schnaiTEC

Environmental Research Solutions

Next-generation air quality monitoring

PAAS Series

The Photoacoustic Aerosol Absorption Spectrometer (PAAS) delivers fast, highly sensitive, and selective quantification of light-absorbing fine particulate matter. Designed for research applications, PAAS enables real-time, long-term monitoring of aerosol absorption up to four visible wavelengths, providing valuable insights into the optical properties and sources of combustion-generated particles.

Quantifying the mass of combustion-derived particles in complex urban environments presents a significant challenge. Traditional filter-based methods often struggle with interferences and measurement artifacts. Photoacoustic spectroscopy directly measures light absorption by aerosols, eliminating uncertainties associated with indirect techniques. The multi-wavelength approach enhances source apportionment, distinguishing between different combustion sources and improving the characterization of atmospheric pollution.

With robust design and automated operation, PAAS-4λ is ideal for unattended long-term deployments in urban, remote, and laboratory environments. Its reliability and minimal maintenance requirements make it a powerful tool for continuous air quality research.

Cutting-Edge Features:

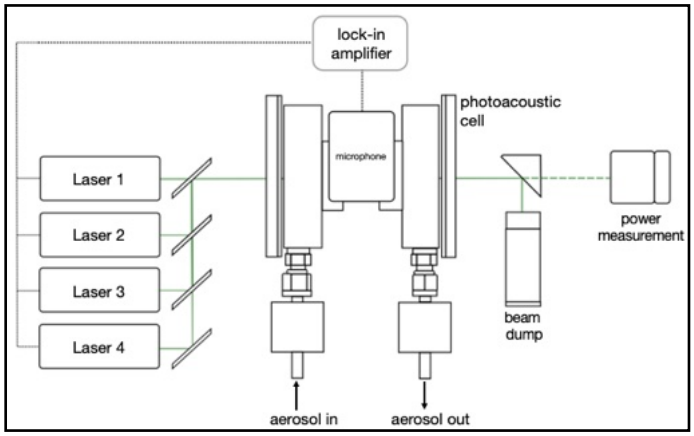
- Detection limit better than 0.5 Mm^{-1} (equivalent to a black carbon concentration (eBC) below 0.05 µg m^{-3})
- Customisable wavelength combinations in the 375 nm to 1550 nm spectral range
- Separate optics, electronics, and flow units for flexible adaptation to your lab environment or implementation of accompanied measurements
- Fully integrated into 19” rack enclosures ready to be integrated in air-quality monitoring stations

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

Operation

Sample aerosol is drawn through the photoacoustic cell, a cylindrical cavity with a fundamental acoustic resonance frequency of 3200 Hz. Up to four laser beams are combined along the cavity axis, modulated at its resonance frequency, and sequentially switched to illuminate the sample with different wavelengths. When light-absorbing particles are present, they absorb energy, convert it to heat, and induce localized pressure changes. The modulation of light creates periodic pressure fluctuations, generating a sound wave that is amplified within the acoustic cavity. A high-sensitivity subminiature microphone detects the resulting signal, which is filtered and processed by a dual-phase lock-in amplifier. The PAAS-4λ is calibrated using NO2/air premixed gas standards to accurately determine the absorption coefficient from the raw signal.



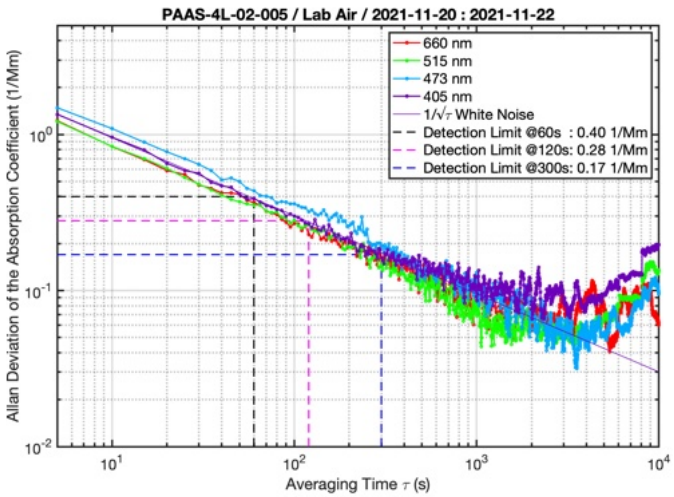
Schematic diagram of the PAAS-4λ measurement setup

References

Schnaiter, F. M., Linke, C., Asmi, E., Servomaa, H., Hyvärinen, A.-P., Ohata, S., Kondo, Y., and Järvinen, E.: The Four-Wavelength Photoacoustic Aerosol Absorption Spectrometer (PAAS-4λ), Atmos. Meas. Tech., 16, 2753-2769, https://doi.org/10.5194/amt-16-2753-2023, 2023.

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.

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



Setup

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 RH sensor, and mass flow controller.
- Interfaces to electronic unit for automated control of zero air measurements.

Allan variance analysis of a two-day PAAS-4λ background measurement.
The PAAS-4λ has a 1σ detection limit of 0.4 Mm^{-1} for a typical averaging period of 60 s

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PAAS Specifications

Concept	Specific measurement of the aerosol absorption coefficient of PM1 aerosol in a single photoacoustic cell at multiple (up to four) wavelengths
Detection limit	0.5 Mm^{-1} (approx. 0.05 µg m^{-3} Black Carbon)
Accuracy & Precision	10% 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 - 1550 nm Typical: 405 nm, 445 nm, 473 nm, 515 nm, 638 nm, 660 nm, 785 nm
Laser Power	100 - 300 mW (depending on wavelength) digitally modulated with 50% duty cycle typical
Acoustic resonator	Compact stainless steel cylindrical cavity with a fundamental acoustic frequency of 3200 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 Flow unit: 436 mm x 449 mm x 177 mm
Weight	Optics Unit: 27 kg Electronics Unit: 17 kg Flow Unit: 5 kg

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Discover Next-generation Air Quality Monitoring

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