Mie Extinction Diagnostics

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Overview

We have developed multiple-color Mie extinction diagnostics for measuring the evolution of the particle size distribution behind the shocks. By using 4-6 laser sources ranging from 635 nm to 9.57 μm, we make time-resolved measurements of the shape of the size distribution and the particle loading.

The general theory for predicting interactions between light and spherical particles was developed by Gustav Mie and first published in 1908. The complexity of the formulas, however, prevented the theory from being applied except to simple cases until computers were available to calculate the scattering and extinction coefficients. While the scattering of light by a single particle is dependent only on the complex index of refraction at the interrogating wavelength and the particle diameter, determining the size distribution from scattered light is a challenging problem. Here, we describe the basis for our technique. We begin by calculating the extinction coefficient for each laser color, given a single particle size. Here, the calculations are for water.

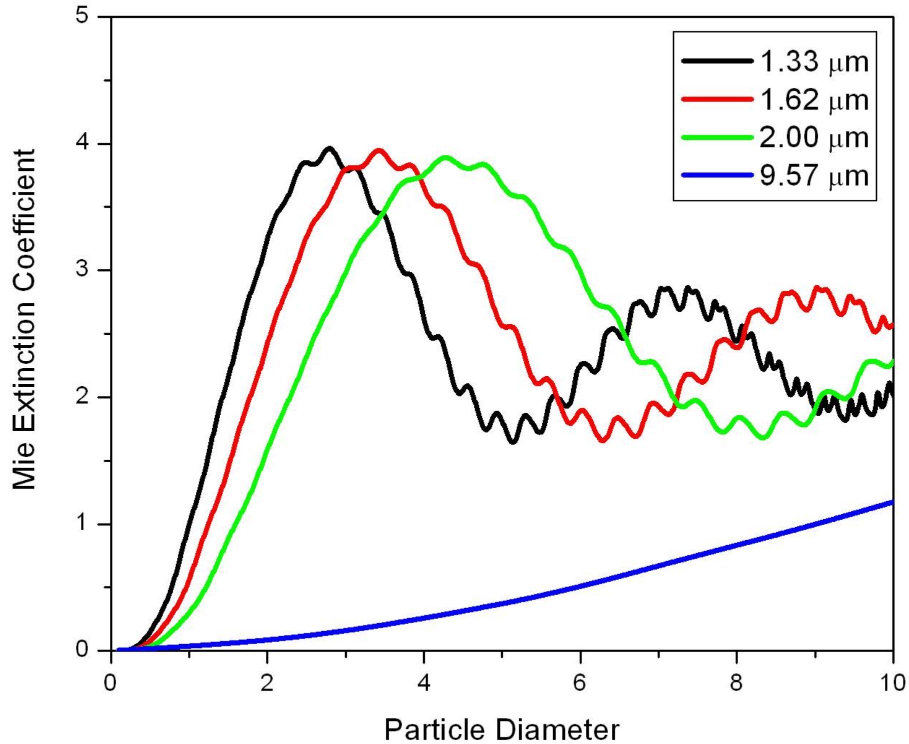

Figure 1

At each wavelength, the extinction by a single particle increases until the particle is about twice the interrogating wavelength. However, all sprays consist of particles of multiple sizes. Therefore, we need to use statistical tools to describe the size distribution. It turns out that the size distributions are particularly well described by lognormal distributions. When we convolve a variety of lognormal distributions with varying mean diameters and distribution widths with one of the extinction curves from above, we have the following:

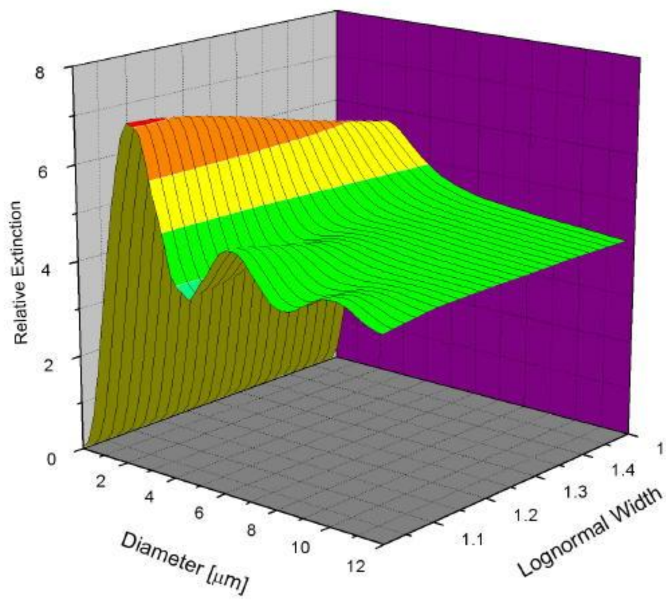

Figure 2

To remove the dependence on particle loading, we take the ratios of these surfaces for different laser colors. Here, the surface for the 3.39/1.997 µm lasers is shown.

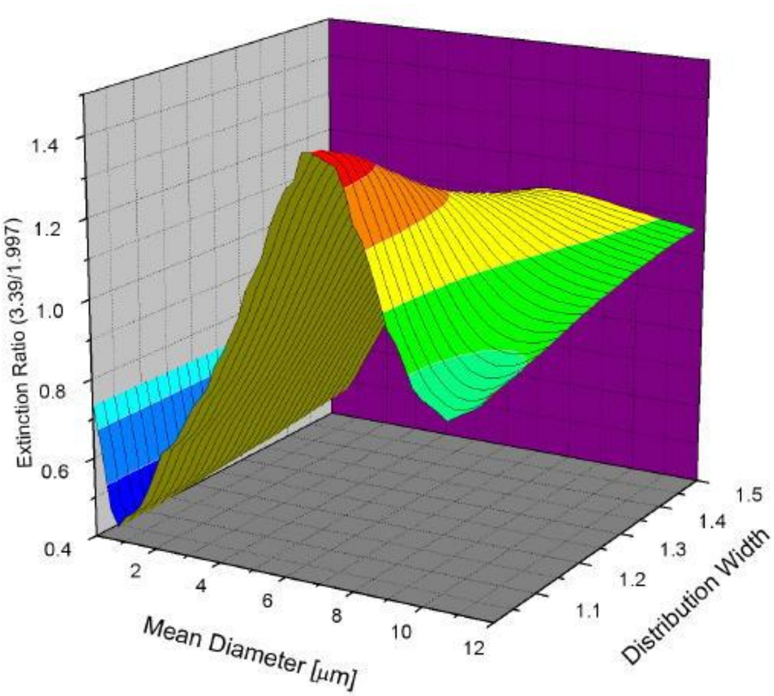

Figure 3

Finally, we compare our experimental data with each of these ratio surfaces to determine where the best fit exists. Usually, there is one peak that dominates the others, indicating that this diameter-width combination best describes our data.

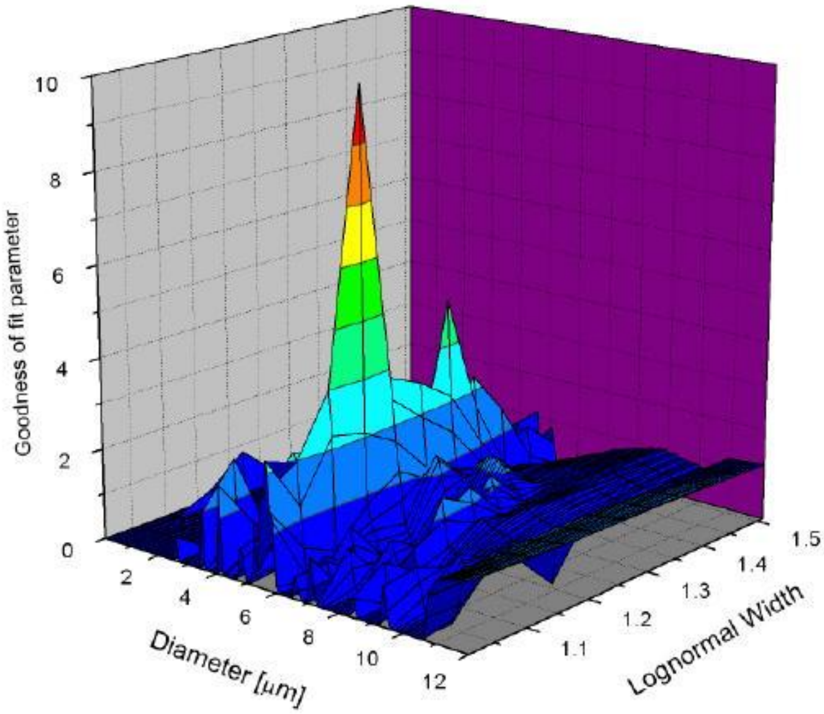

Figure 4