

### **Description of TUSCAT 1.1:**

It is an efficient and reliable software package developed on java platform to calculate and display the plane wave scattering from small particles. The package uses and involves a user friendly GUI in order to enable the users to enter the required input parameters for light scattering calculations and observe the results more intuitively. The numerical results of the scattering matrix elements and the efficiencies can also be saved in a user defined data file. The computational programs behind TUSCAT are based on Mie theory for spherical particles and T-matrix approach for nonspherical particles (cylindrical and spheroids). Another very important facility for comparing experimental results from some unknown particle with theoretical results was also incorporated in the software so as to provide an analytical tool for light scattering experiments from monodisperse and polydisperse particles.

### **Features of TUSCAT 1.1**

1. TUSCAT 1.1 runs under Windows 98/NT/2000/XP/7 operation systems. There are no special hardware requirements.
2. It can calculate and display the results for of extinction, scattering and absorption efficiencies, single scattering albedo and asymmetry parameter.
3. It can calculate the nonzero elements of the scattering matrix and plots graphs for  $S_{11}$ ,  $-S_{12}/S_{11}$ ,  $S_{33}/S_{11}$  and  $S_{34}/S_{11}$ .
4. It has provision for saving the theoretical results in a user defined data file.
5. Can upload experimental data file in '.txt', '.dat' or '.csv' format containing the values of scattering angle,  $S_{11}$ ,  $-S_{12}/S_{11}$ ,  $S_{33}/S_{11}$  and  $S_{34}/S_{11}$  serially separated by a comma and plot graphs for  $S_{11}$ ,  $-S_{12}/S_{11}$ ,  $S_{33}/S_{11}$  and  $S_{34}/S_{11}$  as functions of scattering angle.
6. The experimental graphs can be compared with the theoretical graphs generated by varying the input parameters, to find the characteristic properties of that particle responsible for the scattering results.

### **What was used to design TUSCAT 1.1 (Beta version)**

We have used Java Swing in J2SE1.5 platform to design the software package TUSCAT 1.1. Swing is a widget toolkit for Java. It is part of Sun Microsystems' Java Foundation Classes (JFC) — an Application Programming Interface (API) for providing a Graphical User Interface (GUI) for Java programs. Swing was developed to provide a more sophisticated set of GUI components than the earlier Abstract Window Toolkit (AWT). It provides a native *look and feel* that emulates the *look and feel* of several platforms, and also supports a pluggable *look and feel* that allows applications to have a *look and feel* unrelated to the underlying platform.

#### **Advantages of Java Swing:**

1. Platform independence,
2. Extensible,
3. Customizable,
4. Configurable,
5. Lightweight User Interface,
6. Loosely-Coupled and MVC (Model/View/Controller).

#### **Installation Instructions:**

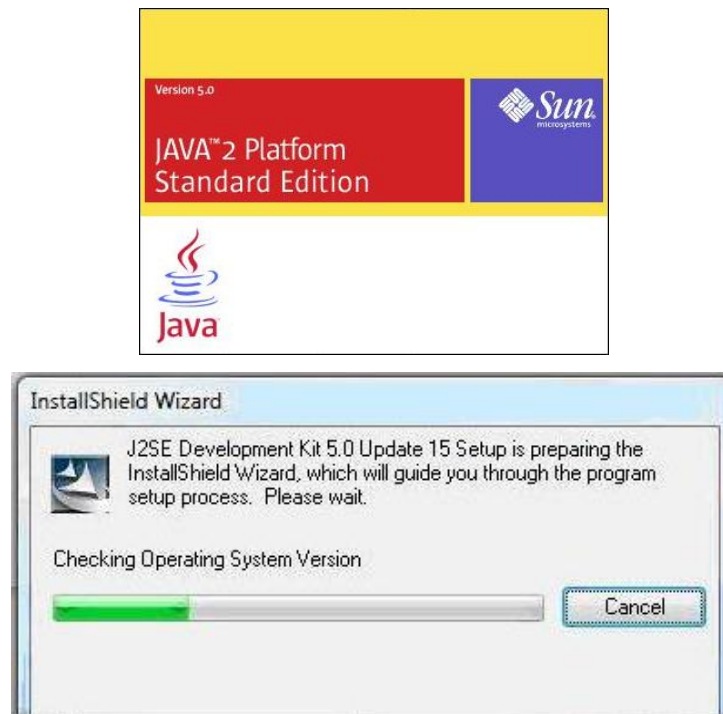
**Step 1.** Copy or download the file TUSCAT 1.1.rar.

**Step 2.** Unzip TUSCAT 1.1.rar and a directory named 'TUSCAT 1.1' will be created.

The contents of the directory are as follows:

Serial No	File name	File type	Description
1	JavaInstaller.bat	Batch file	Installs the J2SE (Java 2 software enterprise) environment.
2	jdk-1_5_0_15-windows-i586-p.exe	Executable file	J2SE installer
3	SetClassPath.bat	Batch file	Set the environment variable of that system.
4	TUScatBatch.bat	Batch file	Batch file for executing the application.
5	TUScat.jar	Executable jar file	Executable file of the application
6	help.pdf	pdf file	help file

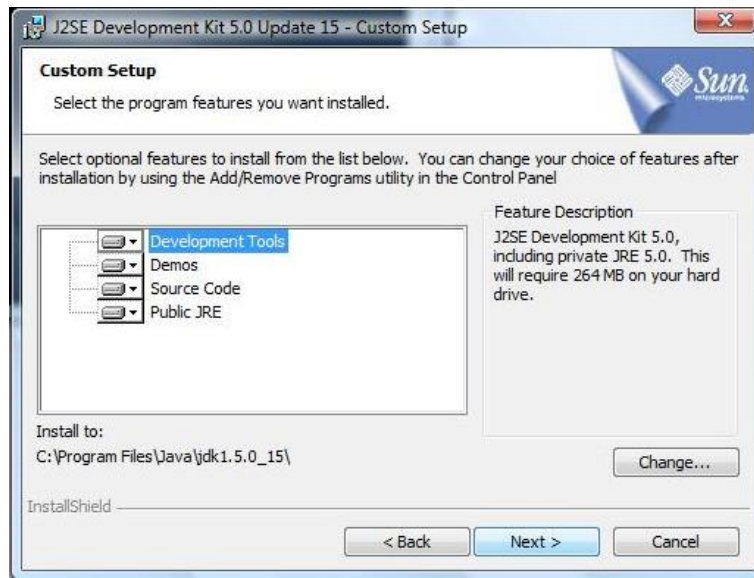
**Step 3.** Double click on the JavaInstaller.bat. This will run 'jdk-1\_5\_0\_15-windows-i586-p.exe' and install java environment in your system as described below.



Screens as shown above will appear first.



Read the license agreement. Accept the agreement and click next.



Then a screen as shown above will appear where by default 'Development Tools' is selected. Click next.



Click finish to complete installation.

**Step 4.** Double click 'SetClassPath.bat' file. It will set the environment variable.

**Step 5.** Double click 'TUScatBatch.bat' file to execute 'TUScat.jar'.

**Note:** If java environment is already installed then an error message as shown below will appear. Ignore the message and follow the step 5 to execute the application.

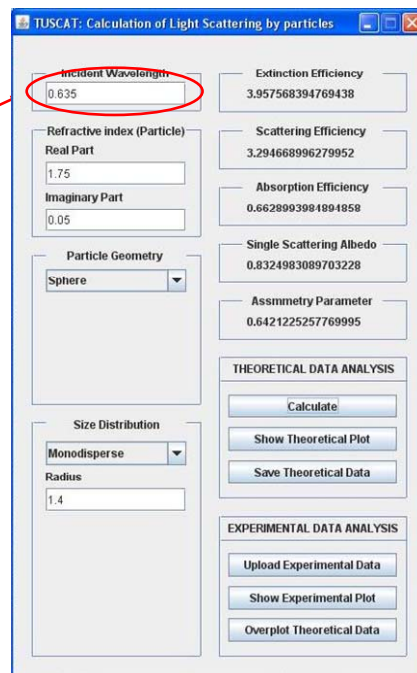


### Description of the GUI:



In this input box the user should give the wavelength of the incident light in micrometers.

Default value = 0.00  $\mu\text{m}$



Input Parameters	Calculated Results
Incident Wavelength: 0.635	Extinction Efficiency: 3.957568394769438
Refractive index (Particle): Real Part: 1.75 Imaginary Part: 0.05	Scattering Efficiency: 3.294668996279952
Particle Geometry: Sphere	Absorption Efficiency: 0.6628993984894858
Size Distribution: Monodisperse Radius: 1.4	Single Scattering Albedo: 0.8324983089703228
	Assymetry Parameter: 0.6421225257769995

**THEORETICAL DATA ANALYSIS**

Calculate  
Show Theoretical Plot  
Save Theoretical Data

**EXPERIMENTAL DATA ANALYSIS**

Upload Experimental Data  
Show Experimental Plot  
Overplot Theoretical Data

Refractive index (Particle)

Real Part  
1.75

Imaginary Part  
0.05

In this input box the user should give the real and imaginary part of the refractive index.

Default value =  $0.00 + i \times 0.00$

\*\*The refractive index of the scattering medium is considered as  $1.0 + i \times 0.0$  (air).

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength  
0.635

Refractive index (Particle)  
Real Part  
1.75  
Imaginary Part  
0.05

Particle Geometry  
Sphere

Size Distribution  
Monodisperse  
Radius  
1.4

Extinction Efficiency  
3.957568394769438

Scattering Efficiency  
3.294668996279952

Absorption Efficiency  
0.6628993984894858

Single Scattering Albedo  
0.8324983089703228

Assymmetry Parameter  
0.6421225257769995

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EXPERIMENTAL DATA ANALYSIS

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Particle Geometry

Sphere

Sphere

Cylinder

Spheroid

In this particle geometry box the user has to select the shape under consideration in the drop down menu. Default shape is sphere.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength  
0.635

Refractive index (Particle)  
Real Part  
1.75  
Imaginary Part  
0.05

Particle Geometry  
Sphere

Size Distribution  
Monodisperse  
Radius  
1.4

Extinction Efficiency  
3.957568394769438

Scattering Efficiency  
3.294668996279952

Absorption Efficiency  
0.6628993984894858

Single Scattering Albedo  
0.8324983089703228

Assymmetry Parameter  
0.6421225257769995

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Particle Geometry

Spheroidal

A/B or C/L ratio

Accuracy of Computation

If anyone of the shapes 'cylinder' or 'spheroid' is selected, the user has to enter the axial ratio, A/B (for spheroid) or the diameter to length ratio, C/L (for cylinder). The default value of both A/B and C/L is 0.00.

Also for such nonspherical geometries, one has to specify the desired accuracy of computation.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength: 0.8

Refractive index (Particle)

Real Part: 1.65

Imaginary Part: 0.1

Particle Geometry

Sphere

Cylinder

Spheroid

Size Distribution

Monodisperse

Radius: 1

Extinction Efficiency: 2.5719080506767567

Scattering Efficiency: 1.3501655283448388

Absorption Efficiency: 1.2217425223319178

Single Scattering Albedo: 0.5249664847036675

Assymetry Parameter: 0.7369124896049597

THEORETICAL DATA ANALYSIS

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Size Distribution

Monodisperse

Radius: 1

Size Distribution

Lognormal

Lowest Particle Radius

Highest Particle Radius

Sigma

Modal Radius

If gamma, normal and lognormal distribution is selected, the user has to give the lowest and highest particle radius, sigma (for normal and lognormal distribution) and alfa (for gamma distribution), and the effective radius of the particles.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength: 0.635

Refractive index (Particle)

Real Part: 1.75

Imaginary Part: 0.05

Particle Geometry

Spherical

Size Distribution

Monodisperse

Radius: 1.4

Extinction Efficiency: 3.957568394769438

Scattering Efficiency: 3.294668996279952

Absorption Efficiency: 0.6628993984894858

Single Scattering Albedo: 0.8324983089703228

Assymetry Parameter: 0.6421225257769995

THEORETICAL DATA ANALYSIS

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Show Theoretical Plot

Save Theoretical Data

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Upload Experimental Data

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TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength  
0.635

Refractive index (Particle)  
Real Part  
1.75  
Imaginary Part  
0.05

Particle Geometry  
Spherical

Size Distribution  
Monodisperse  
Radius  
1.4

Extinction Efficiency  
3.957568394769438

Scattering Efficiency  
3.29466896279952

Absorption Efficiency  
0.6628993984894858

Single Scattering Albedo  
0.8324983089703228

Assymetry Parameter  
0.6421225257769995

THEORETICAL DATA ANALYSIS

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Extinction Efficiency  
2.837253125316736

Scattering Efficiency  
2.7861248327144312

Absorption Efficiency  
0.05112829260230489

Single Scattering Albedo  
0.9819796506183786

Assymetry Parameter  
0.5685983028638945

Above panels give the calculated values of the efficiencies, single scattering albedo and asymmetry parameter for spherical particles.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength  
0.632

Refractive index (Particle)  
Real Part  
1.55  
Imaginary Part  
0.001

Particle Geometry  
Cylinder

A/B or D/L ratio  
3.2

Accuracy of Computation  
.008

Size Distribution  
Lognormal  
Lowest Particle Radius  
0.3  
Highest Particle Radius  
1.2  
Sigma  
0.2  
Modal Radius  
0.8

Extinction Coefficient  
5.458332620977585

Scattering Coefficient  
0.8144669826410267

Absorption Coefficient  
4.643865638336559

Single Scattering Albedo  
0.9877882642779553

Assymetry Parameter  
0.7957596160035378

THEORETICAL DATA ANALYSIS

Calculate

Show Theoretical Plot

Save Theoretical Data

EXPERIMENTAL DATA ANALYSIS

Upload Experimental Data

Show Experimental Plot

Overplot Theoretical Data

Extinction Coefficient  
5.458332620977585

Scattering Coefficient  
0.8144669826410267

Absorption Coefficient  
4.643865638336559

Single Scattering Albedo  
0.9877882642779553

Assymetry Parameter  
0.7957596160035378

The same panels give the calculated values of the coefficients, single scattering albedo and asymmetry parameter for nonspherical particles.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength 0.632	Extinction Coefficient 5.458332620977585
Refractive index (Particle) Real Part 1.55 Imaginary Part 0.001	Scattering Coefficient 0.8144669826410267
Particle Geometry Cylinder	Absorption Coefficient 4.643865638336559
A/B or D/L ratio 3.2	Single Scattering Albedo 0.9877882642779553
Accuracy of Computation .008	Assymetry Parameter 0.7957596160025378
Size Distribution Lognormal	THEORETICAL DATA ANALYSIS
Lowest Particle Radius 0.3	Calculate
Highest Particle Radius 1.2	Show Theoretical Plot
Sigma 0.2	Save Theoretical Data
Modal Radius 0.8	EXPERIMENTAL DATA ANALYSIS
	Upload Experimental Data
	Show Experimental Plot
	Overplot Theoretical Data

THEORETICAL DATA ANALYSIS

Calculate

Show Theoretical Plot

Save Theoretical Data

The theoretical calculations are initiated when the 'Calculate' button is pressed and similarly when 'Show Theoretical Plot' button is pressed the software generated plots for  $S_{11}$ ,  $-S_{12}/S_{11}$ ,  $S_{33}/S_{11}$  and  $S_{34}/S_{11}$  are displayed in a separate window. The result can be stored in a user defined file when the button 'Save Theoretical Data' is pressed.

TUSCAT: Calculation of Light Scattering by particles

Incident Wavelength 0.632	Extinction Coefficient 5.458332620977585
Refractive index (Particle) Real Part 1.55 Imaginary Part 0.001	Scattering Coefficient 0.8144669826410267
Particle Geometry Cylinder	Absorption Coefficient 4.643865638336559
A/B or D/L ratio 3.2	Single Scattering Albedo 0.9877882642779553
Accuracy of Computation .008	Assymetry Parameter 0.7957596160025378
Size Distribution Lognormal	THEORETICAL DATA ANALYSIS
Lowest Particle Radius 0.3	Calculate
Highest Particle Radius 1.2	Show Theoretical Plot
Sigma 0.2	Save Theoretical Data
Modal Radius 0.8	EXPERIMENTAL DATA ANALYSIS
	Upload Experimental Data
	Show Experimental Plot
	Overplot Theoretical Data

EXPERIMENTAL DATA ANALYSIS

Upload Experimental Data

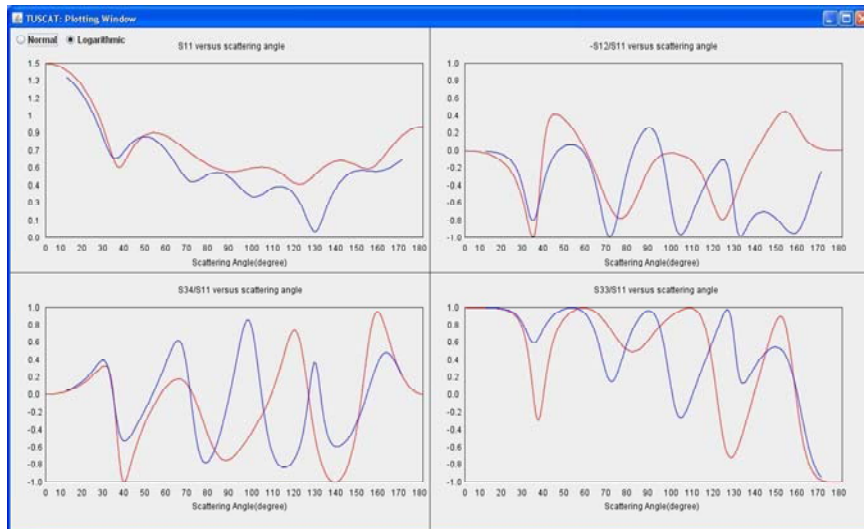
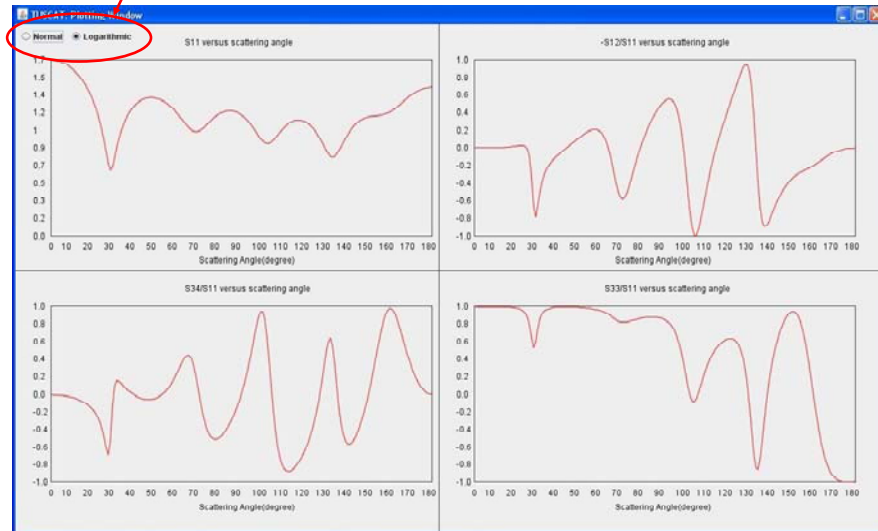
Show Experimental Plot

Overplot Theoretical Data

This is the panel for experimental data analysis. Using this facility one can upload experimental data and plot graphs for it. This facility can be also be used to plot experimental data compare the plots for the experimental data from an unknown scattering particle with the superimposed plots for theoretical data generated by varying the input parameters, to find the characteristic properties of that particle.



The user can select either normal or logarithmic plot for S11 using these buttons.



Plotting window of TUSCAT showing the superimposed plots of the experimental (blue solid line) and theoretical (red solid line) results.

**Future Prospects:**

1. Other light scattering theories like DDA, SVM, FDTD etc. will be incorporated with the software in the near future.
2. The software package will be improved for the calculation of light scattering properties of other nonspherical shapes like chebyshev, star shaped etc.
3. Data acquisition and data processing part will also be added to the software so as to make it self contained for the complete analysis of the experimental results.