CORIA UMR 6614 - CNRS
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Manual of the soft ABSphere

A software for computing **A**ll properties of a shaped **B**eam scattering by a **Sphere**

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[December 2013]

The software ABSphere is a result of theoretical research of the author for more than 20 years on the interaction of a light beam with a particle. It is based on the rigorous theory to calculate various physical quantities, including the scattering diagram, the forces and torques exerted by a beam of light on the particle, the internal and external electromagnetic field of the particle.
The particle is spherical, it can be homogeneous or with concentric layered refractive index gradient. Four different forms of light beam are considered. A user-friendly interface facilitates the use of the software and the interpretation of results

ABSphere

for

Prediction

of

- the scattering diagrams,
- the internal and near field,
- the radiation pressure forces
- and the torques

of

any shaped beam scattered by
a homogeneous
or multilayered
spherical particle

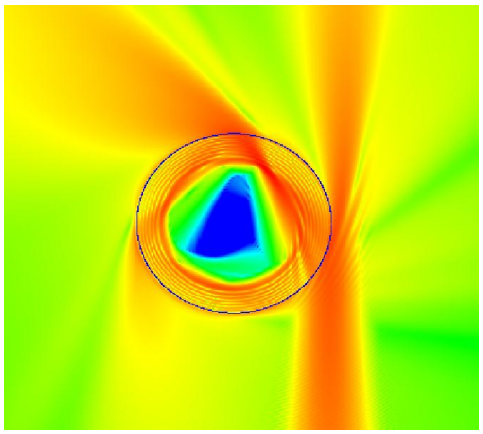

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Table of contents

Version 1.00

1. General description of ABSphere

ABSphere is developed under Windows with Delphi, an integrated development environment (IDE). The kernel part for the calculation is written in Fortran 95.
The following three files are necessary to run the software:

1. `ABSphere.exe`: executable file of ABSphere,
2. `ABSphere.dll`: dynamic link library file necessary for the calculation,
3. `ABSphere.par`: the default parameter file read by the software when launching the software. The user can load another parameter file later with the help of the submenu `Load parameters` in the main menu `File` for other configuration.

Notes:

a. The parameter file is in a text format. In principle, the user can modify it with any text editor. But the user is strongly recommended not to modify it manually.
b. If the file `ABSphere.par` does not exist, an open dialogue window appears for the user to load a parameter file.

2. Main window and main menu of the software:

The main window consists of five parts (see Figure 1 on the next page):

1. **Main menu**: `Files, Parameters, Calculation, View` and `Help`
   - "`Files`": to load and save the parameter file and the calculated data file and also to print, save or copy the graphics on the screen.
   - "`Parameters`": to define the parameters of the beam and of the particles.
   - "`Calculation`": to launch the calculation of
     - Scattering diagram for a given beam and particle
     - Internal – near field for a given beam and particle
     - Radiation pressure as function of particle position or as function of particle size.
     - Radiation torque as function of particle position or as function of particle size.
   - "`View`": to show the results already calculated.
   - "`Help`": to give information about ABSphere.
2. **Toolbar**: there are three groups of speed buttons in toolbar:
   - First group – graphics: for print  , save  or copy  the graphics on the screen,
   - Second group – parameters: for setting of beam parameters  and particle parameters  ,
   - Third group – calculation: for the calculations of diagram  and the internal/near field  , the radiation pressure as function of particle size  or as function of particle position  and radiation torque  .

3. **Graphics zone**: to display the calculated result or the loaded data.
   Notes:
   No special zoom or displacement function is designed, but the user can use simply the mouse to zoom or move the graphics as described below:
   - To zoom in: Point the mouse cursor at the left-top of the zone to be zoomed, click the left button of mouse and drag with until the right-bottom of the part of the zone. When release the mouse button the selected zone is displayed in the all graphic window. The final point (right-bottom) can be out of the graphic window.
   - To zoom out: similar to the zoom in, but from the right-bottom to the left-top.
   - To move: Drag simply with the right button of the mouse.
4. **Status bar** on the bottom of the main window gives some useful information about the scattering diagram, the internal field, the radiation pressure and torque: calculated, loaded or saved.

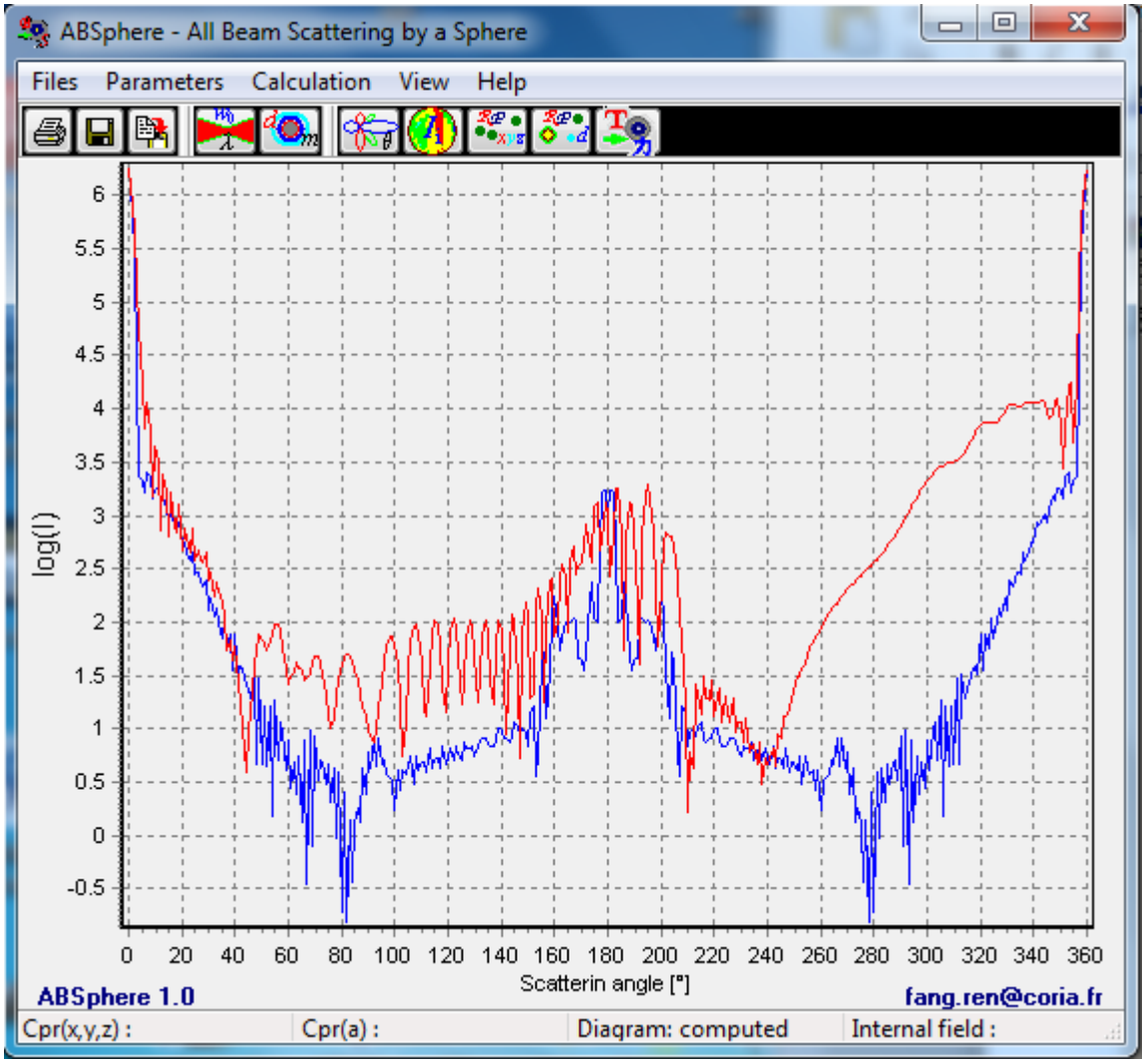


Fig. 1 Main window of ABSphere with calculated scattering diagrams.

3. Submenus:

1) Files

This submenu (see Fig. 2 on the next page) permits:

- to load and save the parameter file to be used for the calculation. Different configurations parameters can be saved and reloaded with a user given file name.
- to save the calculated results in files for the further treatment with other tools. The user can reload the data files and view them with the submenu "view" in the main menu.
  The convention of the extension of file names is following:
  - `par`: parameter file
  - `prp`: radiation pressure as function of particle position in the beam
  - `prs`: radiation pressure as function of particle size for a given position in the beam
  - `sca`: scattering diagram for a given particle size and position
  - `ifi`: internal field intensity for a given particle size and position
- to print, save or copy the graphics shown in the graphic zone
  - The graphics can be saved in Bitmap or in Metafile format.
  - The "Copy graphics" makes a copy of the graphics on the screen to the standard windows clipboard in Enhanced Metafile format. The user can paste it in any windows applications which accept this format, such as word, excel, PowerPoint …
- to "Exit" the software

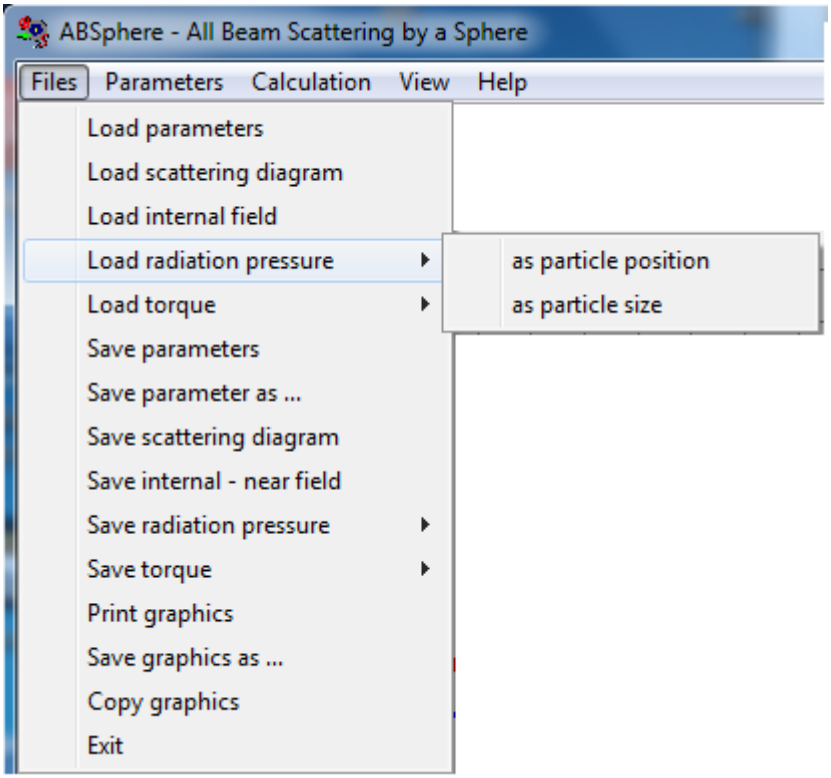


Fig. 2 Submenu `files`

2) Parameters

see Appendix for the definition of the parameters

This menu (Fig. 3) permits to define the beam and particle parameters for the calculation. There are two submenus.

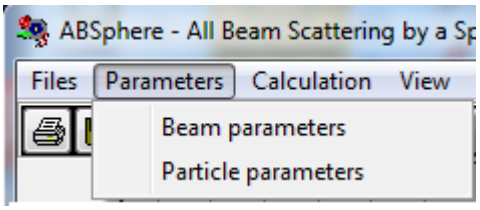


Fig. 3 Submenu `Parameters`

1. By choosing `Beam parameters`, the user will obtain the following sub-window (Fig. 4) which permits to choose the type of the beam and to define the beam parameters.

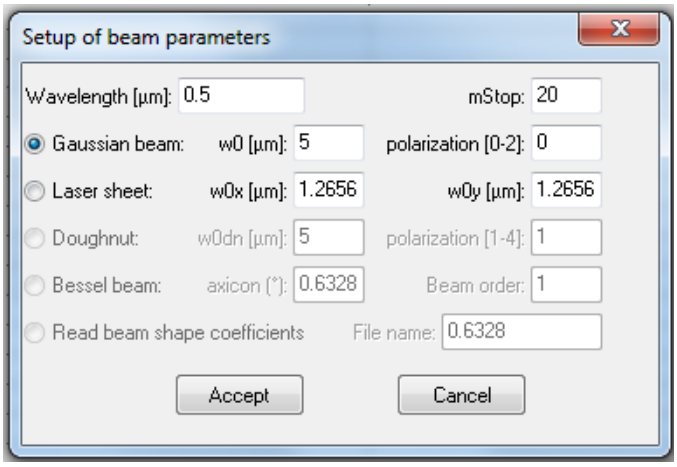


Fig. 4 Sub window for set-up of `beam parameters`

2. By choosing `particle parameters`, the user will obtain the following sub-window (Fig. 5) which permits to choose the type of the particle (homogeneous or multilayed) and to define the particle properties.

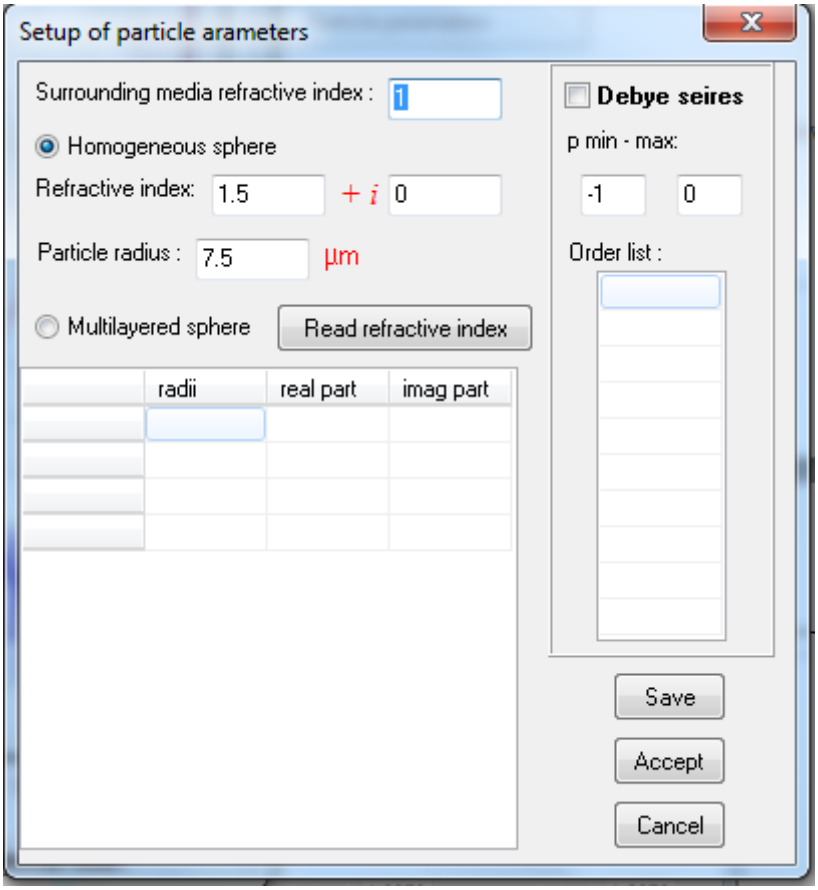


Fig. 5 Sub window for set-up of `particle parameters`

3) Calculation:

This menu (Fig. 6) permits to launch the calculation of radiation pressure as function of particle position or as function of particle size, the scattering diagram and the internal field for given beam and particle with the parameters defined in the sub-menu `Parameters`.

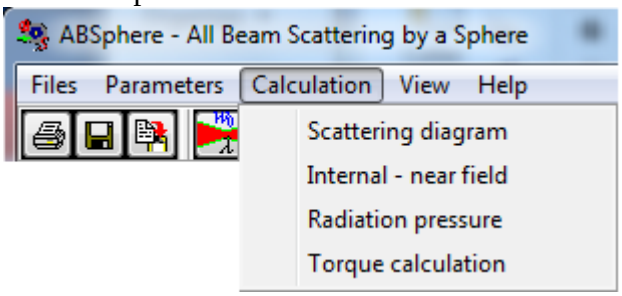


Fig. 6 Submenu of `calculation`

I. Scattering diagram

By choosing `Scattering diagram` in the `Calculation` menu, the following sub-windows (Fig. 7) appears which permits to define the azimuth angle ϕ, the initial and final

angles of scattering θ. The scattering intensity can be shown as linear or logarithmic scale (this choice takes effect even when the window is closed simply with 'Close'). If "Auto clear" is unchecked, the new curve is displayed with the previous ones, in order to compare the results calculated for different parameters for example.

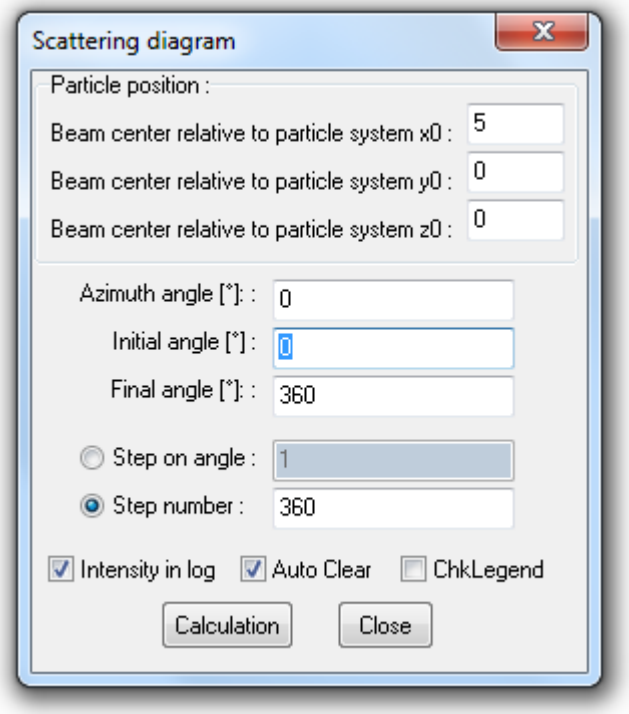


Fig. 7 Sub-window for the calculation of the scattering diagram

II. Internal and near field

By choosing Internal -near field, the following sub-window (Fig. 8) appears. The user can calculate the internal and near electromagnetic field intensity distribution in the plane including the z axis. The orientation of the plane is defined by the angle *phi* relative to the *x* axis. *XYmin* and *XYmax* signify the ranges of calculation on the *xy* plane.
The intensity distribution map can be logarithmic or linear, in colour or grey. These options are also used for the menu View to show the field map (this choice takes effect even when the window is closed simply with 'Close').

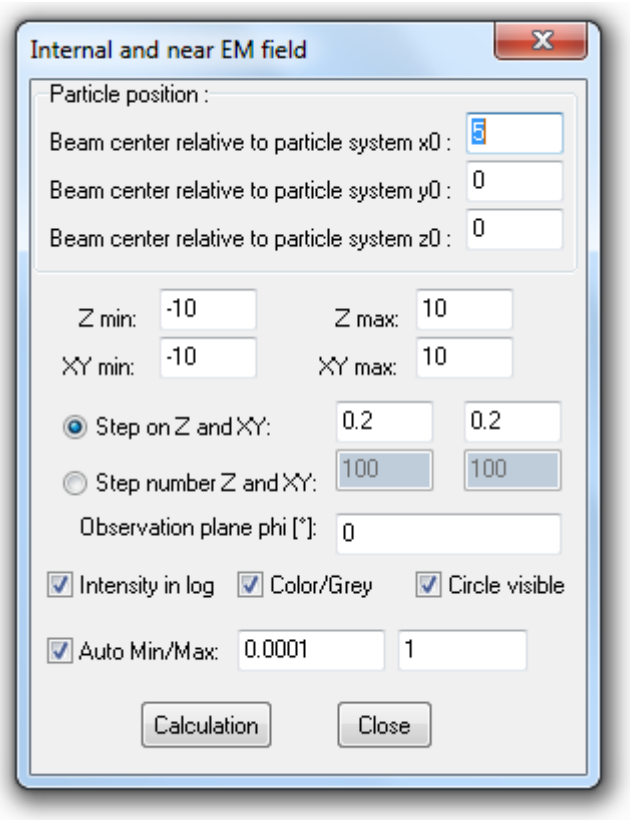


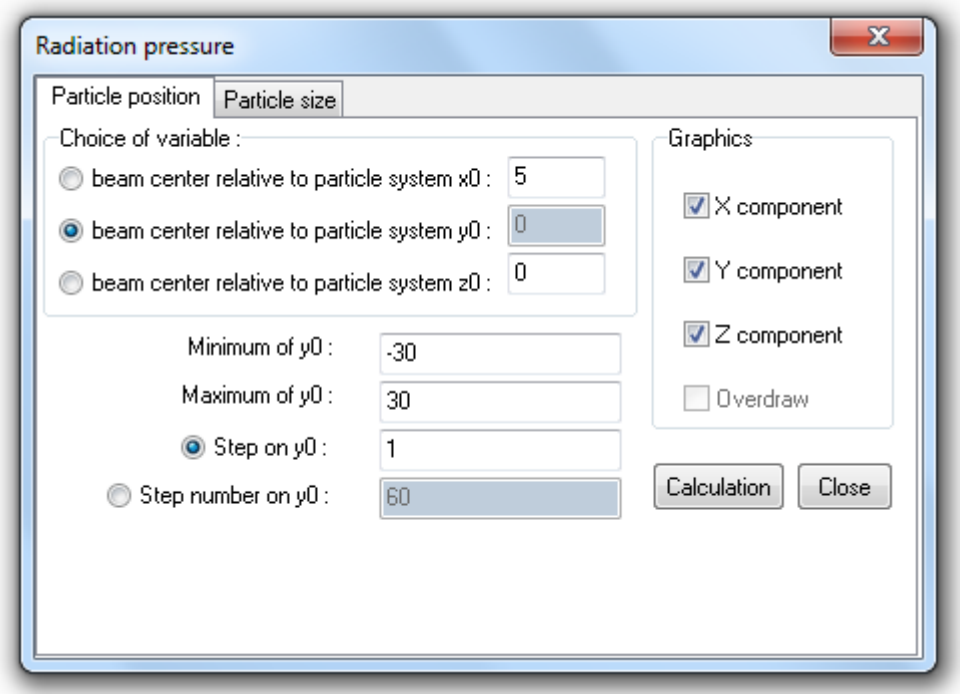
Fig. 8 Sub-window for the calculation of the `internal field intensity`

III. Radiation pressure

By choosing `Radiation pressure` in the `Calculation` menu, the following sub-window (Fig. 9) appears. There are two pages in this menu.

The first page `Particle position` permits to calculate the radiation pressure as function of the position of the particle and to define the range of calculation. The page consists of four parts:

- Top-left: to choose the variable x0, y0 or z0
- Bottom-left: to define the range of calculation and the step
- Top-right: to choose the components of radiation to be shown in the graphic view of main window. These parameters are used also view the radiation pressure with menu `View`.
- Bottom-right: to launch the calculation or close this submenu without calculation (the graphic parameters take effect in any case).



2 Fig. 9 Sub-window for the calculation of radiation pressure as function of particle position in the beam

The second page `Particle size` permits to calculate the radiation pressure as function of the particle size for a given position and to define the range of calculation. The page consists of four parts:

- Top-left: to define the particle position in the beam x0, y0 and z0
- Bottom-left: to define the range of calculation and the step
- Top-right: to choose the components of radiation to be shown in the graphic view of main window. These parameters are used also in the window `view` to show the radiation pressure.
- Bottom-right: to launch the calculation or close this submenu without calculation (the graphic parameters take effect in any case).

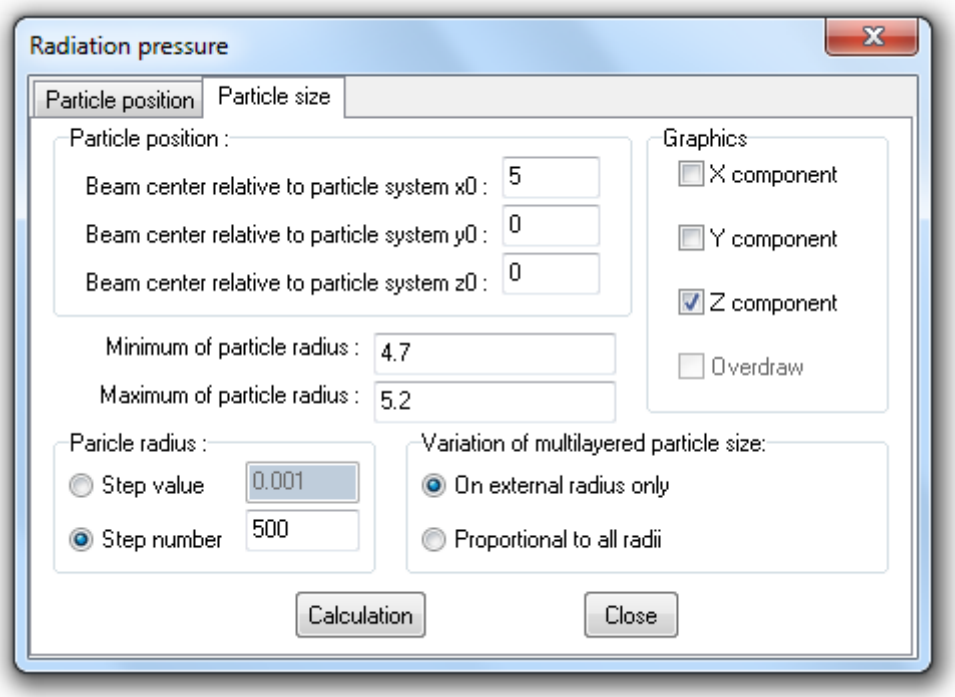


Fig. 10 Sub-window for the calculation of radiation pressure as function of particle size

IV. Radiation torque

The menus and the definition of the parameters for the calculation of the radiation toque is the same as for the radiation pressure.

4) View

This menu permits to show the computed data or the data loaded from the saved files. The graphic parameters used here (the components of radiation pressure to be displayed, the type (linear or in log) of vertical scale for the scattering diagram and the type (linear or logarithmic) and the colour/grey for internal field map) are those defined in the corresponding `Calculation` menu.

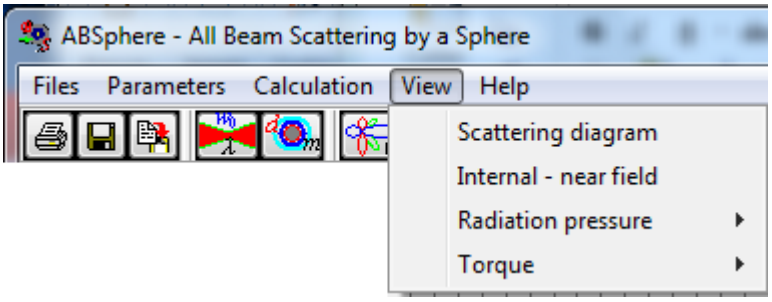


Fig. 11 Submenu `View`

5) Help

This gives some information about the soft.

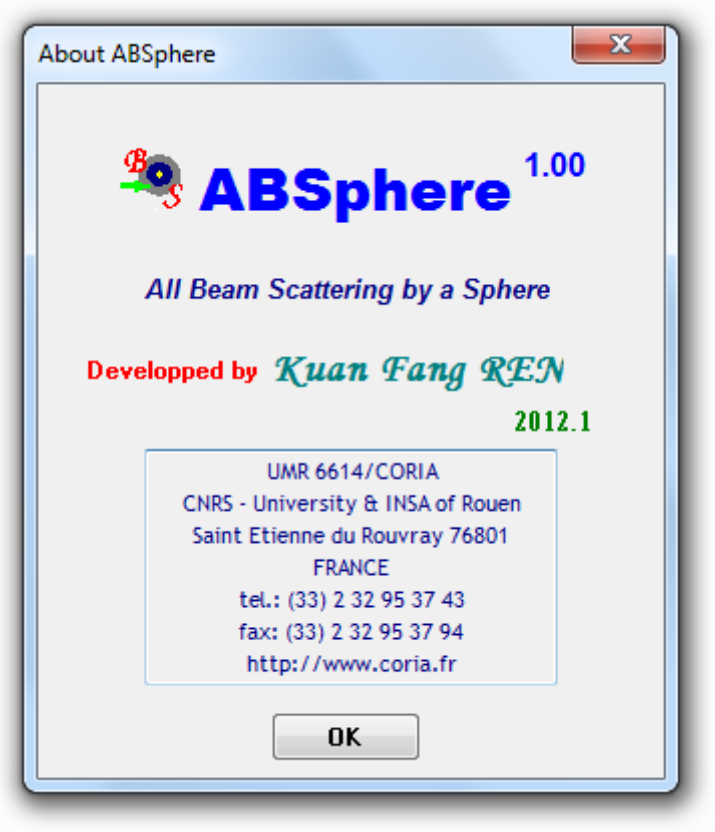


Fig. 12 Submenu `Help`

4. Appendix

1) Refractive index and the wavelength

The refractive index and the wavelength of the incident beam are sometime confusing parameters in the Mie calculation. Here is a principle to take into account for these

> *A particle of refractive index m in a media of refractive index m_0 illuminated with a beam of the wavelength λ_0 in the FREESPACE is equivalent to a particle of refractive index n/n_0 in a media of refractive index $\boldsymbol{n_m}$ =1 illuminated with a beam of the wavelength $\lambda=\lambda_0/\boldsymbol{n_m}$.*

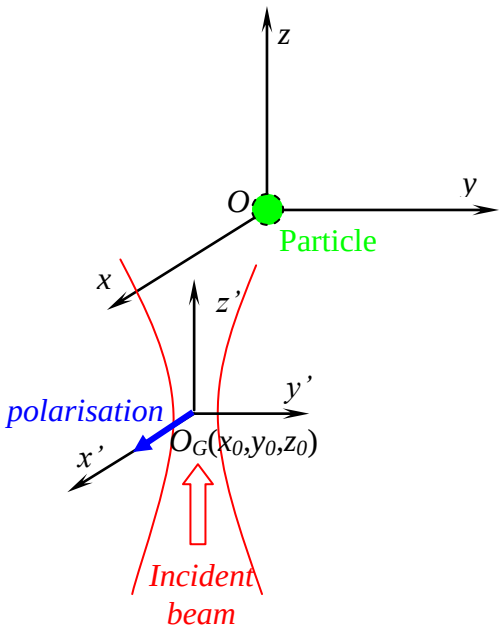
parameters.

Or one can take the following table:

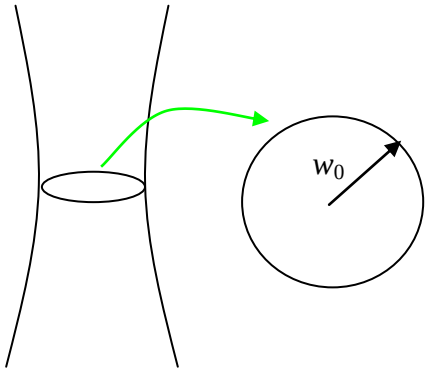
	Real case	Equivalent case
Refractive index of particle	$\boldsymbol{n}$	$\boldsymbol{n/n_m}$
Refractive index of the media	$\boldsymbol{n_m}$	1
Wavelength	λ_0	$\lambda_m=\lambda_0/\boldsymbol{n_m}$

2) Parameter Definition

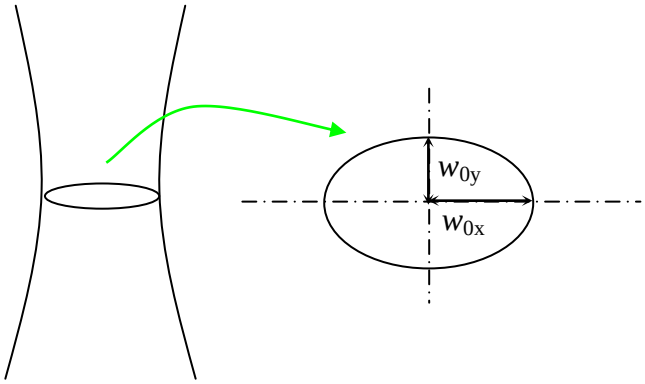
I. Coordinate system



II. Beam parameters

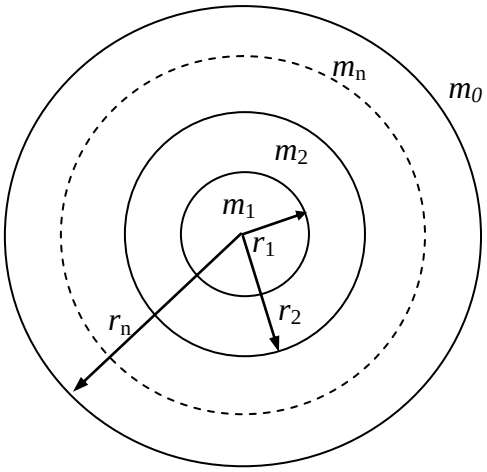


Gaussian beam
(circular Gaussian beam)



Laser sheet
(elliptical Gaussian beam)

III. Particle parameters



m_0 : surrounding media refractive index
m_i : refractive index of nth layer
r_i : radius of nth layer

IV. Observation plane