

Measurements of Black Carbon Aerosol in SENEX

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Black carbon (BC) in the atmosphere plays an important role in global climate change, affecting climate radiative forcing directly through its absorption of solar radiation and indirectly by affecting cloud processes and snow melt. We use a customized Single-Particle Soot Photometer (SP2) to quantify atmospheric BC.

The SP2 is a laser-induced incandescence instrument that measures the BC mass content of individual particles, and thus delivers detailed information not only about BC loadings, but also size distributions, even in exceptionally clean air [Schwarz *et al.*, 2010]. The instrument can also provide the optical size of individual particles containing BC, and identify the presence of coatings associated with the BC fraction (i.e. identify the BC's mixing state) [Schwarz *et al.*, 2008].

An SP2 system is shown schematically to the right. Ambient air is drawn through an intense intracavity laser (a diode-pumped Nd:YAG laser operating in a Gaussian TEM-00 mode at $1.064\ \mu\text{m}$ wavelength). Aerosol particles in the air enter the laser singly, and there scatter laser light according to their size and composition. The quantity of scattered light, and its evolution in time, is recorded. When a

BC-containing particle enters the laser, it is heated to vaporization ($\sim 3500\text{K}$), emitting blackbody radiation (incandescent light) in quantities directly related to its mass, regardless of particle morphology or mixing state. The color of this radiation is detected and used to deduce the vaporization temperature of the particle as a constraint on its

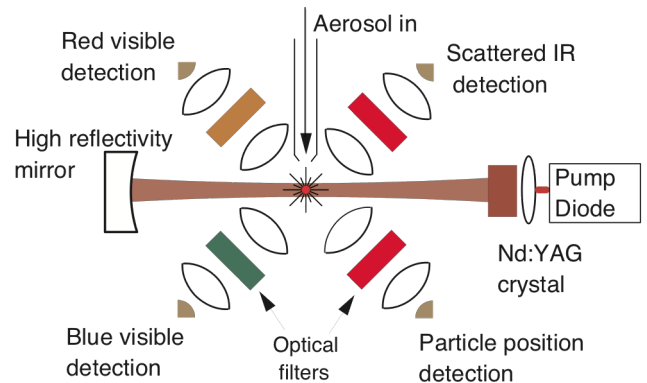


Figure 3. Schematic diagram of the SP2 photometer showing the basic optics and laser-induced incandescence and scattering detectors.

composition. A detector system developed by NOAA is used to optically size BC-containing particles, before they are perturbed by laser heating. This allows quantification of the amount of non-BC material (interpreted as coating thickness via shell-core Mie theory) associated with each BC core, and its impact on the optical properties (including absorption cross-section) of the BC-component.

Table 1: Performance characteristics of the NOAA SP2.

Operational altitude	Ground - 21 km (1013 hPa – 50 hPa)
Flight duration	<12 hours
Weight	135 lbs
BC Aerosol data products	1. Black carbon mass and size distributions 2. Black carbon mixing state
Maximum particle event rate	20,000 s ⁻¹
BC mass detection range	0.5 – 350 fg (corresponding to ~0.08 – 0.6 μ m mass-equivalent diameter assuming a 2 g/cc density)

References:

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