CORIA UMR 6614 - CNRS ROUEN UNIVERSITY

Manual of the soft ABSphere

A software for computing All properties of a shaped Beam scattering by a **Sphere**

Kuan Fang REN [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



- 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



Rouen University

Table of contents

Version 1.00

1.	Ge	neral description of ABSphere
2.	Ma	ain window and main menu of the software:
3.	Su	bmenus:
	1)	Files
	2)	Parameters
	3)	Calculation:
	I.	Scattering diagram7
	II.	Internal and near field
	III	Radiation pressure
	IV	. Radiation torque
	4)	View
	5)	Help
4.	Ap	ppendix
	1)	Refractive index and the wavelength13
	2)]	Parameter Definition
	I.	Coordinate system
	II.	Beam parameters
	III.	Particle parameters
	IV	. Observation plane

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 \Re and the

internal/near field, the radiation pressure as function of particle size as function of particle position as function 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

Search and the search						
Files	Parameters Calculation	View	Help			
	Load parameters					
	Load scattering diagram					
	Load internal field	_				
	Load radiation pressure	÷	as particle position			
	Load torque	•	as particle size			
	Save parameters					
	Save parameter as					
	Save scattering diagram					
	Save internal - near field					
	Save radiation pressure	•				
	Save torque	•				
	Print graphics					
	Save graphics as					
	Copy graphics					
	Exit					

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.

ABSphere - All Beam Scattering by a S						
Files Parameters Calculation View						
a						
	Particle parameters					

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.

Wavelength [µm]: 0.5 mStop: 20 Image: Second structure w0 [µm]: 5 polarization [0-2]: 0 Image: Laser sheet: w0x [µm]: 1.2656 w0y [µm]: 1.2656 Image: Doughnut: w0dn [µm]: 5 polarization [1-4]: 1 Image: Bessel beam: axicon (*): 0.6328 Beam order: 1 Image: Beam shape coefficients File name: 0.6328 1	ſ	Setup of beam pa	rameters			×
 Gaussian beam: w0 [μm]: 5 polarization [0-2]: 0 Laser sheet: w0x [μm]: 1.2656 w0y [μm]: 1.2656 Doughnut: w0dn [μm]: 5 polarization [1-4]: 1 Bessel beam: axicon (*): 0.6328 Beam order: 1 Read beam shape coefficients File name: 0.6328 		Wavelength [μm]: 0).5		mStop:	20
Laser sheet: w0x [μm]: 1.2656 w0y [μm]: 1.2656 Doughnut: w0dn [μm]: 5 polarization [1-4]: 1 Bessel beam: axicon (*): 0.6328 Beam order: 1 Read beam shape coefficients File name: 0.6328		Gaussian beam:	w0 (μm):	5	polarization [0-2]:	0
Doughnut: w0dn [μm]: 5 polarization [1-4]: 1 Bessel beam: axicon (*): 0.6328 Beam order: 1 Read beam shape coefficients File name: 0.6328		🔘 Laser sheet:	wOx (µm):	1.2656	w0y (μm):	1.2656
Bessel beam: axicon (*): 0.6328 Beam order: 1 Read beam shape coefficients File name: 0.6328		🔘 Doughnut:	w0dn (µm): (5	polarization [1-4]:	1
Read beam shape coefficients File name: 0.6328		🔘 Bessel beam:	axicon (*): [0.6328	Beam order:	1
		🔘 Read beam shap	e coefficient	s Fi	e name; 0.6328	
Accept Cancel			Accept		Cancel	

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

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

Setup of particle arame	ters	×
Surrounding media refrac	Debye seires	
Refractive index: 1.5	-1 0	
Particle radius : 7.5	Order list :	
 Multilayered sphere 	Read refractive in	dex
radii	real part imag pa	art
		Save

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.

ABSphere - All Beam Scattering by a Sphere					
Files Parameters	Calc	ulation	View	Help	
/ S B 😫 🎽	Scattering diagram				
		Internal	l - near	field	
	Ra		on press	sure	
	т			tion	

Fig. 6 Submenu of calculation

I. Scattering diagram

By choosing Scattering diagram in the Calculation menu, the following subwindows (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.

Scattering diagram					
Particle position :					
Beam center relative to particle system x0 : 5					
Beam center relative to particle system y0 :					
Beam center relative to particle system z0 :					
Azimuth angle [*]: 0					
Initial angle [*] : 🚺					
Final angle [*]: : 360					
◯ Step on angle : 1					
Step number : 360					
🔽 Intensity in log 🔍 Auto Clear 📄 ChkLegend					
Calculation Close					

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').

Internal and near EM field							
Particle position :	Particle position :						
Beam center relative to particle system x0 : 🗧							
Beam center relative to particle system y0 :							
Beam center relative to partic	Beam center relative to particle system z0 : 0						
Z min: -10 Z max: 10							
XY min: -10 XY max: 10							
● Step on Z and XY: 0.2 0.2							
Step number Z and XY: 100 100							
Observation plane phi [*]: 0							
✓ Intensity in log ✓ Color/Grey ✓ Circle visible							
V Auto Min/Max: 0.0001 1							
Calculation							

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 subwindow (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).

Radiation pressure		×
Particle position Particle size		
Choice of variable :		Graphics
 beam center relative to partic beam center relative to partic 	cle system x0 : 5	✓ X component
beam center relative to partic	cle system z0 : 0	V component
Minimum of y0 :	-30	Z component
Maximum of y0 :	30	Overdraw
◙ Step on y0 :	1	
Step number on y0 :	60	Calculation Close

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).

Radiation pressure					
Particle position Particle size					
Particle position :	Graphics				
Beam center relative to particle system x0 :	X component				
Beam center relative to particle system y0 :	Y component				
Beam center relative to particle system z0 :	Z component				
Minimum of particle radius : 4.7	Overdraw				
Maximum of particle radius : 5.2					
Paricle radius : Variation of mul	Itilayered particle size:				
💿 Step value 🛛 💿 On external	radius only				
Step number 500 Proportional to all radii					
Calculation					

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.

Search Contract Search Scattering by a Sphere				
Files Parameters Calculation View Help				
6 🛛 🛤 💏 🧠 🏀	Scattering diagram			
	Internal - near field			
	Radiation pressure			
	Torque 🕨			

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 $n_m = 1$ illuminated with a beam of the wavelength $\lambda = \lambda_0 / n_m$.

parameters.

Or one can take the following table:

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

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

