Announcing...

The new Photoacoustic Extinctiometer (PAX) is a sensitive, high-resolution, fast-response instrument for measuring aerosol optical properties relevant for climate change and carbon particle sensing. The instrument directly measures in-situ light absorption and scattering of aerosol particles, from which it derives extinction, single scattering albedo and black carbon (soot) mass concentration. With no filter collection required, and consequently no filter-media artifacts, the PAX provides a highly accurate measure of absorption from black carbon.

Advantages
- Direct in-situ measurement of light absorption and scattering in a single instrument
- Absorption measurement correlates to black carbon mass concentration
- Reciprocal nephelometry provides excellent scattering coefficient sensitivity
- Choice of wavelengths: 870 nm (standard); optional 405 nm, 532 nm or 781 nm
- Fast response, one-second resolution, real-time data display
- Wide dynamic range suitable for pristine regions to source sampling
- Continuous and autonomous operation
- High-resolution touch screen display for real-time data and instrument status
- No filter collection required - no filter data artifacts

Applications
- Air quality and visibility
- Atmosphere and climate
- Health effects
- Combustion source emissions
- Biomass burning
Suitable for fixed site, mobile or airborne sampling
How the Instrument Operates

The PAX uses a modulated diode laser to simultaneously measure light scattering and absorption. The standard 870-nm wavelength has strong sensitivity to black carbon particles, and relatively little absorption from gases and other aerosol species.

PAX laser wavelength options:
- Red (870 or 781 nm) – absorption is highly specific for black carbon (soot) particles; scattering best for large particles
- Green (532 nm) – measures in the visual range, typically what the human eye observes
- Blue (405 nm) – absorption correlates to the organic, or brown carbon content; efficient scattering for fine and ultrafine particles

A 1 L/min aerosol sample flow is drawn into the PAX using an internal vacuum pump controlled by a critical orifice. The flow is split between the nephelometer and photoacoustic resonator for simultaneous measurement of light scattering and absorption.

The absorption measurement uses in-situ photoacoustic technology. A laser beam directed through the aerosol stream is modulated at the resonant frequency of the acoustical resonator. Absorbing particles heat up and quickly transfer heat to the surrounding air. The periodic heating produces pressure waves that can be detected with a sensitive microphone. An integral speaker is used to determine the resonator quality factor and resonance frequency, which are needed to quantitatively determine aerosol light absorption. Phase-sensitive detection is used for all sensors.

The PAX uses a wide-angle integrating reciprocal nephelometer to measure the light scattering coefficient. The scattering measurement responds to all particle types regardless of chemical makeup, mixing state, or morphology.

What are Scattering, Absorption, Extinction and Single Scattering Albedo?

The scattering coefficient is a measure of the efficiency of particles to scatter light photons, while the absorption coefficient is a measure of how many photons are absorbed. The coefficients are expressed as a number proportional to the amount of photons scattered or absorbed per unit distance.

The extinction coefficient is the sum of the scattering and absorption coefficients and in climate models is used to help determine the amount of solar radiation that is blocked from reaching the surface of the earth.

Single scattering albedo (SSA) is a measure of the reflectivity of a particle and is a key optical characteristic in assessing the radiative effects of aerosols. SSA is the dimensionless ratio of the scattering relative to extinction. Albedo is one for a perfectly white object and zero for a perfectly black object. SSA helps determine whether aerosols have a heating or cooling effect on climate in their interaction with solar radiation.

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PAX Software

The PAX is controlled by fully-integrated software that presents an intuitive user interface via either the front-panel touch-screen or a web browser on any networked computer. This interface provides real-time display of measured and calculated data and instrument status, and allows the configuration of the instrument’s operating parameters. Access to this interface by web-browser is password-protected and allows full instrument operation and configuration from remote locations.

Data is written to an easy-to-read ASCII file. An external program which can be run on a network-connected computer can be used to download, archive, and display these data files. This program can also upload calibration information to the PAX and perform other maintenance functions.

Specifications

<table>
<thead>
<tr>
<th>Measured Parameters</th>
<th>Absorption coefficient, $B_{abs}$</th>
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</thead>
<tbody>
<tr>
<td>Scattering coefficient, $B_{scat}$</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Parameters</td>
<td>Temperature</td>
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<tr>
<td></td>
<td>Pressure</td>
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<td></td>
<td>Relative Humidity</td>
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<tr>
<td>Derived Parameters</td>
<td>Extinction coefficient, $B_{ext}$</td>
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<td></td>
<td>Single scattering albedo, SSA</td>
</tr>
<tr>
<td>Measurement Range – Absorption and Scattering</td>
<td>&lt; 1 Mm$^{-1}$ - 100,000 Mm$^{-1}$ (870 nm, 60 sec. averaging)</td>
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<tr>
<td>Laser</td>
<td>870 nm (2 W)</td>
</tr>
<tr>
<td>Modulation Frequency</td>
<td>1500 Hz nominal, square wave</td>
</tr>
<tr>
<td>Angular Integration for Scattering</td>
<td>5 to 175°</td>
</tr>
<tr>
<td>Sample Flow</td>
<td>1 L/min</td>
</tr>
<tr>
<td>Flow Control Pump</td>
<td>Critical orifice Diaphragm</td>
</tr>
<tr>
<td>Response Time</td>
<td>&lt; 10 sec; one second resolution</td>
</tr>
<tr>
<td>Data Averaging Time</td>
<td>1, 10 or 60 seconds; user selectable</td>
</tr>
<tr>
<td>Calibration Particles</td>
<td>Strongly absorbing particles such as black smoke from a fuel-rich gas lamp, or glassy black carbon.</td>
</tr>
<tr>
<td>Absorption</td>
<td>Strongly scattering particles such as ammonium sulfate, or polystyrene latex (PSL) spheres, 200-260 nm diameter.</td>
</tr>
<tr>
<td>Scattering</td>
<td>Recommend every 2-3 months, or before a critical project.</td>
</tr>
<tr>
<td>Calibration Interval</td>
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</tbody>
</table>
### Zero Check and Acoustic Calibration
On demand, or automated at user selectable interval at 5, 15, 20, 30, or 60 minutes. Zero check with high-efficiency filtered air sample; acoustic calibration for resonance frequency and resonator quality factor.

### Maintenance Schedule
Recommended monthly for ambient air sampling. High concentration source sampling may require more frequent maintenance. Recommended annual cleaning and calibration at DMT service facility.

### Front Panel Features
Graphical color touch-panel display screen, two USB-A ports, Ethernet port, power switch; user interface via touch screen or standard keyboard and mouse.

### Rear Panel Connections
Sample inlet (¼ in. Swagelok® connector), pump exhaust (¼ in. Swagelok® connector), power, Ethernet port, two analog BNC inputs, four analog BNC outputs.

### Communications Output
Ethernet 100/10 Mbps

### Power Requirements
110/120/220/240 V, 50-60 Hz

### Dimensions, HWD
18 x 48 x 61 cm (7 x 19 x 24 inches); rack mountable

### Weight
18 kg (40 lb)

### Environmental Operating Conditions:
- Temp: 0 – 40°C (32 – 104°F)
- RH: 0 – 95% RH non-condensing

### PAX Software (included)
Executable program written in LabVIEW; external software package for instrument maintenance, data playback and archiving. Computer and software are not required to operate the instrument.

### Computer Requirements for PAX Software (computer not included)
Windows XP, Vista, or Windows 7
Minimum 1GB RAM

Specifications are subject to change without notice. Swagelok® is a registered trademark of the Swagelok Corporation. The PAX is a Class 1 Laser Product.

**How to Order**
The Photocoustic Extinctiometer (PAX) System includes analytical spectrometer with internal data storage, data playback and archiving software, operator manual, hard-body shipping case, and one-year warranty. The standard version features an 870 nm wavelength laser; wavelengths of 405, 532 or 781 nm are also available.

Contact Enviro Technology for pricing or more information: +44 (0) 1453 733200 sales@et.co.uk.