PAAS-4λ

“hear your absorption”

The four wavelengths Photoacoustic Aerosol Absorption Spectrometer (PAAS-4λ) provides a fast, sensitive and specific quantification of light absorbing fine particulate matter (PM1).

Applications

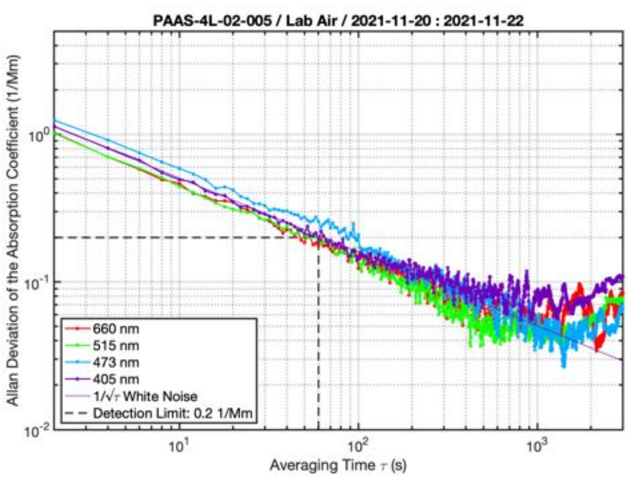
- Quantification of PM1 combustion aerosol, including black and brown carbon mass concentrations
- Aerosol ageing processes under complex urban conditions
- Source apportionment studies for light absorbing particulate matter from fossil fuel and biomass burning
- Air quality monitoring networks
- Pollution characterisation in sensitive remote environments

The reliable quantification of combustion particle mass under complex urban pollution conditions is challenging and requires new methods.

Photoacoustic spectroscopy can reliably discriminate absorbing aerosol mass under complex air pollution conditions. A multi-wavelength approach in the visible spectral region allows a source apportionment of the combustion emissions.

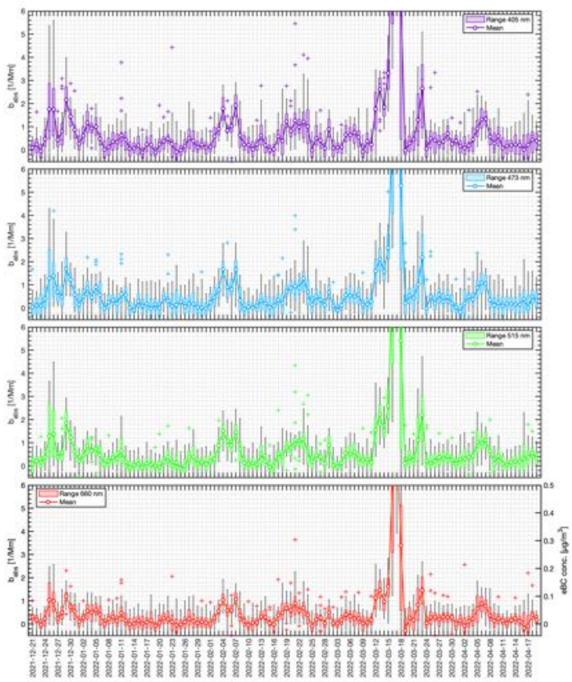
Features

- Detection limit better than 1 Mm^{-1} (equivalent to a black carbon concentration (eBC) below 0.1 µg m^{-3})
- Customisable wavelength combinations in the 375 nm to 785 nm spectral range
- Separate optics, electronics, and flow units for flexible adaptation to your lab environment or implementation of accompanied measurements
- Fully integrated into 19” rack enclosures ready to be integrated in air-quality monitoring stations



Allan variance analysis of a two-day PAAS-4λ background measurement. The PAAS-4λ has a 1σ detection limit below 0.5 Mm^{-1} for a typical averaging period of 60 s (left).

Daily particle light absorption statistics over a four-month period measured at the Pallas GAW air quality station in Northern Finland (right).

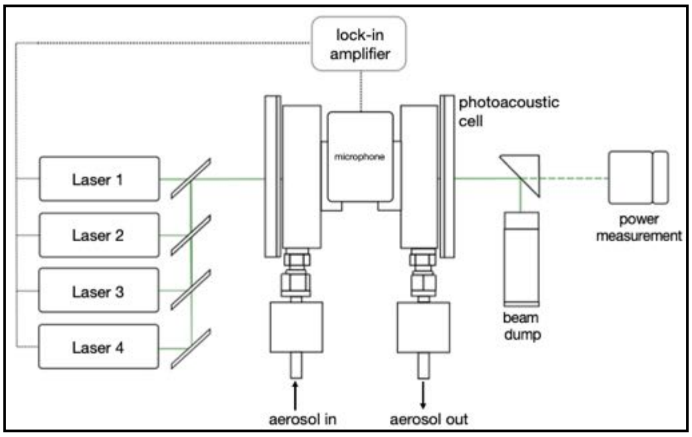


Werner-von-Siemens-Str. 2 – 6
Gebäude 5137c
76646 Bruchsal, DE

+49 160 9095 7917
schnaitec.com
info@schnaitec.com

schnaiTEC

Operation



Schematic diagram of the PAAS-4λ measurement setup

Sample aerosol is led through the photoacoustic cell of the instrument. This cell consists of a cylindrical cavity that has a fundamental acoustic resonance frequency of 3180 Hz. Laser beams of up to 4 lasers are combined on the axis of the cavity. The lasers are modulated at the resonance frequency of the cavity and are sequentially switched on and off to illuminate the sample in the cell with light of different wavelengths. If light absorbing particles are present in the aerosol sample, a part of the light is absorbed and transferred to heat which is released to the surrounding air resulting in a local pressure change. As the light is modulated this change in pressure is also periodic which translates into a sound wave that is amplified by the acoustic cavity. A subminiature microphone is detecting this sound. The signal is filtered and processed by a dual phase lock-in amplifier. The PAAS-4λ is calibrated with NO_2/air premixed gas standards to deduce the absorption coefficient from the raw signal.

Reference:

Linke, C., et al., A novel single-cavity three-wavelength photoacoustic spectrometer for atmospheric aerosol research, Atmos. Meas. Tech., 9, 5331–5346, https://doi.org/10.5194/amt-9-5331-2016, 2016.

Schnaiter, M., et al., Specifying the light-absorbing properties of aerosol particles in fresh snow samples, collected at the Environmental Research Station Schneefernerhaus (UFS), Zugspitze, Atmos. Chem. Phys., 19, 10829–10844, https://doi.org/10.5194/acp-19-10829-2019, 2019.

Specifications

Concept	Specific measurement of the aerosol absorption coefficient of PM1 aerosol in a single photoacoustic cell at multiple wavelengths
Detection limit	0.5 Mm^{-1} (approx. 0.05 μg m^{-3} Black Carbon)
Accuracy & Precision	15% and 3%
Laser Beam	Up to four wavelengths efficiently combined to a 0.7 mm ($1/e^2$) collimated beam
Available Laser Wavelengths	375 nm, 395 nm, 405 nm, 415 nm, 425 nm, 445 nm, 457 nm, 460 nm, 473 nm, 488 nm, 515 nm, 638 nm, 642 nm, 660 nm, 785 nm
Laser Power	100 - 300 mW (cw) digitally modulated with 50% duty cycle*
Acoustic resonator	Compact stainless steel cylindrical cavity with a fundamental acoustic frequency of 3150 Hz
Sample Flow Rate	0.5 - 2.0 LPM
Cell volume	236 cm^3 (including acoustic buffer volumes)
Time resolution	1 s sampling rate. Typical averaging time per wavelength: 60 s
Control Unit	Dual core (667 MHz) real time embedded controller
Instrument Computer	2.0 GHz CPU, 4 GB RAM, 120 GB SSD Panel PC with 8” touch screen
Software	Graphical data acquisition software. SQL database storage for long-term monitoring
Power requirements	220 VAC / 110 VAC
Power Consumption	180 W typical
Physical Dimensions	Optics Unit: 462 mm x 422 mm x 210 mm Electronics Unit: 496 mm x 449 mm x 310 mm
Weight	Optics Unit: 27 kg Electronics Unit: 17 kg Flow Unit: 5 kg

*Laser power depends on requested wavelength

Setup

The PAAS-4λ consists of separate optics, electronics and flow units that are prepared for 19” rack integration or desktop installation.

Optics Unit

- Aluminum base plate that carriers laser combiner, photo acoustic cell and power measurement on vibration insulating stands
- Integrated in a ventilated plywood housing with good sound isolation characteristics

Electronics Unit

- Robust 19” enclosure that hosts lock-in amplifier, embedded controller and instrument computer
- 8” touch panel with 800 x 600 pixels
- RT data acquisition software, SQL data base and GUI preinstalled

Flow Unit

- Robust 19” enclosure that hosts filtered air bypass valves, aerosol temperature and r.h. sensor, and mass flow controller.
- Interfaces to electronic unit for automated control of zero air measurements.

Werner-von-Siemens-Str. 2 – 6
Gebäude 5137c
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+49 160 9095 7917
schnaitec.com
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schnaiTEC