A CAPS-Based Single Scattering Albedo Monitor - CAPS PM_{ssa}

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WHY

Instrumentation for the Measurement of Aerosol Optical Properties

- Simple in Operation
- Rugged
- Inexpensive Components
- Stable
- State-of-the Art Performance

HOW

Extinction

Cavity Attenuation Phase Shift Extinction Spectrometer (CAPS PM_{ex})

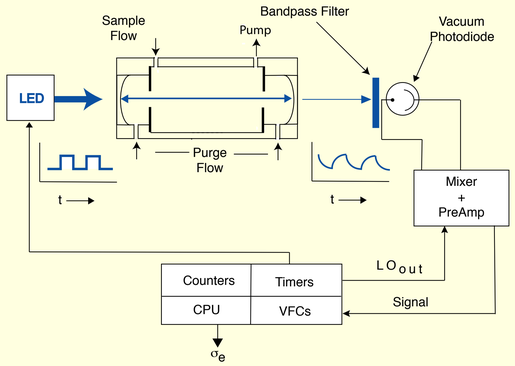
- Use Low-Loss Optical Cavity to Produce km Pathlengths
- Square Wave Modulate Light Souce
- Detect Distorted Waveform Emitted from Cavity
- Phase Shift Provides Information on Particle Extinction

$$\cot\vartheta = \cot\vartheta_0 + (c/2\pi f)\,\sigma_e$$

where ϑ = Measured Phase Shift
ϑ_0 = Phase Shift for Particle-Free Cell
f = Modulation Frequency
σ_e = Extinction

CAPS PM_{ex} Particle Extinction Monitor

- Time Response ~1 s (10-90%)
- LOD (3σ, 1s) = 2 Mm^{-1}
- Rack Mount, 12 kg, 50 W, 0.85 l min^{-1} Flow



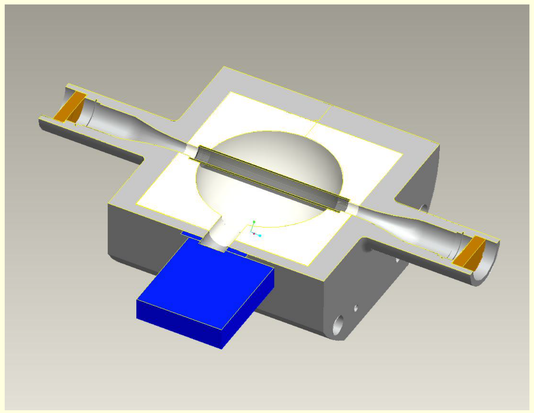
- Near-Confocal Optical Cavity
  26 cm Base Length
- Light Emitting Diode (LED) Light Source
  450 nm, 530 nm, 630 nm or 660 nm (780 nm)

HOW

Scattering

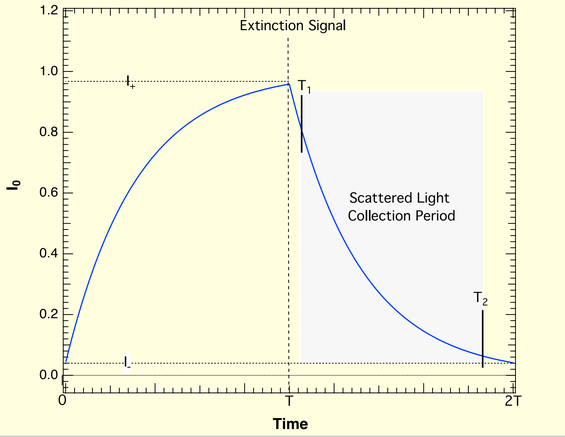
Inverse Nephelometer

- Construct Integrating Sphere Within Optical Cavity
  - Cut Ringdown Cell in Two
  - Install two Teflon Hemispheres
  - Bolt Cell Back Together
    Cell Stays Aligned
  - Install Single Photon Counting PMT to Observe Scattered Light



- Collect Scattered Light Only During LED-Off Phase
  Light in Cell Highly Collimated
  No Scattering from Cell Surfaces
  Scattering Proportional to DC Light Levels and Cell Loss

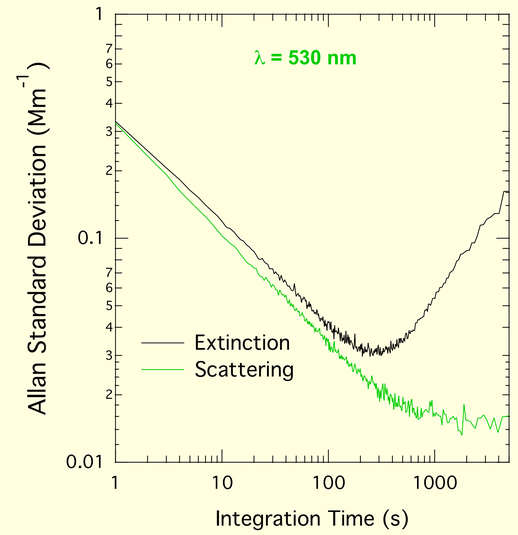
$$\sigma_{sp} \propto \left(\frac{Signal}{I_{ave}}\right)(Loss)$$



RESULTS

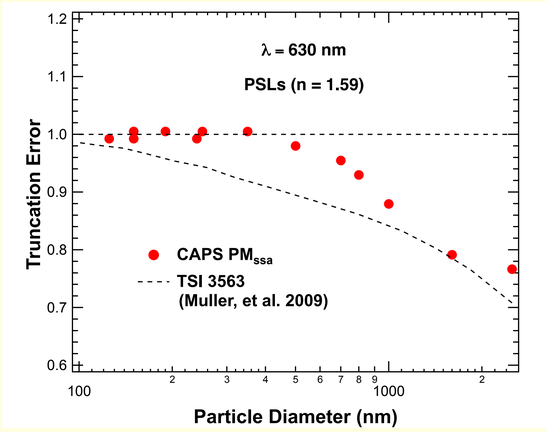
Sensitivity
λ=530 nm

- Allan Analysis
  Noise as a Function of Integration
  Noise < 0.5 Mm^{-1} in Both Channels
  Noise in Extinction and Scattering Channels
  Are Uncorrelated



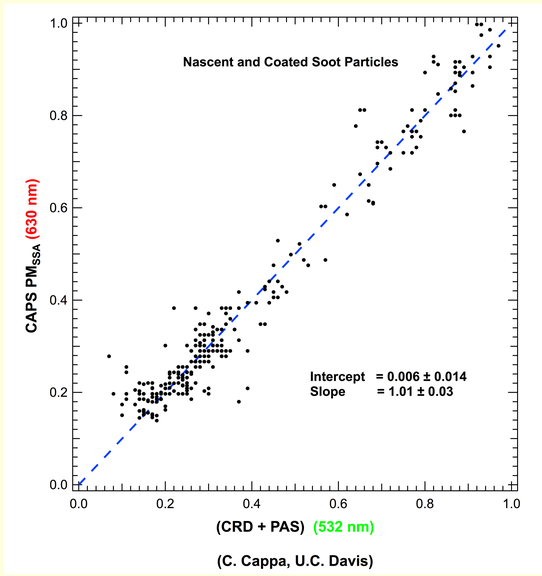
Truncation

- Measured Extinction and Scattering
  70-2500 nm PSL
- Minimal Truncation Effects out to 1 micron
- Modest Truncation Effects for Particle Size > 1 micron



Comparison

- U.C. Davis SSA Monitor (courtesy of C. CAPA)
  Cavity Ringdown Extinction
  Photoacoustic Spectroscopy-Based Absorption Monitor
  λ = 532 nm
- ARI PM_{ssa}
  λ = 630 nm
- Measurements Using Coated Soot (Boston College)
  Flame Generated Soot
  SSA Varied by Coating Soot with Different Thickness of Sulfuric Acid or DOS
  Size-Selected at 350 nm to Avoid Truncation Issues
- Excellent Agreement 0.2 < SSA < 1



(C. Cappa, U.C. Davis)

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