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Research poster: Measuring the aerosol asymmetry parameter \( g \) instrument description and initial measurements

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Measuring the Aerosol Asymmetry Parameter g Instrument
Description and Initial Measurements
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Introduction

- In addition to aerosol scattering and absorption coefficients, the angular distribution of light scattered by aerosol particles is needed to determine the aerosol contribution to radiative forcing. This angular distribution is commonly parameterized into a single value, the asymmetry parameter g. It is defined as the intensity-weighted average cosine of the scattering angle with values ranging from −1 for pure backscattering to +1 for pure forward scattering.
- No instruments for the direct measurement of aerosol g in the atmosphere are available. Commonly the asymmetry parameter g is determined from measurements of the aerosol size distribution and refractive index using Mie calculations under the assumption of spherical particles. The problem is that size distribution and refractive index data are often poorly known and the particles may not be spherical.
- Here a g-meter which can measure aerosol g directly is introduced. It is made of a quadrant detector conjunction with a laser beam. An accurate g value can be achieved by the signals of four detectors. The initial measurement will be discussed.

Schematic diagram

1) Concept of Asymmetry parameter g

- The angular distribution of light scattered by aerosol is needed to determine the aerosol contribution to radiative forcing. Phase function from Mie theory for spherical particles (needs size parameter $s = \pi D/\lambda$, and complex refractive index).

2) 1-D Physical meaning of g

- We can calculate back scattering percentage and forward scattering percentage very easily if asymmetry parameter g is known.

3) Design of the g meter

- The g-meter needs to reproduce the (sinθ/θ) angular weighting.

4) Schematic diagram and picture of the g-meter

- Calibration (1): angular response
  1. Mount the cylindrical detector on a rotation stage and rotate it around the cylinder axis.
  2. Illuminate the detector with a plane wave (e.g., expanded laser beam) propagating perpendicularly to the cylinder axis.
  3. Record the angular response and normalize the angular response to sinθ/θ(θ).

- Calibration (2): sensitivity
  Calibrate the reciprocal nephelometer with two gases (Clean Air and CO₂).

- truncation angle analyze (right fig)
  Since the tube is not infinite long, there are different truncation angles for different detectors. The top in the right show the difference of g caused by truncation angle.
  Where black line is the g value from Mie theory, red line shows the g value of g-meter without truncation angle correction and green line is the fit line of the black line and red line. It can be seen easily that the green line does match the black line.

5) Calibration and truncation angle analyze

- System diagram

- Initial measurement of salt particle

- Size distribution 1
  Measured g value: 0.82
  Calculated g value: 0.74

- Size distribution 2
  Measured g value: 0.78
  Calculated g value: 0.69

- Initial measurement of latex sphere

- g value vs Control voltage of four PMT

- g-meter[heuris]: Mie

- Diameter

- Co2: 3.95302E-06 V

- Y=0.13758+2092.8382*X

- $s_g = \frac{P_{g+} + P_{g-}}{2}$ - $P_{g+} - P_{g-}$

- $P_{g+} = \frac{1 + g}{2}$

- $P_{g-} = \frac{1 - g}{2}$

$P_{g+}$ and $P_{g-}$ are the photons detected by detectors of angle $g=0$ and $g=\pm 1$, respectively. g is the asymmetry parameter. $P_{g+}$ and $P_{g-}$ are the photons detected by detectors of angle $g=0$ and $g=\pm 1$, respectively. g is the asymmetry parameter.