Aerodyne's mini-Aerosol Mass Spectrometer (mAMS) and Cavity Attenuated Phase Shift Spectrometer (CAPS- PM_{ex})

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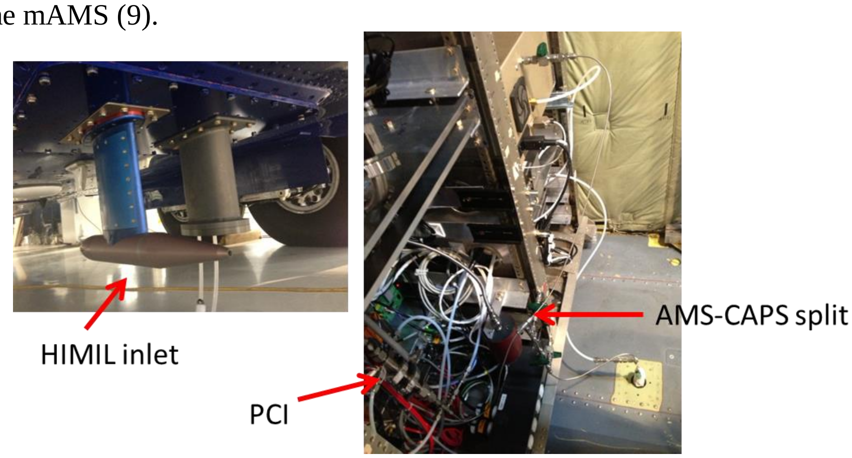
I) Principles of Operation

The Aerodyne's mini-Aerosol Mass Spectrometer (mAMS) is a compact version of the AMS that has been used widely in the past to obtain fast, size-resolved, non-refractory chemical composition of submicron aerosol particles (e.g., 1, 2, 3). Similar to previous versions, air is sampled through a critical orifice and a system of aerodynamic lenses in which particles are focused into a narrow beam. After exiting the lens and passing through a skimmer, sample flow is expanded into a differentially pumped chamber in which particles travel at different speeds, depending on their size. At the end of the chamber, particles impact on a tungsten vaporizer (600 °C) and non-refractory components are vaporized. Vapors are ionized by electron impact and ions are extracted into the mass analyzer. A chopper wheel is used to chop, block, or open the particle beam to allow for measurements of aerosol mass distributions or mass spectra. This model is equipped with a compact time-of-flight mass spectrometer (C-ToF). With the mass resolution (M/dM) of a C-ToF mass spectrometer typically being ~1000 Th/Th (4), higher-resolution analysis of the OA spectra will provide information on the relative contribution of purely hydrocarbon vs. oxygenated hydrocarbon ions to the signal at each fragment (i.e., $C_xH_y^+$ vs. $C_xH_yO_z^+$, where x, y, and z are positive integers) (5).

Optical extinction at λ=632 nm is measured by Cavity Attenuated Phase Shift spectrometry (CAPS-PM_{ex}). Detailed design and first results from laboratory and ambient measurements of CAPS-PM_{ex} are provided in *Kebabian and Freedman* (6) and *Massoli et al.* (7). In short, the extinction measurements are made in a 26cm long cavity with highly reflective mirrors (reflectivity >99.98%) at both ends, providing an effective optical path-length of ~ 2 km (7, 8). Square-wave modulated light from a light emitting diode (LED) at λ=632 nm is guided to the cavity cell through the mirror at one end. Distortions in the square-wave due to light extinction in the cavity are measured as a phase-shift by a vacuum photodiode located behind the mirror at the other end, and the observed phase-shift is related to aerosol extinction. Particle-free (i.e., filter) measurements are automatically made for determining the baseline and corrections for any gas-phase absorption interference. Temperature and pressure of the cavity are recorded continuously.

II) Inlet Assembly

Ambient air is drawn through a diffuser, centered forward-facing within a HIMIL inlet under the aircraft. Inside the cabin, sampled air is split between CAPS-PM_{ex} and a pressure-controlled inlet (PCI) upstream of the mAMS (9).



III) Data

The data obtained by mAMS will be analyzed to produce mass concentrations and mass distributions of non-refractory sulfate, nitrate, chloride, ammonium, and organic aerosol (OA). The archived data will include 15-s mass concentrations of the above species while 15-s mass distributions will be available upon request. Additionally, extinction data (1 Hz) will be archived daily. The following table provides detection limits and uncertainty estimates of the data provided by mAMS and CAPS-PM$_{ex.}$

Measured Parameter	Sampling Interval	Detection Limit	Uncertainty	Reference
Sulfate	15 s	0.09 μg m^{-3}	36%	Bahreini *et al.* [2009]
Nitrate	15 s	0.13 μg m^{-3}	34%	Bahreini *et al.* [2009]
Chloride	15 s	0.10 μg m^{-3}	36%	Bahreini *et al.* [2009]
Ammonium	15 s	0.54 μg m^{-3}	34%	Bahreini *et al.* [2009]
OA	15 s	0.35 μg m^{-3}	38%	Bahreini *et al.* [2009]
Optical Extinction (632 nm)	1 s	3 Mm^{-1}	3%	Massoli *et al.* [2012]

IV) References

1. Canagaratna, M.R., et al. (2007), Chemical and Microphysical Characterization of Ambient Aerosols with the Aerodyne Aerosol Mass Spectrometer, *Mass Spectrometry Reviews*, *26*, 185-222.
2. Jayne, J.T., et al. (2000), Development of an Aerosol Mass Spectrometer for size and composition analysis of submicron particles, *Aerosol Sci. Technol.*, *33*, 49-70.
3. Bahreini, R., et al. (2009), Organic aerosol formation in urban and industrial plumes near Houston and Dallas, TX, *J. Geophys. Res.*, *114*(D00F16), doi:10.1029/2008JD011493.
4. DeCarlo, P.F., et al. (2006), Field-Deployable, High-Resolution, Time-of-Flight Aerosol Mass Spectrometer, *Analytical Chem.*, *78*(24), 8281-8289, doi: 10.1021/ac061249n.
5. Bahreini, R., et al. (2012), Mass Spectral Analysis of Organic Aerosol Formed Downwind of the Deepwater Horizon Oil Spill: Field Studies and Laboratory Confirmations, *Environ. Sci. Technol.*, *46*(15), 8025-8034, doi:10.1021/es301691k.
6. Kebabian, P.L. and A. Freedman, *System and method for trace species detection using cavity attenuated phase shift spectroscopy with an incoherent light sources*, 2007: USA
7. Massoli, P., et al. (2012), Aerosol Light Extinction Measurements by Cavity Attenuated Phase Shift (CAPS) Spectroscopy: Laboratory Validation and Field Deployment of a Compact Aerosol Particle Extinction Monitor, *Aerosol Sci. Technol.*, *44*, 428-435, doi:10.1080/02786821003716599.
8. Petzold, A., et al. (2013), Intercomparison of a Cavity Attenuated Phase Shift-based extinction monitor (CAPS PMex) with an integrating nephelometer and a filter-based absorption monitor, *Atmos. Meas. Tech.*, *6*, 1141-1151, doi:10.5194/amt-6-1141-2013.
9. Bahreini, R., et al. (2008), Design and Operation of a Pressure-Controlled Inlet for Airborne Sampling with an Aerodynamic Aerosol Lens, *Aerosol Sci. Technol.*, *42*(6), 465-471, doi:10.1080/02786820802178514.