Aerosol optical absorption and spectral dependence measurement with photoacoustic spectroscopy

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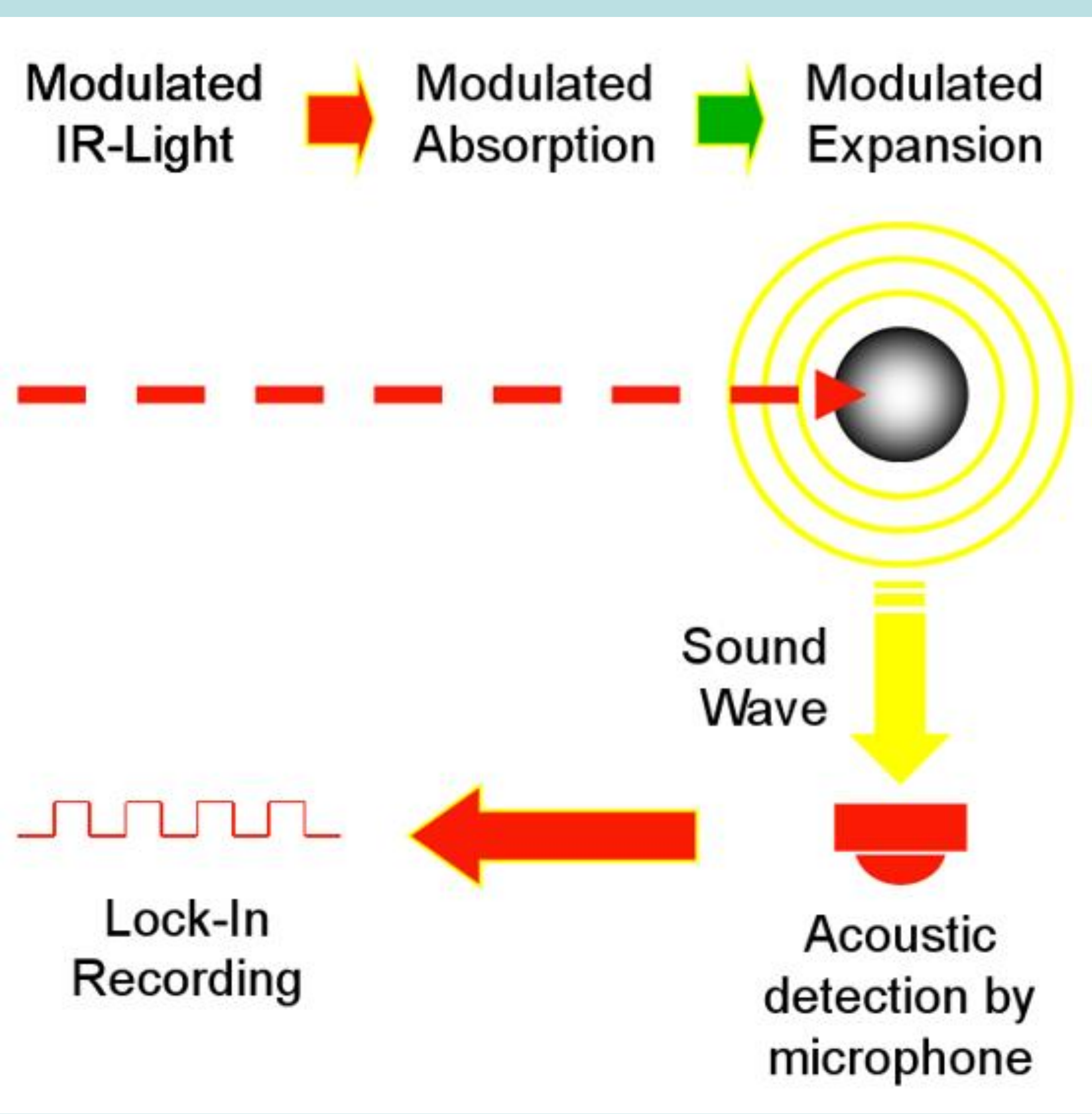
Light-absorbing carbonaceous aerosols mainly generated from the combustion of biomass and fossil fuels, play an important role in the global environment. Multi-wavelength in-situ measurement of carbonaceous aerosol optical absorption is important both for reduce errors in assessing radiative forcing and component identification or source appointment of aerosols (such as biomass burning and diesel soot) with absorption Ångström exponent (AAE). A differential photoacoustic spectrometer (PAS) using a 438 nm laser diode was developed for simultaneously measure the aerosol optical absorption coefficient and the concentration of NO_2. In addition, a novel multi-wavelength photoacoustic spectrometer (MW-PAS) was developed to measure the aerosol optical absorption coefficients and its wavelength-dependent characteristics in the UV-VIS-NIR bands (405, 638, 808 nm).

Fundamental

Photoacoustic spectroscopy:
Spectral technology based on photoacoustic effect.



Schematic diagram of basic principles of photoacoustic effect

Measurements of aerosol light absorption

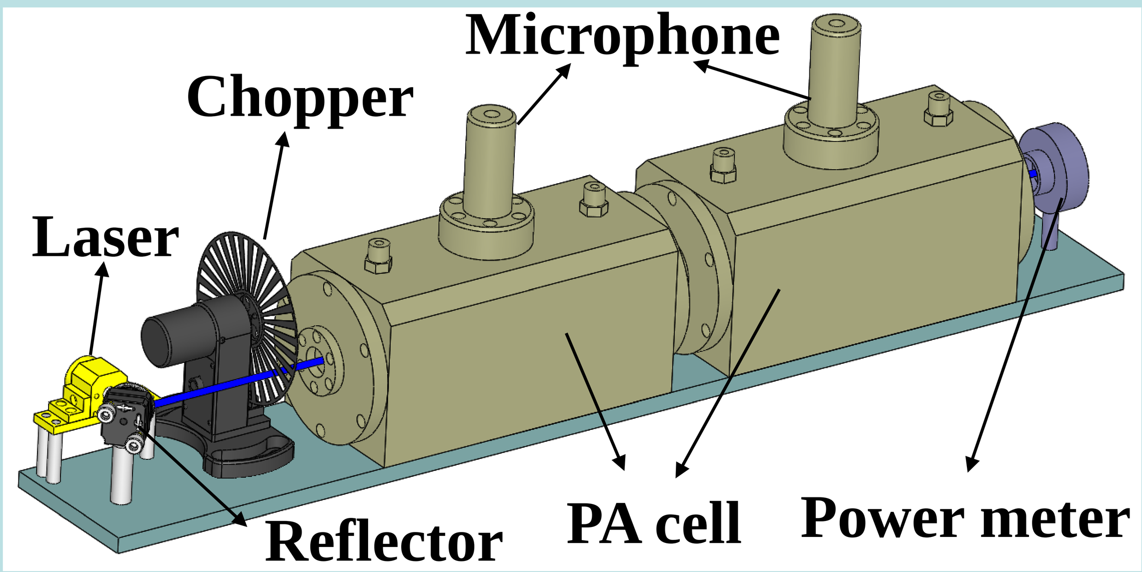
Filter-based techniques:
A. Aethalometer;
B. Particle Soot Absorption Photometer;
C. Multi-Angle Absorption Photometer

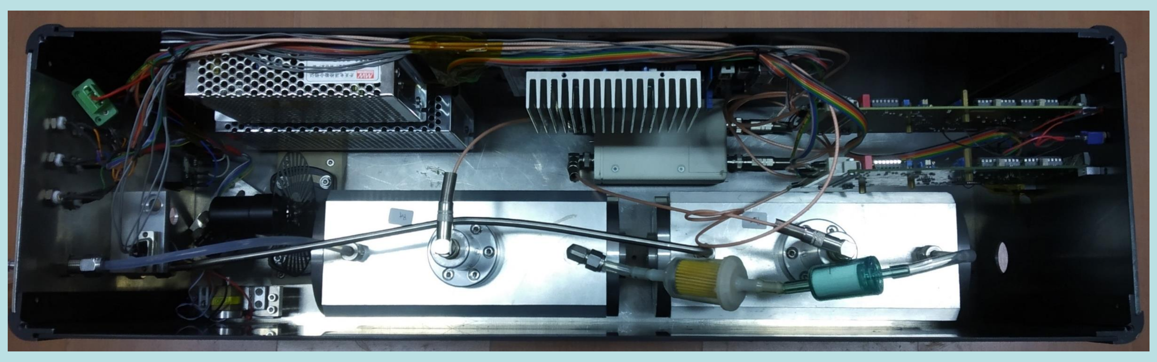
In situ measurements of aerosol optical absorption:
A. Incandescence-based techniques;
B. Refractive index-based techniques;
C. Extinction-minus-scattering techniques;
D. Photoacoustic technique

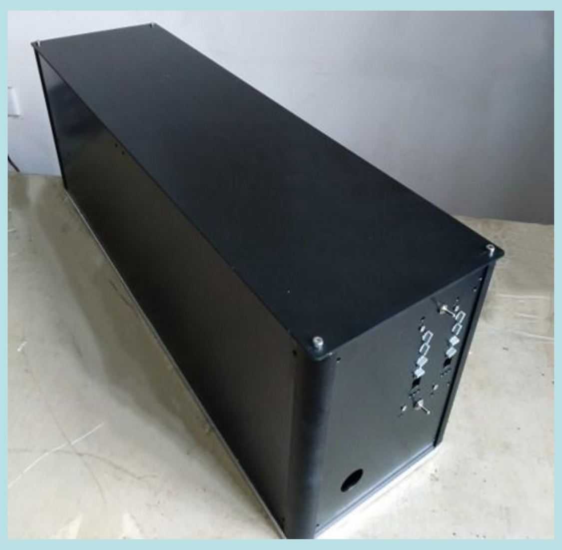
Advantages of photoacoustic techniques:
1) Zero background;
2) High accuracy;
3) Wide linear dynamic range (10^8);
4) Sensitivity is proportional to laser power;
5) Acoustic microphone is not limited by the optical band

Aerosol optical absorption measurement

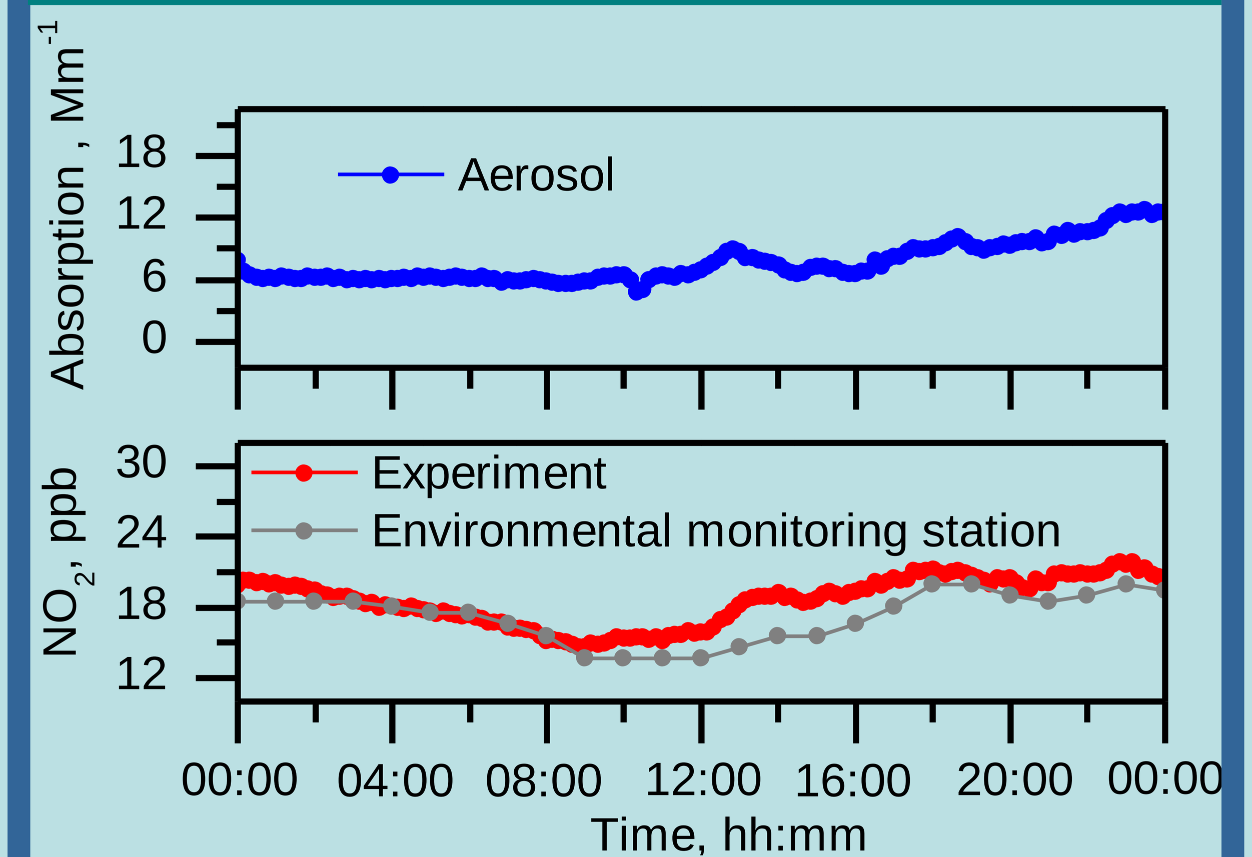
Differential aerosol absorption PAS







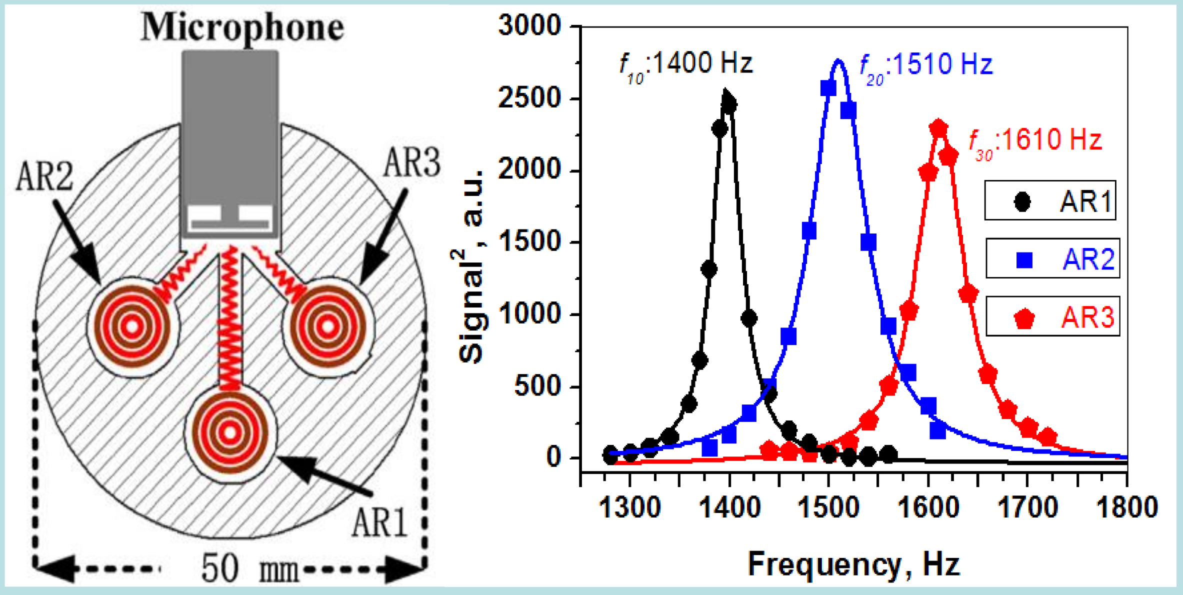
Experimental setup and physical map



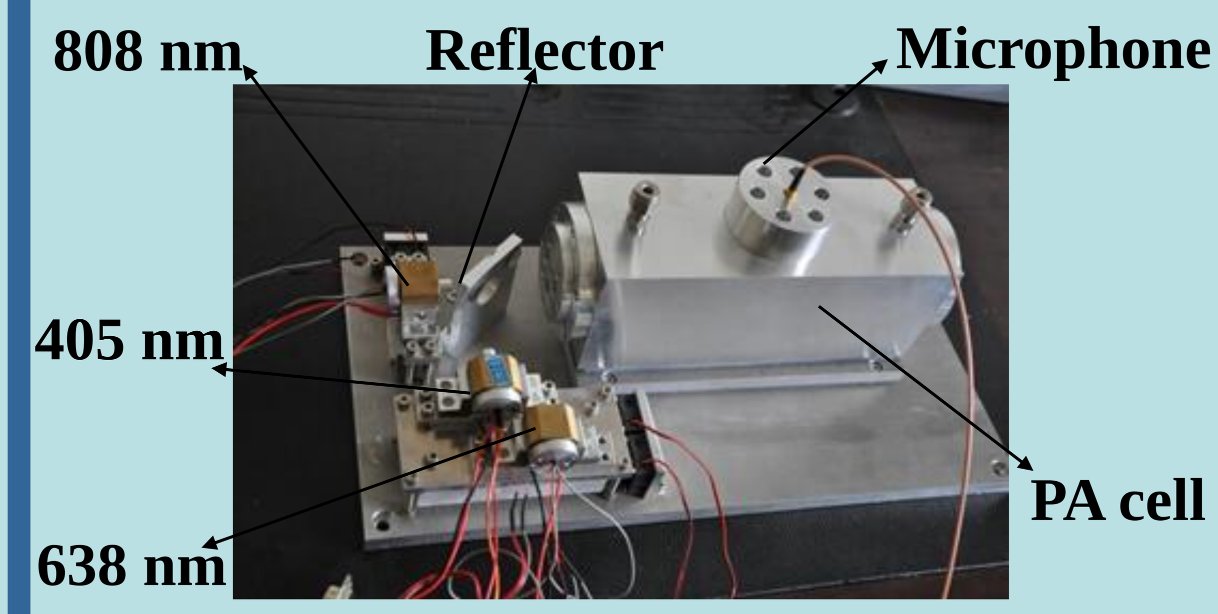
Continues observation of the atmospheric aerosol optical absorption coefficient and atmospheric NO_2 concentration

Features: 1) High sensitivity(~0.5 Mm^{-1});
2) High time resolution(1 s);
3) In situ measurement;
4) Portable

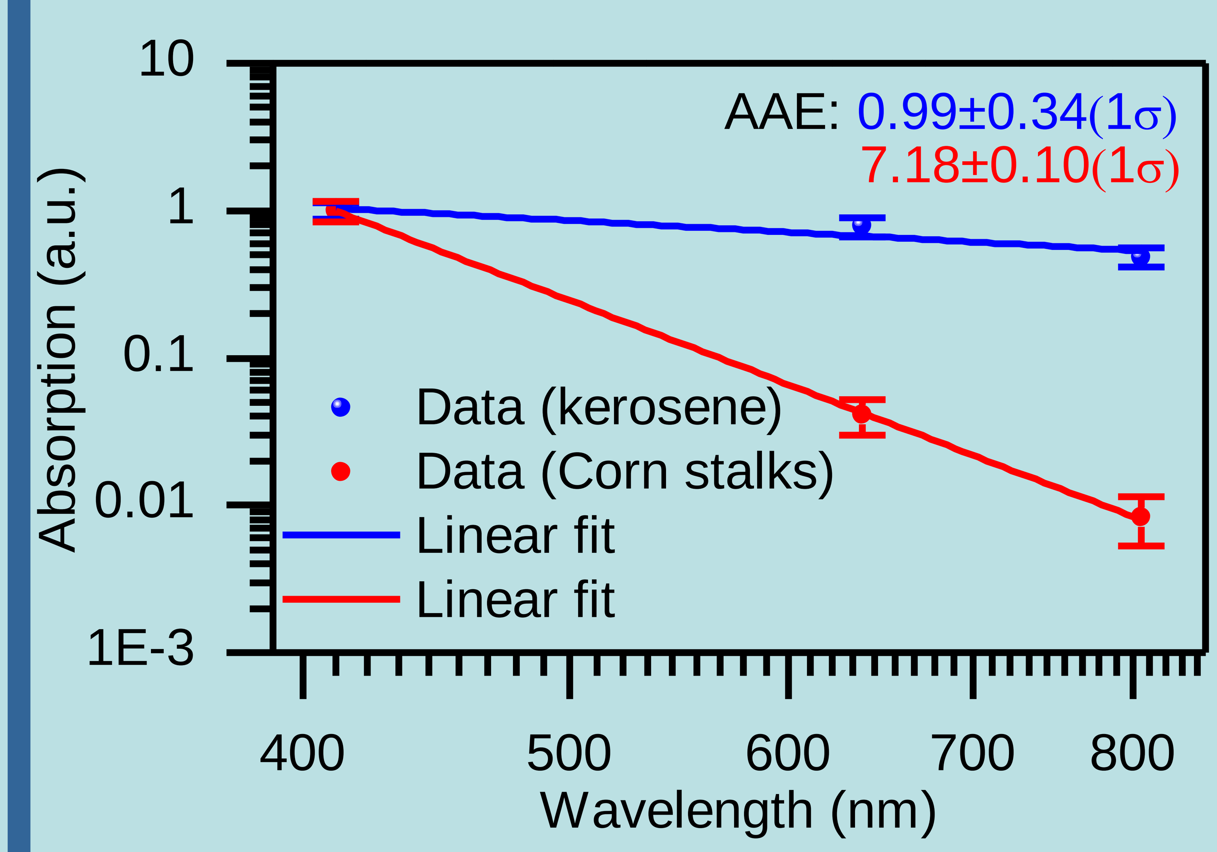
Three-wavelength aerosol absorption PAS



Geometric distribution of multi-resonators integrated in a cylinder (left) and square of the MW-PAS signals amplitude as a function of frequency (right)



Schematic of MW-PAS



Determine the AAE values of different types aerosols by using MW-PAS

Features: 1) Simultaneous;
2) Continuous;
3) In situ measurement;
4) High time resolution(1 s)