Determining size and geometry of the particles from the polarisation change of the light scattered from the particles

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An important problem in atmospheric physics is to characterize the ambient aerosol distribution. While a majority of current laser-based detectors can measure the size spectrum of the scattering particles, they do not give information about the geometry of the scatterers. We aim to compute the effect of the scatterers on the polarization of the incoming radiation and to use the measured radiation to infer the size as well as the geometry. In order to do so, we will write a code to solve Maxwell's equations for arbitrary geometries using the Discontinuous Galerkin method and then use this code to explore the effect of scatterer geometry on the incoming radiation.

I. INTRODUCTION

Current optical aerosol counters used to characterize the particulate matter suspended in air are only capable of measuring the size spectrum of the particles, but they assume that the particles are spherical in shape. We aim to recover additional information about the particles by modeling the particles as an ellipsoid and calculate the size spectrum $N(r)$ where r defines the size of the particles, eccentricity spectrum $N(e)$ and where e is the eccentricity of the particles.

A. Experimental Setup

A typical aerosol counter setup has a LASER light source, a sample chamber in which air sample to be investigated is held and an array of photosensitive detectors which detects the scattered light, it will provide us our scattering data. Figure.1 shows a schematic of a typical aerosol counter.

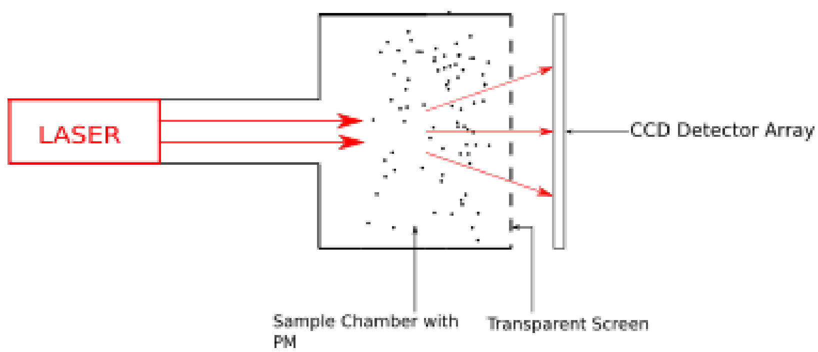

FIG. 1. Schematic of a typical aerosol counter

II. SIMULATION

1. Simulation Domain

We find the scattering solution for an arbitrarily shaped particle inside a rectangular domain by solving the Maxwell's equations. A schematic of the domain is shown in the figure 2.

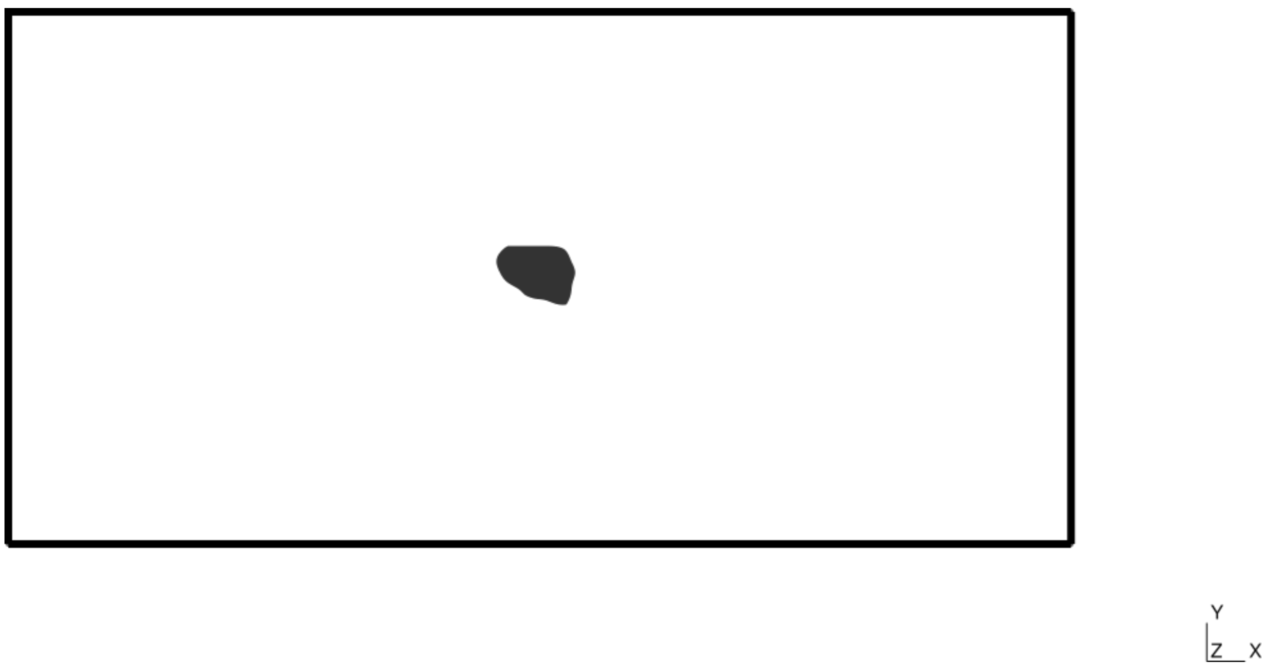

FIG. 2. Figure showing an arbitrarily shaped particle inside a rectangular domain in which we will solve Maxwell's equations.

2. Maxwell's Equations

The Maxwell's Equations are given by(ref[1]):

$$\nabla \cdot \vec{D} = \rho \tag{1}$$

$$\nabla \cdot \vec{B} = 0 \tag{2}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \tag{3}$$

$$\nabla \times \vec{H} = \vec{J}_f + \frac{\partial \vec{D}}{\partial t} \tag{4}$$

here,

$\vec{E}$ is the electric field.

$\vec{B}$ is the Magnetic field.

$\vec{H}$ is the magnetic field strength.

$\vec{D}$ is the electric displacement field.

$\vec{J_f}$ is the free current density.

3. Tools and Methods to be used for simulation

To solve Maxwell's equations for the domain shown in the figure 2 we are divide the domain into second order quadrangular elements. We will then use the Discontinuous Galerkin method to solve Maxwell's equations over the domain. Figure 3 shows an example mesh made over the domain shown in figure 2. Our mesh for solving Maxwell's equations will similar to this.

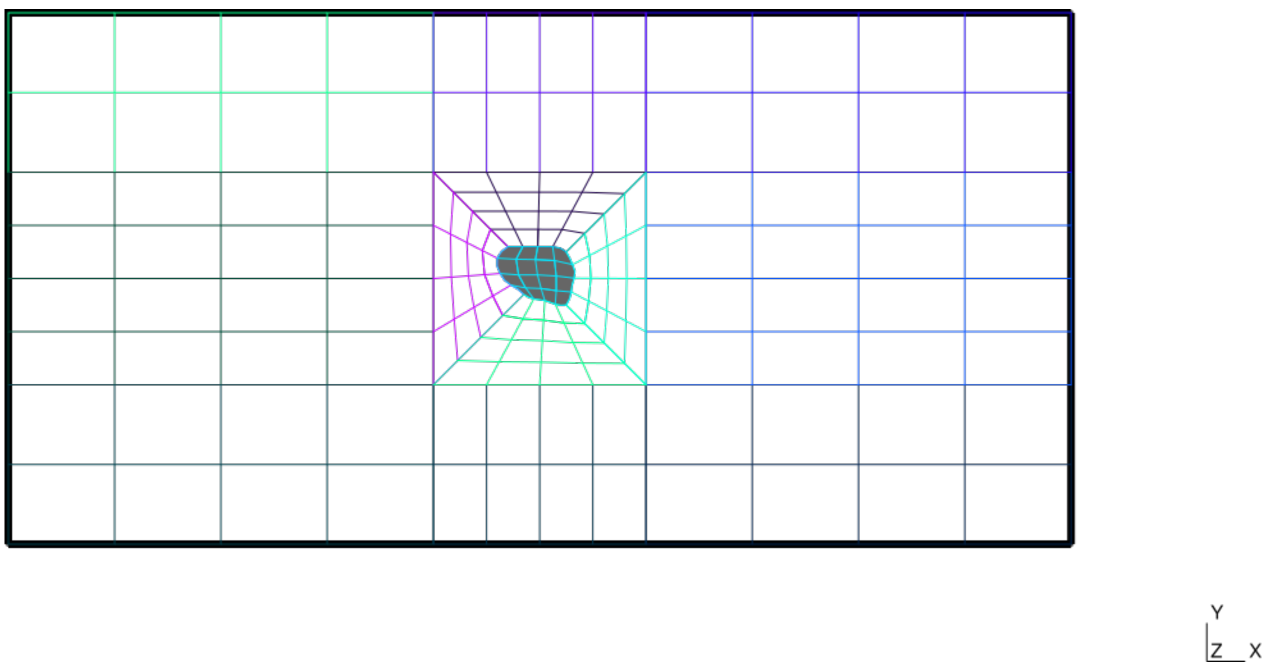

FIG. 3. 2^{nd} order Quadrangular meshing done over the domain shown in the figure 2.

A. Code Verification

To test our code for solving Maxwell's equations in the domain shown in figure 2, we plan to compare the numerical scattering solution against analytic as well as semi-analytic solutions.

We also plan to test the code by solving the scattering solution for a homogeneous sphere. The analytic scattering solutions for scattering by a homogeneous sphere is given by the Mie scattering solutions[2]. We will compare our numerical solutions against the Mie scatt ering solutions.

B. Extracting particle characteristics

The domain of our final version of our simulation will be a rectangular domain similar to the one shown in figure 2 but with much more number of particles inside it.

We aim to find the relationships $N(r)$ vs r and $N(e)$ vs e from the simulation for a given input scattering data. We plan to do this by iteratively varying the total number of particles N_0, and r, e, and ϵ(dielectric constant) for each of the particle inside the domain until we get a scattering solution same as the input scattering data.

III. CONCLUSION

Through this project we aim to devise an algorithm to extract more information from the scattering data than is commonly available.

[1] David J. Griffiths. *Introduction to Electrodynamics*. PHI Learning Private Limited, 1999.

[2] Wikipedia. Mie scattering — wikipedia, the free encyclopedia, 2017. [Online; accessed 3-August-2017].