Light Scattering Module

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User:

- One that uses: a user of public transportation.
- Law. The exercise or enjoyment of a right or property.
- One who uses addictive drugs (AKA- Real time semi-quantitative aerosol instrumentation)
Machined Laser Light Inlet

f(x) Minimize the background scatter light

100 mW Diode Pumped NdYag 532 nm CW Laser

Precision Mirror Mounts:

f(x) Laser Alignment Control

USER FRIENDLY!!!!
Advantages of the Light Scattering System

• Refractory Aerosol Counting - diagnostic tool for better understanding particle beam divergence and bounce off of the vaporizer.
  – Internal perspective on the particles after they have been transmitted through the focusing lens.
  – Beginnings of a single particle analysis
• Non-Refractory Aerosol > 280nm
  – Light Scattering Signal, Chemical ion signal, and Dva.
  – Light Scattering Signals are a function of particle composition, shape, and geometric diameter.
  – Independent measurement of particle density (convoluted by shape and RI) from ambient light scattering signals of known Dva.
    • Laboratory Aerosols: Pure Organic vs. Inorganic
    • Ambient Aerosol Plumes: Mixed Organic and Sulfate
Percent Coverage of the Laser Beam on the Oven

Oven Diameter = 3.8 mm

Laser beam 1/e height Coverage 2.0 mm at the oven 63.8%*

Laser beam height for 100% particle detection = 1.7 mm 55%*

*NOTE that these calculations are based on the long chamber (5 Port) version of the AMS

The laser beam is assumed to be parallel across the width of the oven. In reality, the beam is expanding as it moves from left to right. Difference in height across the oven surface is 0.0009”
Singlet, Doublet and Triplet Peaks for NH4NO3 275 nm
Mobility Diameter Particles
Correlated LS and MS signals

Example of Oleic Acid particle where the Light Scattering and Oven Pulses Correlate
[Particle appears on the linear fit]
static constant dx_ellipsoid = 259.8  // distance in mm for the long chamber between the chopp
static constant dx_ellipsoid_oven = 130.2  // distance between ellipsoid center and oven in mm.
static constant dx_chopper_oven = 390.0

static constant numprints_baseline = 10

// Info Matrix definitions and baseline parameters
static constant info_dimensions = 11  // 10 section matrix to define info_tof_run_no and info_tof_run_u
Light Scattering Detection Limit

**LS Signal = Dmob^4**

![Graph showing Light Scattering Signal vs. Mobility Diameter (nm) with data points for different compounds.](image)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Density</th>
<th>Refractive Index</th>
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<tbody>
<tr>
<td>hexadecane</td>
<td>0.7733</td>
<td>1.4345</td>
</tr>
<tr>
<td>dotriacontane</td>
<td>0.8124</td>
<td>1.455</td>
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<tr>
<td><strong>Oleic Acid</strong></td>
<td><strong>0.895</strong></td>
<td><strong>1.46</strong></td>
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<tr>
<td>PSL</td>
<td>1.05</td>
<td>1.59</td>
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<tr>
<td>glyoxal</td>
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<td>pyruvic acid</td>
<td>1.2272</td>
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<tr>
<td>adipic acid</td>
<td>1.36</td>
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<tr>
<td>glutaric acid</td>
<td>1.424</td>
<td>1.4188</td>
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<tr>
<td>maleic acid</td>
<td>1.59</td>
<td></td>
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<tr>
<td>AN</td>
<td>1.73</td>
<td>1.554</td>
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<tr>
<td>AS</td>
<td>1.77</td>
<td>1.53</td>
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<tr>
<td>oxalic acid</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>

64% LS particles/CPC particles
Calibration Curve for Light Scattering Signals

Coefficient values ± one standard deviation

\[ y_0 = 3.665 \pm 14.2 \]
\[ A = 2.4097 \times 10^{-10} \pm 6.79 \times 10^{12} \]
\[ \text{pow} = 4.3364 \pm 1.03 \times 10^4 \]

\[ y = y_0 + A \times x^{\text{pow}} \]

- **Ammonium Nitrate**
- **Oleic Acid**
Mean Peak Height (bits)

- Dry NH₄NO₃ RI = 1.55
- PSL RI = 1.59

Dmob (nm)
Polydisperse Distributions of Organic and Inorganic Compositions-Shifted According to the Particle Density
Measuring the Density of Laboratory Aerosols with our Calibration

NH4NO3 measured density = 1.34
Oleic Acid measured density = 0.831
Time Trend for Pollution Event #1
Organic Dominated Plume

Date and Time

12:00 AM 7/26/2004
12:00 AM 7/27/2004
12:00 AM 7/28/2004
12:00 AM 7/29/2004
12:00 AM 7/30/2004

Mass Concentration (µg m$^{-3}$)
Time Trend for Pollution Event #2 - Mixed Sulfate and Organic Plume

![Graph showing time trend for pollution event #2 with mixed sulfate and organic plume concentration over 7/30/2004 to 8/1/2004. The graph includes data for Nitrate (blue), Sulphate (red), Ammonium (orange), and Organics (green).]
Ambient Aerosol Plume Dominated by Organics

Organics = 88%
Sulphate = 9%
Nitrate = 3%
Ambient Aerosol Plume of Mixed Sulfate and Organic

Organics = 39%
Sulphate = 58%
Nitrate = 3%

Vacuum Aerodynamic Diameter (nm)

$dM/d\log D_{va} (\mu g m^{-3})$
Light Scattering Signal for Two Different Pollution Plumes

Vacuum Aerodynamic Diameter (nm)

Light Scattering Signal

- Sulfate-Organic Mixed Plume
- Organic-Dominated Plume
Distribution m/z Specific Light Scattering Signals

Determination of the Internal Mixing of Particles in Pollution

Event #2
What is the end result of having a light scattering module on your AMS?
Screen Shots of Data Acq.

Nitrate and Sulfate

Emphasis of the Particle Bounce Phenomenon
NH₄NO₃ Monodisperse distribution of 387nm Dmob particles.

Look at the histogram for comparison between light scattering counts vs MS counts.
Monodisperse (NH$_4$)$_2$SO$_4$ 387 nm Dmob
Laser is detecting 80% more particles than the Oven