

# 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 (PM<sub>2.5</sub>).



## Applications

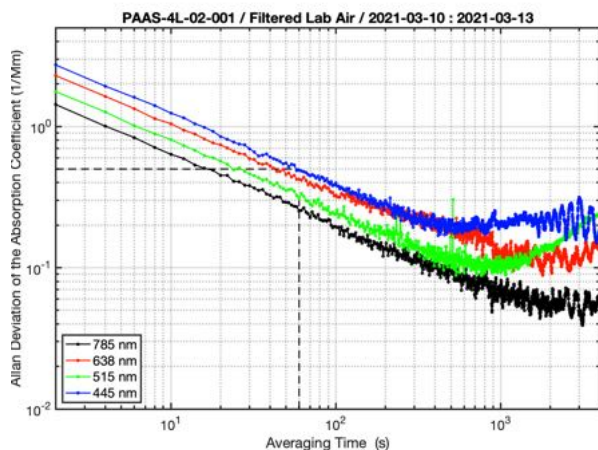
- Quantification of PM<sub>2.5</sub> combustion aerosol, including black and brown carbon mass concentrations
- Aerosol ageing processes under complex urban conditions
- Source apportionment studies for light absorbing particulate matter from fossil fuel and biomass burning
- Air quality monitoring networks
- Pollution characterisation in sensitive remote environments

## Features

- Detection limit better than 1 Mm<sup>-1</sup> (equivalent to a black carbon concentration below 0.1 µg m<sup>-3</sup>)
- Customisable wavelength combinations in the 375 nm to 785 nm spectral range
- Separate optics and electronics 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

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

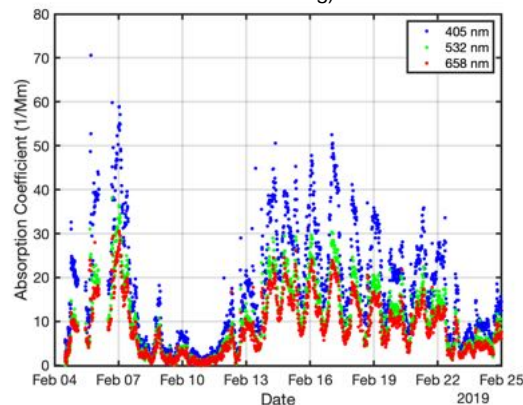
Photoacoustic spectroscopy can reliably discriminate absorbing aerosol mass under complex air pollution conditions. A multi-wavelength approach in the visible spectral region allows a source apportionment of the combustion emissions.



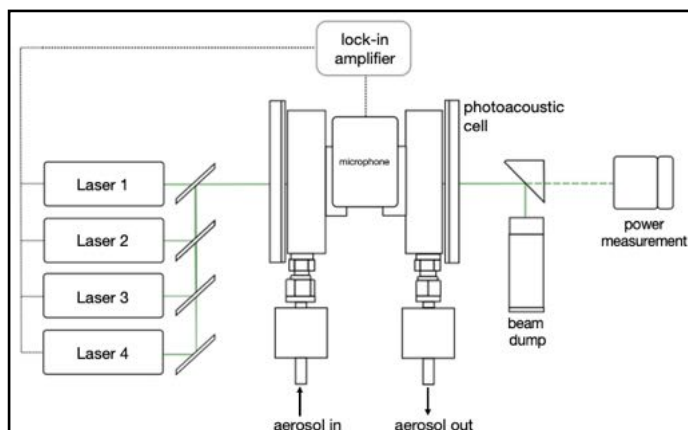
Allan variance analysis of a long-term (70h) PAAS-4λ background measurement. A custom wavelength combination of 445, 515, 638, and 785 nm was used in this measurement.

The PAAS-4λ instrument is capable to detect absorption signals well below 1 Mm<sup>-1</sup>, with a 1σ detection limit below 0.5 Mm<sup>-1</sup> for a typical averaging period of 60 s (dashed lines).

Ambient aerosol measurements conducted at a suburban site in southwestern Germany during a winter period. The median absorption Angström exponent is 1.53, which indicates contributions from brown carbon (most likely from residential wood burning).



## 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 3150 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<sub>2</sub>/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

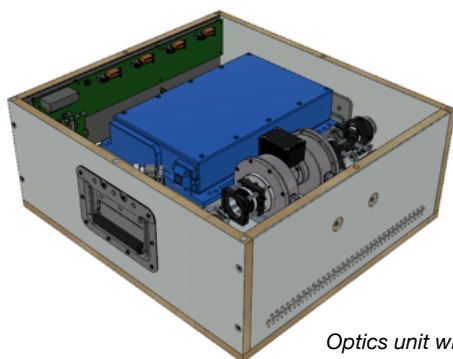
<b>Concept</b>	Specific measurement of the aerosol absorption coefficient of PM <sub>2.5</sub> aerosol in a single photoacoustic cell at multiple wavelengths
<b>Detection limit</b>	0.5 Mm <sup>-1</sup> (approx. 0.05 µg m <sup>-3</sup> Black Carbon)
<b>Accuracy &amp; Precision</b>	5% and 3%
<b>Laser Beam</b>	Up to four wavelengths efficiently combined to a 0.7 mm (1/e <sup>2</sup> ) collimated beam
<b>Available Laser Wavelengths</b>	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
<b>Laser Power</b>	100 - 300 mW (cw) digitally modulated with 50% duty cycle*
<b>Acoustic resonator</b>	Compact stainless steel cylindrical cavity with a fundamental acoustic frequency of 3150 Hz
<b>Sample Flow Rate</b>	0.5 - 2.0 LPM
<b>Cell volume</b>	236 cm <sup>3</sup> (including acoustic buffer volumes)
<b>Time resolution</b>	1 s sampling rate. Typical averaging time per wavelength: 60 s
<b>Control Unit</b>	Dual core (667 MHz) real time embedded controller
<b>Instrument Computer</b>	2.0 GHz CPU, 4 GB RAM, 120 GB SSD Panel PC with 8" touch screen
<b>Software</b>	Graphical data acquisition software. SQL database storage for long-term monitoring
<b>Power requirements</b>	220 VAC / 110 VAC
<b>Power Consumption</b>	180 W typical
<b>Physical Dimensions</b>	Optics Unit: 462 mm x 422 mm x 210 mm Electronics Unit: 496 mm x 449 mm x 310 mm
<b>Weight</b>	Optics Unit: 27 kg Electronics Unit: 17 kg

\*Laser power depends on requested wavelength

**Specifications is subject to change without notice**

## Setup

The PAAS-4λ consists of an optics and an electronics unit that are prepared for 19" rack integration or desktop installation.



Optics unit with housing

### Optics Unit

- Aluminum base plate that carries 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

### 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