deg)

AFM measurement data of nx·ny (for x and y-axis) points, each value in μm, displayed in 10 digits



Input file afm.dat

** AFM data

nx	ny	dx(um)	dy(um)	amp	theta(deg)	phi(deg)	psi(deg)
15	15	0.07	0.07	1.000	0.000	0.0000	0.0000

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007605	0.011817	0.007605	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.032162	0.064350	0.086619	0.094445	0.086619	0.064350	0.032162	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.007605	0.057395	0.110630	0.153556	0.180427	0.189501	0.180427	0.153556	0.110630	0.057395	0.007605	0.000000	0.000000
0.000000	0.000000	0.057395	0.127439	0.189501	0.235001	0.261937	0.270777	0.261937	0.235001	0.189501	0.127439	0.057395	0.000000	0.000000
0.000000	0.032162	0.110630	0.189501	0.253019	0.296660	0.321334	0.329225	0.321334	0.296660	0.253019	0.189501	0.110630	0.032162	0.000000
0.000000	0.064350	0.153556	0.235001	0.296660	0.336921	0.358735	0.365534	0.358735	0.336921	0.296660	0.235001	0.153556	0.064350	0.000000
0.007605	0.086619	0.180427	0.261937	0.321334	0.358735	0.378339	0.384319	0.378339	0.358735	0.321334	0.261937	0.180427	0.086619	0.007605
0.011817	0.094445	0.189501	0.270777	0.329225	0.365534	0.384319	0.390000	0.384319	0.365534	0.329225	0.270777	0.189501	0.094445	0.011817
0.007605	0.086619	0.180427	0.261937	0.321334	0.358735	0.378339	0.384319	0.378339	0.358735	0.321334	0.261937	0.180427	0.086619	0.007605
0.000000	0.064350	0.153556	0.235001	0.296660	0.336921	0.358735	0.365534	0.358735	0.336921	0.296660	0.235001	0.153556	0.064350	0.000000
0.000000	0.032162	0.110630	0.189501	0.253019	0.296660	0.321334	0.329225	0.321334	0.296660	0.253019	0.189501	0.110630	0.032162	0.000000
0.000000	0.000000	0.057395	0.127439	0.189501	0.235001	0.261937	0.270777	0.261937	0.235001	0.189501	0.127439	0.057395	0.000000	0.000000
0.000000	0.000000	0.007605	0.057395	0.110630	0.153556	0.180427	0.189501	0.180427	0.153556	0.110630	0.057395	0.007605	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.032162	0.064350	0.086619	0.094445	0.086619	0.064350	0.032162	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007605	0.011817	0.007605	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Execution file afm.exe

Click to generate (overwrite) the output file in a folder

Output file

afm.out For being pasted into sub.dat.

afm_xy.out AFM data before and after correction which Wscnt visualizes as 1st and 2nd picture.

In case of theta=phi=psi=0, AFM data is the same before and after correction and one is selected.

afm_xy.out 2nd picture visualized by Wscnt

25. Pasting converted data of AFM (wsb11.dat), 1.8s

```
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)  kot         ms         ity
          1          0.5         0         0          0          0
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
        2.0         2.0         0.02        0.02
*       Lam(um)      th(deg)     fi(deg)   kps
       0.75         0.0         0.0         0
*       wx0(um)     wy0(um)     xrm(rim)    yrm(rim)   sx0(um)     sy0(um)     dfc(um)     kap
        1.8         1.8         0.0         0.0        0.0         0.0         0.0          0
*       stx(um)     sty(um)     csx(um)     csy(um)
        0.0         0.0         0.0         0.0
* km    *     Name   ko          an          ab          ak
   1#           Si    1     1.0000        0.00      0.0000
   2          -SiO2   1     1.4500        0.00      0.0000
* kr          * kd    kt       ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp
   1#             0     4       0.0        1.50        1.50        0.500       0.50        0.00        0.00        0.0
* kf  km    kr  kd    kt       ps(deg)     px(um)      py(um)      wx(um)      wy(um)      sx(um)      sy(um)      xp          xq
   1    2     0   1    11       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   2    2     0   1    12       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   3    2     0   1    13       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   4    2     0   1    14       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   5    2     0   1    15       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   6    2     0   1    16       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   7    2     0   1    17       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   8    2     0   1    18       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
   9    2     0   1    19       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  10    2     0   1    20       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  11    2     0   1    21       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  12    2     0   1    22       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  13    2     0   1    23       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  14    2     0   1    24       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  15    2     0   1    25       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  16    2     0   1    26       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  17    2     0   1    27       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  18    2     0   1    28       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
  19    2     0   1    29       0.0        1.00        1.00        0.00        0.00        0.000       0.00        0.0         0.0
* kb  kl  km  kp        tk      kf    *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
   1   0   0   0      0.200     0     0
```

Input file

afm.dat

paste

sub.dat

afm.out

Output file

Continued

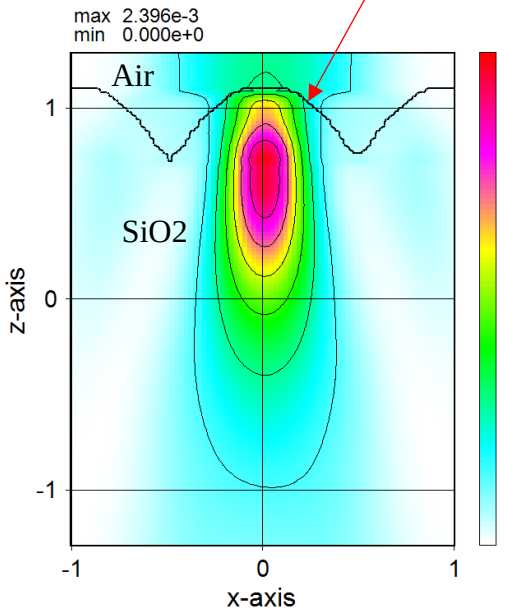
```
   2   0   0   0   0.0200    1   0
   3   0   0   0   0.0200    2   0
   4   0   0   0   0.0200    3   0
   5   0   0   0   0.0200    4   0
   6   0   0   0   0.0200    5   0
   7   0   0   0   0.0200    6   0
   8   0   0   0   0.0200    7   0
   9   0   0   0   0.0200    8   0
  10   0   0   0   0.0200    9   0
  11   0   0   0   0.0200   10   0
  12   0   0   0   0.0200   11   0
  13   0   0   0   0.0200   12   0
  14   0   0   0   0.0200   13   0
  15   0   0   0   0.0200   14   0
  16   0   0   0   0.0200   15   0
  17   0   0   0   0.0200   16   0
  18   0   0   0   0.0200   17   0
  19   0   0   0   0.0200   18   0
  20   0   0   0   0.0200   19   0
  21   0   2   0     2.0     0   0
```

Rewritten

As it is

Rewritten

Measurement shape of AFM expressed by sub.dat

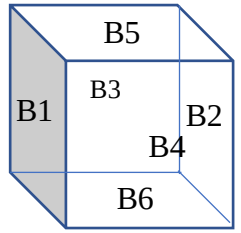


i_xz.out & m_xz.out

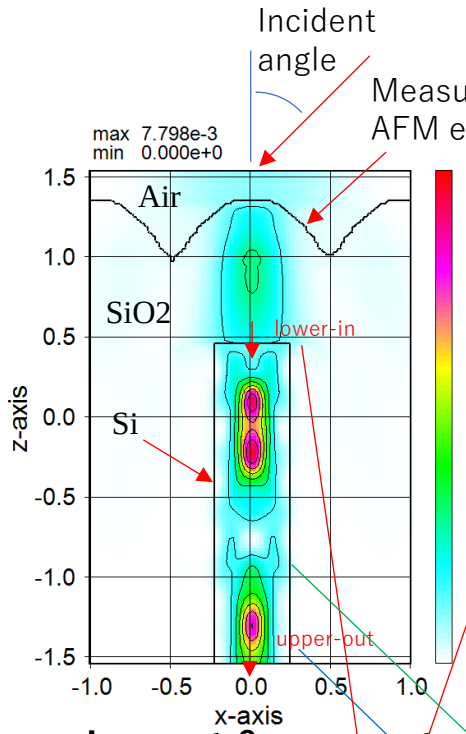
26. Calculation example (wsb12.dat), 2.6s×40

```
** wsb.dat
*       ncy(>0)      wb(um)    kfl(0,1)   kot         ms        ity
            1       0.500           0         0          0          0
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
        2.000       2.000       0.020       0.020
*       Lam(um)     th(deg)     fi(deg)    kps
        0.750        0.00        0.00          0
*       wx0(um)     wy0(um)     xrm(rim)   yrm(rim)   sx0(um)    sy0(um)    dfc(um)    kap
        1.800       1.800       0.00        0.00       0.000      0.000      0.000          0
*       stx(um)     sty(um)     csx(um)    csy(um)
        0.000       0.000       0.000       0.000
* km    *     Name  ko          an          ab         ak
  1             Si    1     1.0000        0.00     0.0000
  2           -SiO2   1     1.4500        0.00     0.0000
* kr           * kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp
  1#             0     4         0.0        1.50       1.50       0.500      0.50       0.00       0.00       0.0
* kf    km    kr kd    kt        ps(deg)    px(um)     py(um)     wx(um)     wy(um)     sx(um)     sy(um)     xp         xq
    1     2     0  1    11         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    2     2     0  1    12         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    3     2     0  1    13         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    4     2     0  1    14         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    5     2     0  1    15         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    6     2     0  1    16         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    7     2     0  1    17         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    8     2     0  1    18         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
    9     2     0  1    19         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   10     2     0  1    20         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   11     2     0  1    21         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   12     2     0  1    22         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   13     2     0  1    23         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   14     2     0  1    24         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   15     2     0  1    25         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   16     2     0  1    26         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   17     2     0  1    27         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   18     2     0  1    28         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   19     2     0  1    29         0.0        1.00       1.00       0.00       0.00       0.000      0.00       0.0        0.0
   20     1     0  0     1         0.0        0.0        0.0        0.50       0.50       0.000      0.00       0.0        0.0
* kb   kl   km   kp        tk     kf     *     *     *     *     *     *     *     *     *     *     *     *     *     *     *
    1    0    0    0     0.200      0     0
    2    0    0    0    0.0200      1     0
    3    0    0    0    0.0200      2     0
    4    0    0    0    0.0200      3     0
    5    0    0    0    0.0200      4     0
    6    0    0    0    0.0200      5     0
    7    0    0    0    0.0200      6     0
    8    0    0    0    0.0200      7     0
    9    0    0    0    0.0200      8     0
   10    0    0    0    0.0200      9     0
   11    0    0    0    0.0200     10     0
   12    0    0    0    0.0200     11     0
   13    0    0    0    0.0200     12     0
   14    0    0    0    0.0200     13     0
   15    0    0    0    0.0200     14     0
   16    0    0    0    0.0200     15     0
   17    0    0    0    0.0200     16     0
   18    0    0    0    0.0200     17     0
   19    0    0    0    0.0200     18     0
   20    0    0    0    0.0200     19     0
   21    0    2    0     0.500      0     0
   22    0    2    0     2.000     20
```

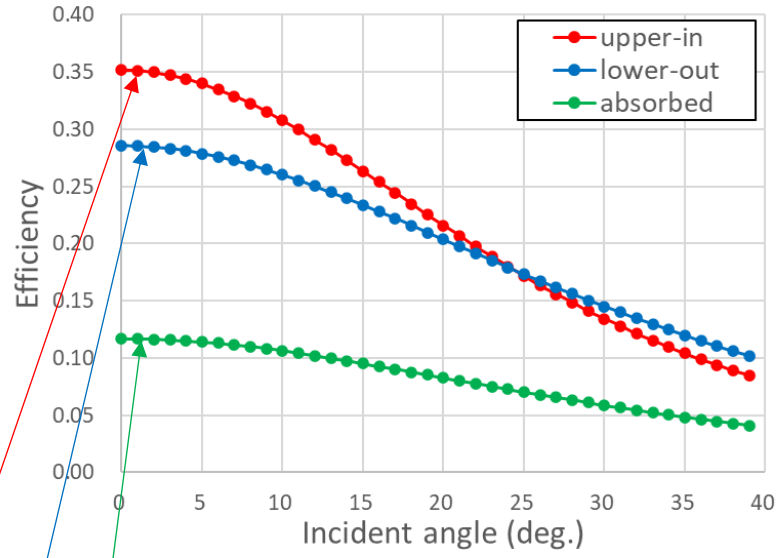
The computation speed is more than 250 times faster than that for wsf (FDTD).



When up/down is set to a reversal mode in Wscnt, “up” is correspond to -z side and “down” is to +z side.



i_xz.out & m_xz.out



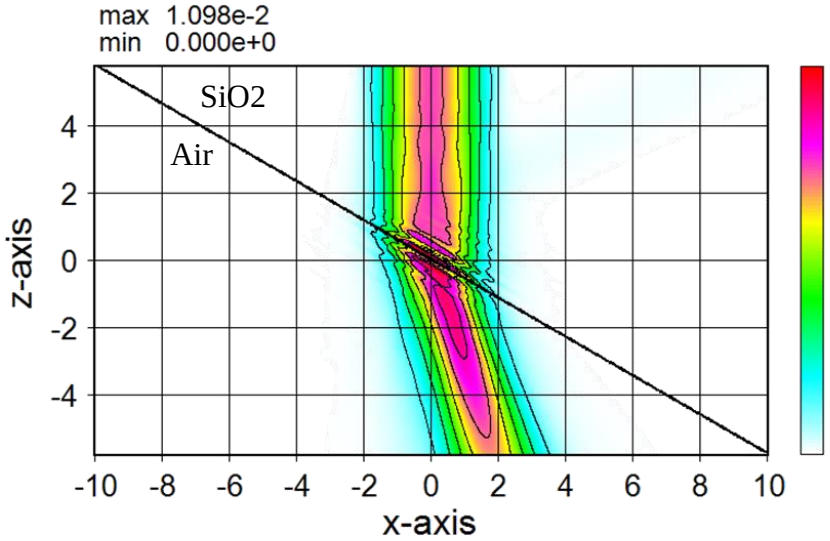
Output of wsb1.out (Detected light amount)

Transmitted	Reflected	Absorbed	Rest 01/lower-in	upper-out	absorbed 02/lower-in	upper-out	absorbed
3.5005E-01	0.0000E+00	1.1701E-01	5.3295E-01	3.5197E-01	2.8565E-01	1.1701E-01	6.5720E-01	4.1471E-01	0.0000E+00

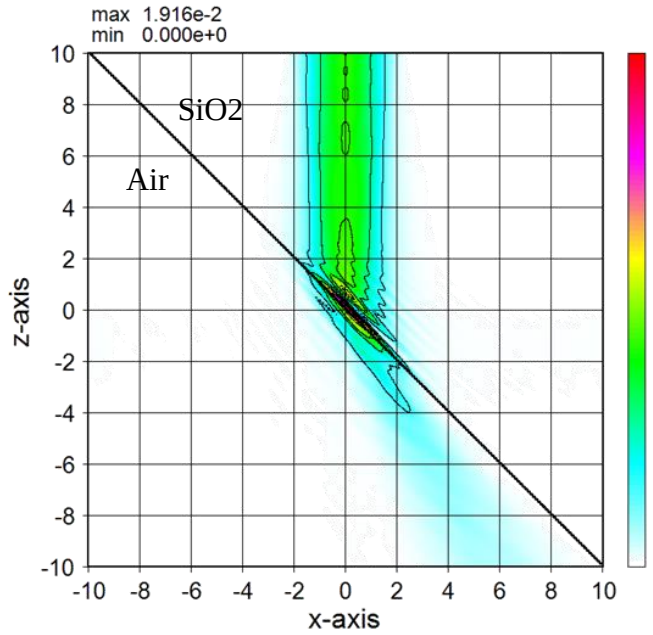
wsb1.out

27. Notes (wsb13.dat), 6s

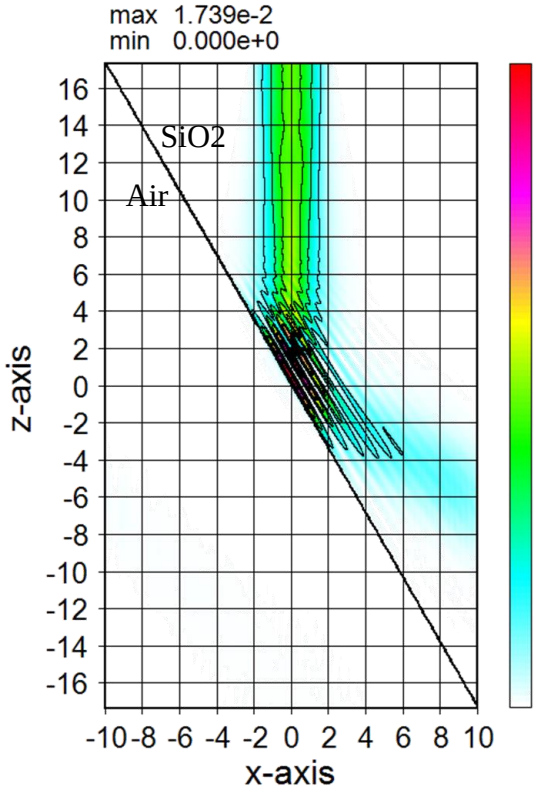
1. Internally defined materials (SiO2, Ag, Al, Au, Be, Cr, Cu, Ni, Pd, Pt, Ti, W) are prefixed with -, like -Ag. This is done to distinguish from externally definitions.
2. Long slopes with a high gradient relative to the xy-plane, especially when the propagation direction of reflected light is aligned horizontally (in the xy-plane) (e.g., total reflection with a 45-degree gradient slope, like wsb13.dat), introduce errors in the reflection calculation.
3. If an execution error occurs, please check the following items.
   a. Do input numbers contain half-width ones?
   b. Is the right edge of an input number aligned with the right edge of the variable label (or the * mark) above?
   c. Is the type of input digits (integer type or real number type) correct? An integer type is without a decimal point, and a real number type with a decimal point.
   d. Are there any numbers not specified in km, kb, or kf specification fields?



tk=0.00577



tk=0.0100



tk=0.01732

i_xz.out & m_xz.out 3rd picture visualized by Wscnt