NASA TECH BRIEF
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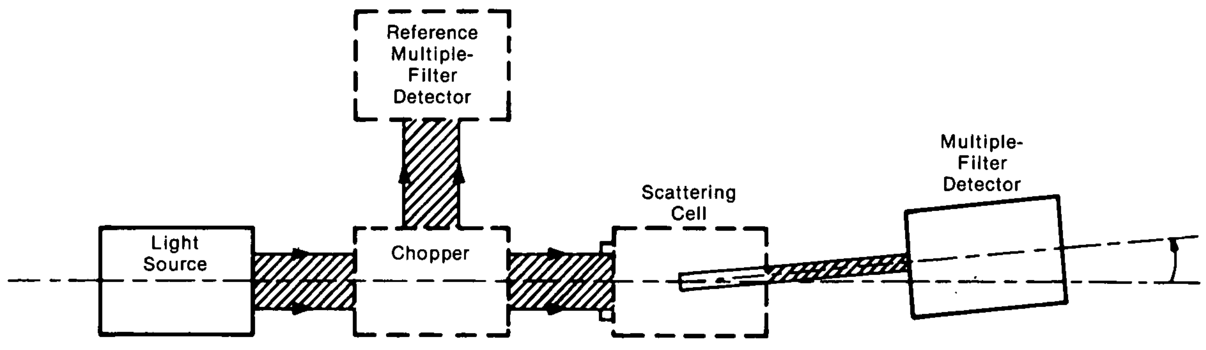
Developments in Spectrophotometry II: A Multiple-Frequency Particle-Size Spectrometer

A newly developed spectrometer can be used to remotely determine the complete spectrum of sizes of particles of unknown composition suspended in a gas or a liquid. The instrument does not require a direct physical sample of the particles. Its measurement capability circumvents problems associated with sampling rates, collection efficiencies, sample alterations, and other troublesome features characteristic of direct sampling.

Particle sizes are determined in equivalent spheres, and the mode radius (corresponding to the largest concentration of particles) can be determined. The instrument employs a fixed-field-of-view photometer to measure the forward scattered light from the sample medium. Measurement of the light at several frequencies allows the particle-size distribution to be reconstructed in detail.

This instrument is made possible by an improved theoretical treatment of light scattering by particles. Mie's theory best describes the relationship between incident light, scattering-medium properties (particle size and refractive index), and scattered light. But, using Mie's theory, it is not possible to separate the effects of the two scattering-medium properties from measurements of the incident and scattered light. It has been shown, however, that at a restricted scattering angle (between 100 and 200 minutes of arc) and over a limited frequency range (between 0.2 and 4.0 μm^{-1}), this separation is possible using the Fraunhofer theory of angular diffraction. Using this theory, a closed inverse solution to the diffraction integral has been derived. Solutions to the integral and the approximations inherent in the Fraunhofer theory have been analyzed to show their validity within experimental error over the prescribed range of scattering angles and frequencies.

A simplified block diagram of the photometer is shown in the figure. The system as shown is designed



Multiple-Frequency Particle Size Spectrometer

(continued overleaf)

to measure particles in a sample cell, using a controllable light source. However, the sample could be suspended in the air, an industrial emission, or a fluid such as blood or other medical plasmas. The light source can be any source that contains the frequencies of interest.

In the instrument as shown, incident light is directed to a reference multiple-filter detector to measure the intensity at each frequency and is also directed to the sample where it is scattered. The intensity of the forward scattered light is measured at several frequencies, all at the same scattering angle. The ratios of incident to scattered light, at frequency increments of 0.2 μm^{-1} or less, can then be used to reconstruct the particle-size distribution independent of the refractive index.

Notes:

1. Further discussion may be found in "Satellite Determination of Nature and Microstructure of Atmospheric Aerosols," by A. L. Fymat in Satellites For Meteorology and Earth Resources, ed. Rassegna, Rome, Italy, vol. 14, March 1974, p. 327.
2. Other recent developments in spectrophotometry that may be of interest to readers of this Tech Brief are found in:
   a. NASA Tech Brief B75-10332, Developments in Spectrophotometry I: An Instrument for High-Resolution Measurement of Optical Intensity and Polarization
   b. NASA Tech Brief B75-10334, Developments in Spectrophotometry III: Multiple-Field-of-View Spectrometer To Determine Particle-Size Distribution and Refractive Index
   c. NASA Tech Brief B75-10338, Minimization Search Method For Data Inversion
3. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP75-10333

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its development should be addressed to:

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Categories: 03 (Physical Sciences)
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