

## Lecture 16

### Measurements of aerosol optics.

#### Objectives:

1. Measurements of aerosol optical depth (or light extinction by particles).
2. Underlying principles of measurements of light absorption by particles. Aethalometer.
3. Underlying principles of measurements of light scattering by particles. Nephelometer.

#### Required Reading:

Le93: 22.2.1

### 1. Measurements of aerosol optical depth.

**Measured direct solar radiation => retrieved aerosol optical depth**

- Direct solar radiation can be measured by a sunphotometer at selected wavelengths.



#### **CIMEL sunphotometer CE-318:**

(used in AERONET network)

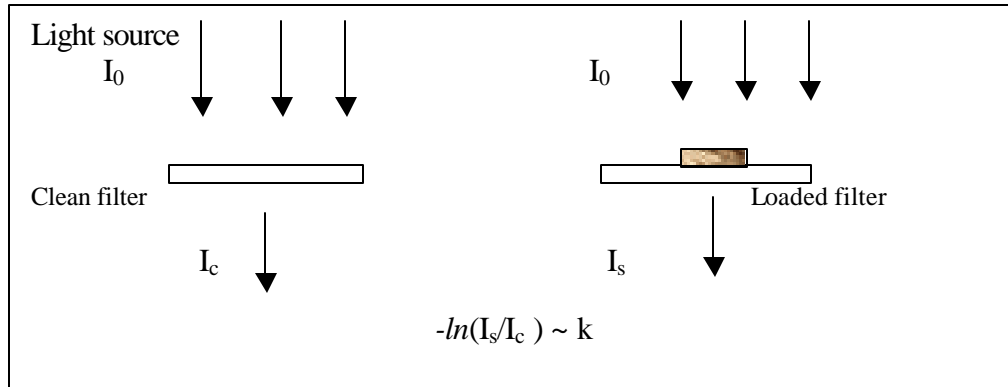
- Automatic sun tracking photometer
- Wavelengths: 340, 380, 440, 670, 870, 1020 nm (aerosols)  
936 nm (water vapor)
- Fully automatic system

**NOTE:** Laboratory 7 deals with the retrieval of aerosol optical depth from sunphotometer measurements.

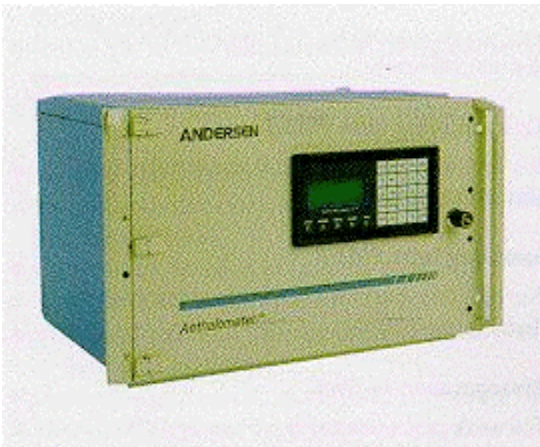
## 2. Underlying principles of measurements of light absorption by particles.

### Aethalometer.

**Filter based techniques** (transmission attenuation technique):



Aethalometer continuously measures the amount of light transmitted through a quartz filter, while particles are being deposited on the filter. Instruments are pre-calibrated by the manufacturer in terms of the equivalent amount of black carbon.



*New aethalometer MODEL AE-31 has the following wavelengths (half-width of about 20 nm) :*

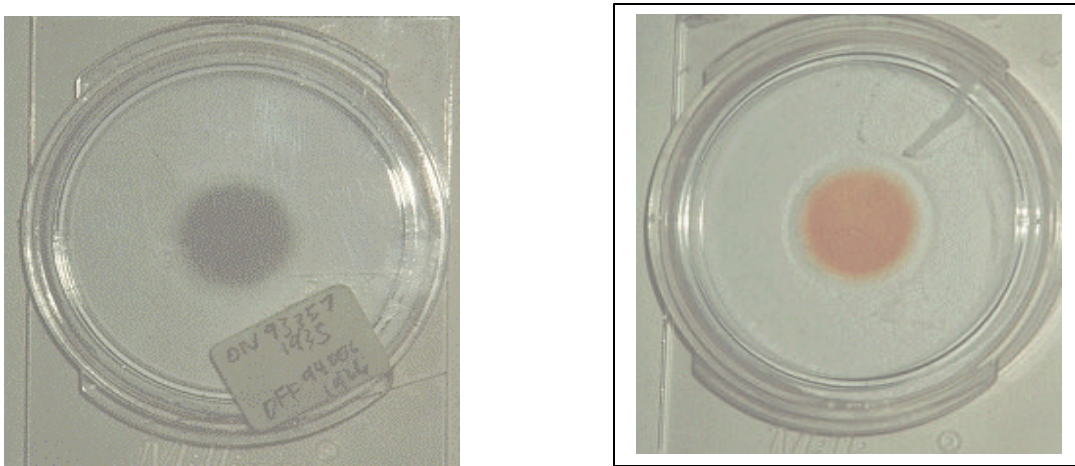
UV	350 nm
Blue	450 nm
Green	571 nm
Yellow	590 nm
Red	660 nm
IR-1	880 nm
IR-2	950 nm

Operational definition of 'aerosol black carbon' (BC):

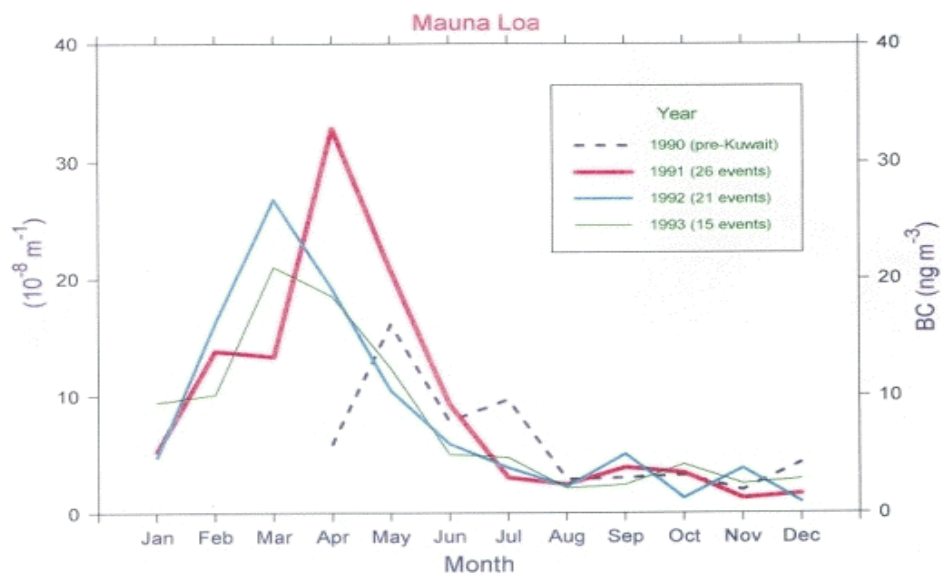
BC is that fraction of aerosol particulate matter that is insoluble in polar and non-polar solvents, is stable in a pure oxygen atmosphere to a temperature of 350 °C, and which is strongly optically absorbing in the visible spectrum.

- In the presence of other light absorbing aerosols (such as mineral dust and some organics), aethalometer measures the total absorption (i.e., the sum of absorption of individual species). By firing the quartz filters, one can separate the absorption by dust and BC.

**Figure 16.1** Aethalometer filters collected at Mauna Loa Observatory (Schnell et al.): the filter with BC (left) and filter loaded by Gobi dust (right) transported to Mauna Loa Observatory from China.



**Figure 16.2** Absorption coefficient measured by the aethalometer at Mauna Loa Observatory.



Other techniques to measure light absorption by particles:

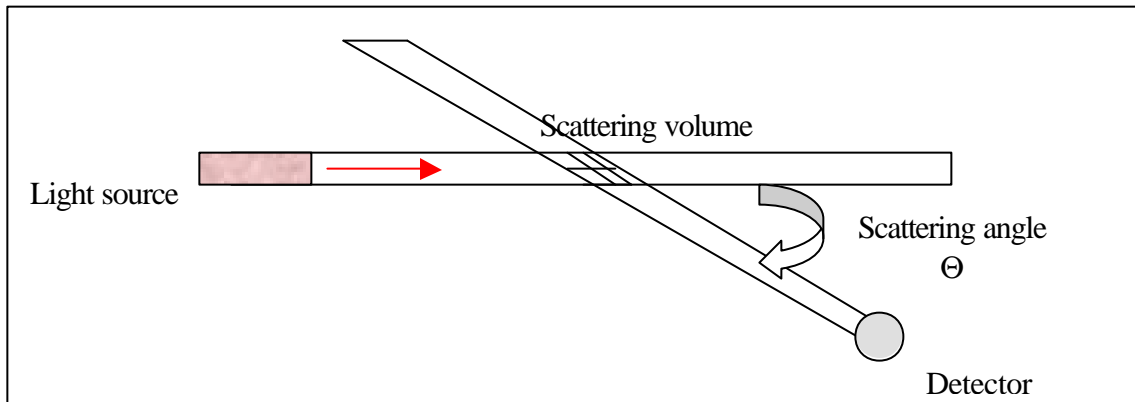
- i) Photoacoustic technique (i.e., absorption of chopped light by the particles gives the rise to periodic heating which alters pressure (sound) detected by a microphone);
- ii) Laboratory measurements (i.e., analysis of filter samples)

2. Underlying principles of measurements of light scattering by particles.

Nephelometer.

[Polar Nephelometer](#)

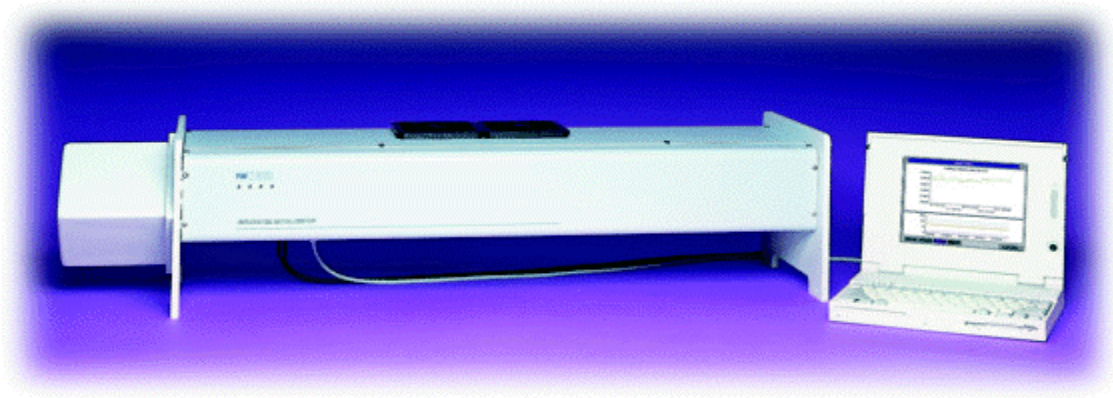
**Figure 16.3** Simplified schematic diagram of a polar nephelometer for measuring angular scattering.



NOTE: A polar nephelometer with polarizes is used for measurements of the scattering phase matrix.

## Integrating Nephelometer

**Figure 16.4** Integrating nephelometer manufactured by the TSI



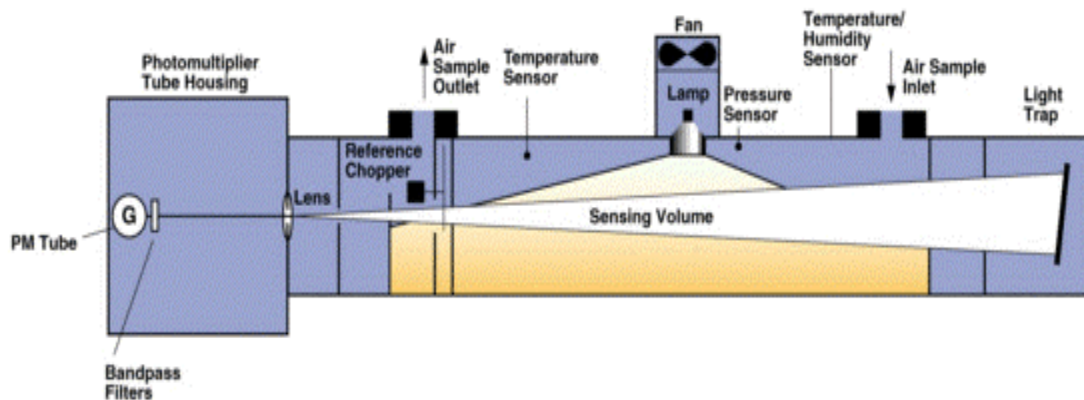
### **One-wavelength Integrating Nephelometer (Model 3551)**

- ❖ Sensitivity to scattering coefficients  $<2.0 \times 10^{-7} \text{ m}^{-1}$
- ❖ Wavelength: 550 nm (green). Bandwidth: 40 nm
- ❖ Measurement of total (7- to 170-degree) scattering coefficient

### **Three-wavelength Integrating Nephelometer (Model 3563)**

- ❖ Sensitivity to scattering coefficients  $<2.0 \times 10^{-7} \text{ m}^{-1}$
- ❖ Wavelengths: 450 nm (blue), 550 nm (green), and 700 nm (red). Bandwidth: 40 nm (all wavelengths)
- ❖ Measurement of total (7- to 170-degree) scattering coefficient and backscattering (90- to 170-degree).

**Figure 16.5** Operation of the integrating nephelometer.



*Example of analysis of nephelometric data.*

**Figure 16.6** Annual cycle of the scattering coefficient measured by NOAA/CMDL group at several locations (BRW = Barrow, Alaska; MLO=Mauna Loa Observatory, Hawaii; SMO = Samoa; SPO = South Pole)

