Single Particle Soot Photometer (SP2)

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Parameters measured by SP2

1) Mass and coating thickness of individual black carbon (BC) particles at diameters between 90-400 nm.
2) Diameters of individual and non-light absorbing particles at diameters of 250-1000 nm.
3) Size distributions of BC and non-light absorbing particles every 1-5 minutes, depending on aerosol concentrations

Uncertainty

The accuracy of the BC diameter determination is 13%.

Outline of SP2

The Single Particle Soot Photometer (SP2) was designed for measurements of the size-segregated concentration of BC by laser-induced incandescence (LII) using continuum laser. The schematic diagram of the SP2 is depicted in Figure 1.

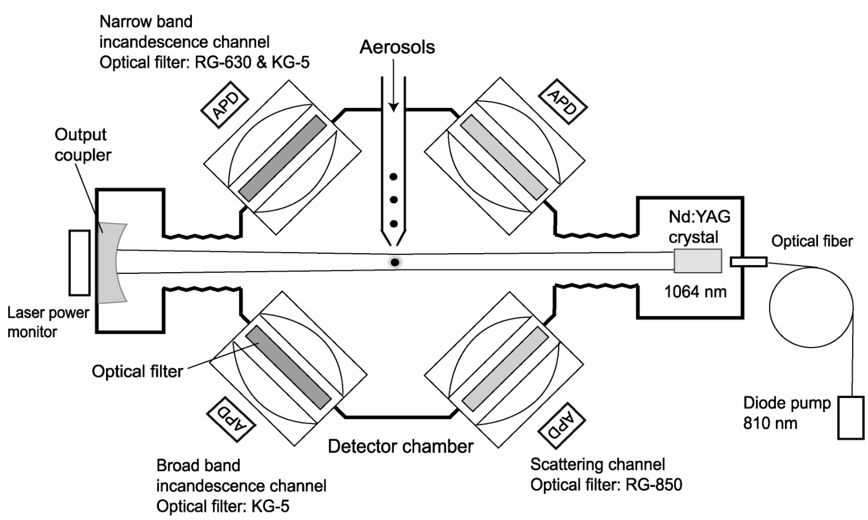

Figure 1. Schematic diagram of the single-particle soot photometer (SP2). Although the axis of the aerosol jet is perpendicular to the plane containing the APDs and the beam of the YAG laser, it is drawn in parallel for simplicity.

An air jet containing sample aerosol intersects an intense (~1 MW cm^{-2}), Nd:YAG, intra-cavity, continuous laser beam (λ = 1064 nm) pumped by a diode laser. The laser is in a TEM00 mode, with a Gaussian intensity distribution. Aerosol particles elastically scatter light in the laser beam and, if they contain light absorbing material at the wavelength of the incident light, like BC, they are also heated as they absorb the laser radiation and eventually incandesce and vaporize due to evaporation at high temperatures. The mass of BC with diameters between about 90-400 nm is derived by measuring the intensity of the LII signal from individual particles. Non-light absorbing aerosols, e.g., sulfate, nitrate, and organics, elastically scatter laser light without evaporation during laser irradiation. The size of non-light absorbing aerosol with diameter of 250-1000 nm can be measured by the intensity of scattering. BC particles coated by non-light absorbing material scatter laser light more efficiently than uncoated BC due to the larger scattering cross section. The chemical composition of an incandescing particle can be constrained based on the temperature at the point of peak LII intensity because it is a proxy of the boiling point of the composition. Scattering signals, in comparison with the LII signals, are also used for assessing the coating state of BC particles.

The laser beam power is monitored by a detector that measures a small fraction of the light that passes through the output coupler with an efficiency of 15 part per million (ppm). The light detection system consists of four detectors; one for scattered light, two for LII, and one for redundancy. Each detector system consists of an avalanche photo-diode (APD) (Perkin Elmer C30916E), a complex lens to focus light onto the APD, and optical filters. The broadband and narrowband LII channels are equipped with band pass filters for wavelength regions of λ = 350-800 nm (Schott KG5) and λ = 630-800 nm (Schott KG5 and RG630), respectively. The scattering channel uses a low pass filter that rejects light at λ < 850 nm (Schott RG850).

References

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