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. In this article we try to find the time evolution of the $1D$ and $2D$ wave equations using the discontinuous Galerkin method.

I. INTRODUCTION

Light based aerosol counters are used to determine the size distribution of particles in the air. An optical aerosol counter[?] determines the size distribution by analysing the light scattered by the particles. It works by illuminating the sample with a LASER beam, which gets scattered by the particles. A detector is used to detect the scattered radiation. By analysing the scattered radiation, it determines the size distribution of the particle.

The problem with these aerosol counters is that they assume spherically shaped particles. They also discard information about the polarisation changes in the scattered light which can be helpful in finding more information about the shape and size of the particles. In this research, we assume ellipsoidal shaped particles and use the polarisation change of the scattered radiation to determine the parameters describing the ellipsoid.

To find the shape and size distribution of the particles from the scattered radiation, we plan to numerically calculate the scattering solution for particles of different shape and size parameters present in the medium. By doing this iteratively for different number of particles, with varying shape and size parameters, we plan to get the given scattering solution.

A Maxwell's equation solver needs to be developed to determine the scattering solution. To find the scattering solution we are developing a Maxwell's equation solver using the discontinuous Galerkin method. In this article we try to find the solution of the $1D$ and $2D$ wave equation using the discontinuous Galerkin method. Developing these solvers are the primary steps towards the development of the full Maxwell's equation solver.

A. Earlier Work

This project is a continuation of the project I took in the last semester. By the end of the last semester we managed to develop an Advection equation solver for 1D domain. Prototype code for 2D Advection solver was also written and tested.

II. OBJECTIVES

- Modify the Advection equation solver to solve the Maxwell's equations with reflective boundary conditions for both 1D and 2D case.
- Enhance the 2D Advection equation solver to work for Arbitrary shaped meshes.
- Parallelize the Advection equation solver.
- Obtain the scattering solutions numerically using the Maxwell's equations solver and compare it with the analytically calculated scattering solution.

III. METHODS

We use the Nodal Discontinuous Galerkin method to solve the Advection equations. We divide our domain of interest in a mesh. We use 2^{nd} order quadrangular mesh for solving the Advection equation in 2D.

IV. PLAN

I have planned to finish the listed tasks by the given dates.

1. **January 30, 2018:** Get numerical solutions for Maxwell's equations being solved inside a metallic cavity (using both 1D and 2D solver).
2. **February 10, 2018:** Modify the 2D Advection solver to work for arbitrary shaped mesh made of 2^{nd} order quadranular elements.
3. **February 18:** Code cleanup and refactoring.
4. **March 1, 2018:** Parallizing the 1D and 2D Advection equation solver.
5. **Before End-semester:** Modify the code to obtain the scattering solution for particles of arbitrary geometry and test the scattering solution against the analytically obtained solution.

V. COMMENTS

One of the hurdles is that the solver is very slow even when running on GPU. The code has to be parallelized so that numerical solution can be obtained to increase the simulation speed.