CAMBUSTION CPMA Mk2

Centrifugal Particle Mass Analyzer Mk 2

Re-engineered for 2020

Bench-top self-contained instrument for classification of *positively or negatively* charged aerosol particles by mass : charge ratio

An aerosol particle mass standard for instrument calibration

Determination of particle density and morphology

High particle throughput at high resolution due to unique design

Introduction

The Cambustion Centrifugal Particle Mass Analyzer (CPMA, Olfert and Collings, 2005) is an aerosol classifier which selects particles according to their mass : charge ratio. It produces a monodisperse aerosol based on a mass metric, compared with a DMA which uses an electrical mobility metric.

The CPMA uses opposing electrical and centrifugal force fields to classify aerosol particles, a concept first developed by Ehara *et al.* (J. Aerosol Sci. 1996) as the Aerosol Particle Mass Analyzer (APM).

However, the CPMA's unique design ensures that the classification field is stable across the classification zone, thereby ensuring a high throughput of particles at the selected mass : charge ratio, even at high resolution.

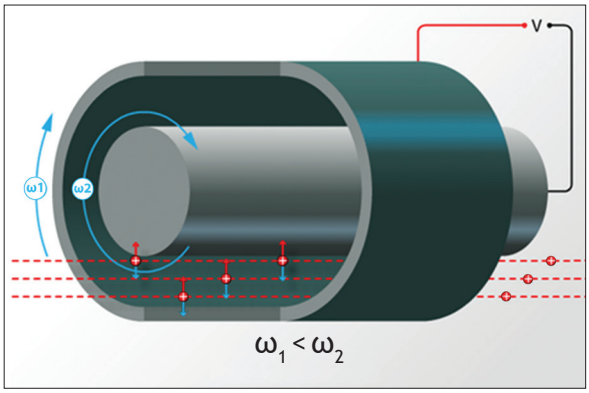
Commercially available since 2012, the CPMA Mk 1 is well established in aerosol research and metrology labs around the world. Now in 2020 we introduce the CPMA Mk 2.

New features

- Classifies positive or negative particles (switchable)
- Re-engineered to be lighter but with the same high resolution classifier as the Mk 1
- All stainless-steel inlet and outlet with lower associated losses
- Larger 5.7" touchscreen
- Auto drive-belt tensioning
- Additional serial port and a native USB port for PC connectivity
- Direct interface with the DMT SP2 for black carbon studies
- Lid seal leak detection
- Supports the digital version of the optional aerosol flowmeter

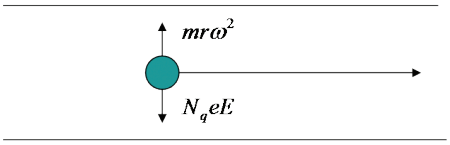
Operating Principle

The CPMA's classifier consists of two concentric rotating cylinders, with a variable potential difference between them. Particles which have a higher mass : charge ratio than that selected precipitate on the outer cylinder. Particles which have a lower



mass:charge ratio than that selected precipitate on the inner cylinder. Particles which have the selected mass:charge ratio follow a trajectory through the classifier.

Crucially and uniquely to the CPMA, the cylinders are rotated at slightly different speeds. If the cylinders rotated at the same

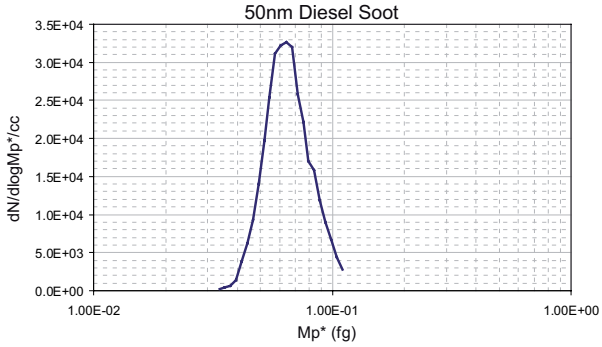


$$\frac{m}{N_q} = \frac{eV}{r^2\omega^2 \ln\left\{r_o / r_i\right\}}$$

speed, only particles of the correct mass which also enter along the central trajectory would emerge.

The difference in rotation speed sets up a *stable* centrifugal/electric field across the classification region. A particle of the correct mass:charge ratio will therefore transit the classifier if it enters at any point along the annular radius. This reduces particle losses in the CPMA, even at high resolution.

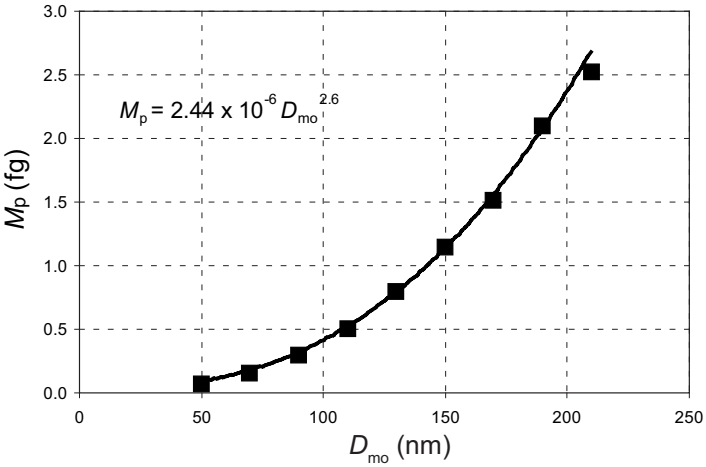
The CPMA is a fundamental standard for particle mass — provided particles are singly charged, the mass setpoint depends on just the set speed and voltage, and the physical dimensions of the classifier (optional traceable gauging certificate available). Unlike a DMA, the setpoint does not depend upon the gas properties (such as viscosity and mean free path) or ambient conditions (temperature and pressure), and furthermore is not



affected by particle morphology.

Applications

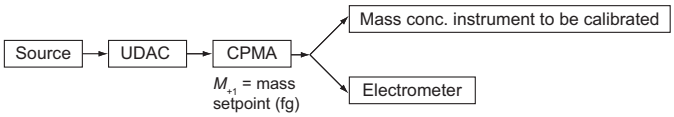
Monodisperse aerosol selection



With the addition of a neutralizer (or charger), the CPMA may be used as an alternative to a DMA to select a monodisperse aerosol — with high resolution.

Mass spectral density scan

Add a particle counter (e.g. a CPC or aerosol electrometer), and the mass spectral density may be step-scanned (offline multiple charge correction is required).



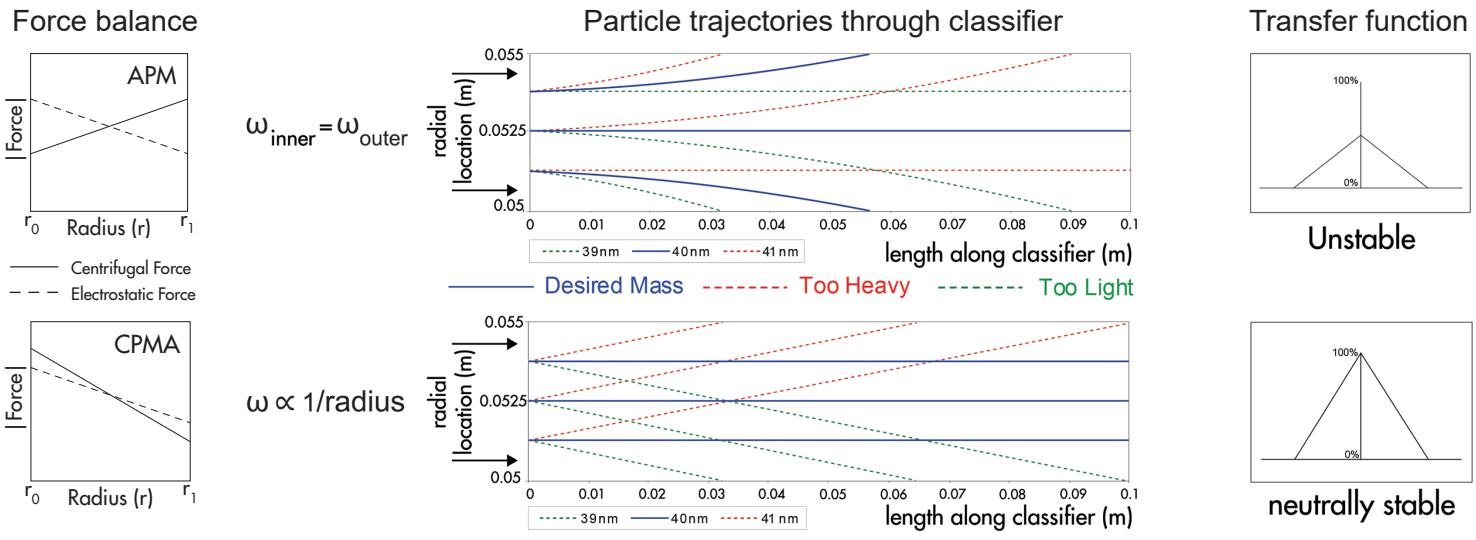
m_{total} = mass ***setpoint*** × indicated electrometer ***concentration*** + zero charge correction

Density and morphology determination

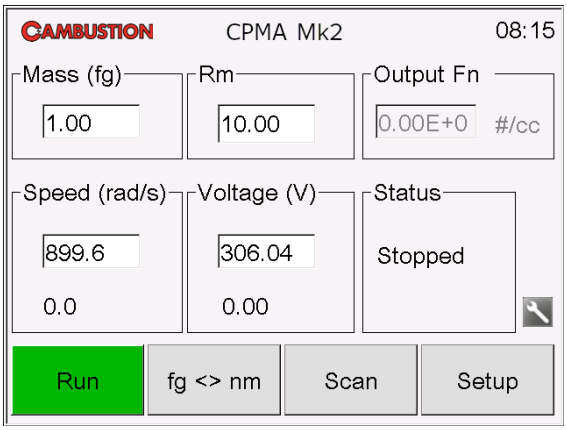
In conjunction with a DMA, it may be used to determine the relationship between size and mass for an aerosol (fractal dimension), thus giving information about particle morphology [e.g. Olfert, Symonds & Collings, 2006]:

As a calibration standard

The CPMA may be used as a calibration standard for other instruments such as aerosol mass spectrometers or black carbon

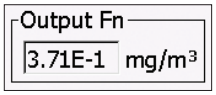


detectors [e.g. Cross *et al.*, 2010]. In combination with a unipolar



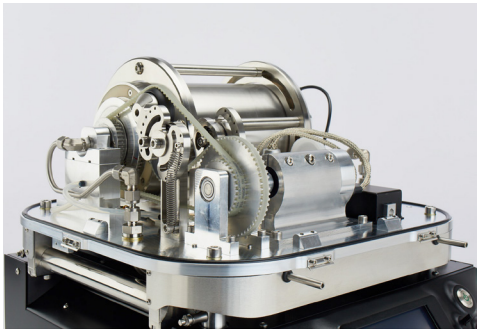
charger (e.g. Cambustion UDAC) and an aerosol electrometer, it may be used as a suspended mass standard [Symonds *et al.*, 2013]:

Using this arrangement, a source of particles of accurately known mass concentration can be generated for instrument calibration. The screen can directly give a mg/m^3 output when combined with an electrometer:

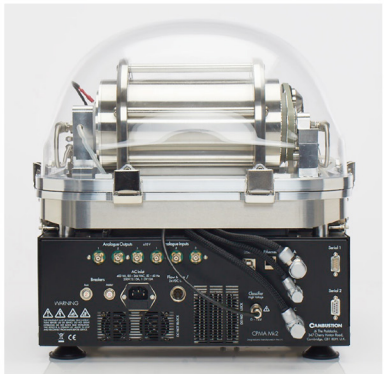


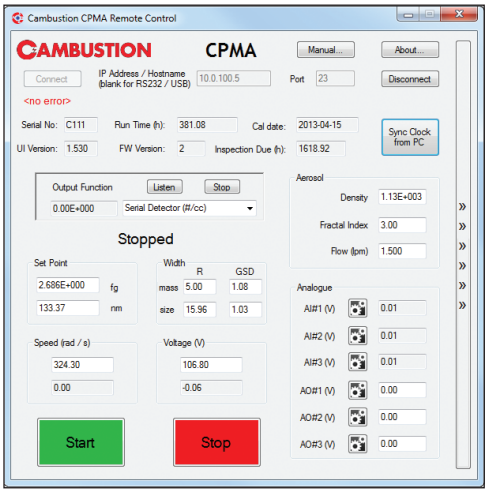
Software

The CPMA is a self-contained bench-top instrument with touch-screen interface. As with most commercial DMAs, the user can directly enter the desired setpoint (in mass or size metrics) and resolution, and the instrument is automatically controlled to give those settings. If a density is supplied, it is simple to switch between mass and size metrics.



Step-scanning can be performed directly from the instrument, with data being saved to a (supplied) USB flash memory drive.





The CPMA can scan the voltage alone, or both voltage and speed simultaneously which maintains a constant resolution over the scan. The sophisticated motor controller allows both fast acceleration and deceleration of the classifier.

The CPMA is also supplied with PC software including a remote control application, Excel tools for plotting data, and an Application Programming Interface library which allows control of the CPMA from your own programs. An example Excel/VBA project is included to allow automated mass-mobility exponent determination by controlling the CPMA, and a DMA (via an analogue output of the CPMA), with the data automatically scanned into an Excel workbook. The CPMA front panel interface can also be viewed and controlled via a web browser on a device connected to the same network. A remote file access facility allows data files to be accessed via a web browser.

Advantages

- Reduced particle loss at high resolution due to unique cylinder speed differential
- Stand-alone bench-top instrument with fully integrated touch screen interface, and built-in scan facility
- Simultaneous scanning of speed and voltage for maintenance of a fixed resolution over a scan (or fixed speed scan for increased scan speed)
- Direct entry of mass and resolution; automatic calculation of required speed and voltage
- Sophisticated remote control options, including integration with Excel and user programs; powerful Application Programming Interface
- Highly configurable analogue inputs and outputs
- A direct interface with particle detectors (serial and analogue interfaces); preset for many common CPCs & electrometers
- High particle flow possible for use with electrometer and for particle supply to other analyzers
- Auto-switching dual-range voltage source

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Integration with other aerosol equipment (not supplied)

Particle Charger or Neutralizer

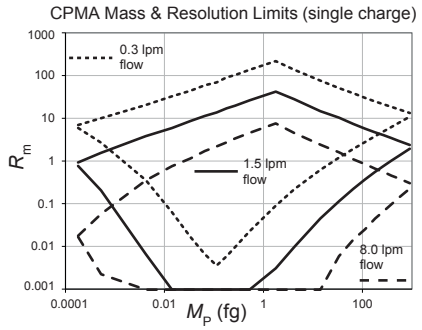
Bipolar or unipolar (depending on application); radioactive, X-Ray or corona.

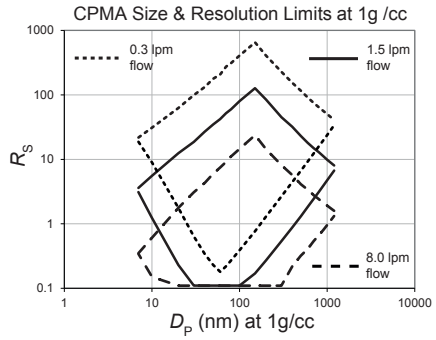
Particle Detector(s) (e.g. CPC or electrometer)

The CPMA can interface with any detector with an analogue output connection, or to most detectors with an RS232 interface. Current serial communications presets include: Aerosol Devices MAGIC CPC, Airmodus A20 CPCs, Brechtel 1720, DMT SP2, Grimm CPCs, Palas UF CPCs, TSI 30xx and 37xx series CPCs (inc. water based CPCs), Keithley 651x electrometers and TSI 3068B aerosol electrometers.

Differential Mobility Analyzer (for density measurements)

It is also possible to use the CPMA with the Cambustion DMS500 fast particle sizer.





Aerosol Flowmeter Accessory

Cambustion produces an optional digital aerosol flowmeter accessory for the CPMA for measuring the sample flow using an orifice plate, to maintain a constant resolution under dynamic conditions. The accessory interfaces directly with (and is powered by) the CPMA, and is fully integrated with the software.

Specifications

The absolute limits on the operation range of the CPMA are within the bounds on the diamond shaped areas below, depending on the sample flow:

$$\text{where : } R_m = \text{mass resolution} = \Delta M_{p,FWHM} / M_p^*$$

$$R_s = \text{size resolution} = \Delta D_{p,FWHM} / D_p^*$$

Mass range	0.2 ag* – 1,050 fg (depending on sample flow and desired resolution)
Equivalent diameter range at unit density	7 nm* – 1.3 µm (depending on sample flow and desired resolution)
Rotational speed	500 – 12,000 rpm
Voltage range	±0.1 – ±1,000 V
Classifier dimensions	200 mm × 120 mm (1 mm gap) optional traceable gauging certificate available
Sample flow	Recommended 1.5 lpm (down to ~0.3 lpm with increased diffusion loss, up to ~8 lpm with decreased resolution)
Detector input (e.g. for CPC — detector not supplied)	RS232 (×2) or analogue (×2) See above for list of detectors which are known to be digitally compatible.
Remote external PC interface	USB, Ethernet or RS232 Control via web interface, text commands (terminal) or via PC remote application (or user software via API). Remote file access.
Analogue inputs	× 3; ±10 V, 20 kΩ, single ended, configurable for control of any parameter, detector input or data logging
Analogue outputs	× 3; ±10 V, 50 Ω, single ended, output of any parameter, control of DMA voltage
Mass accuracy	5% or better (across the whole size range)
Ambient sensors	Temperature and Pressure
Ambient conditions	5 – 40 °C non-condensing humidity
Data storage	USB flash drive (supplied)
Motor controller	4-quadrant type with active braking
Auxiliary power port	24 VDC, 0.6 A max
Software supplied	Integrated 5.7” touchscreen interface Remote control application API dll for user programs Excel Utility and VBA API
Overall Dimensions & Weight	461 mm w × 546 d × 445 h (inc. feet / handles). 42 kg
Power requirements	90 – 240 VAC, 50/60 Hz, 1,000 W maximum
Safety features	Guards, full interlocks, overcurrent / short circuit detection & imbalance detection, to BS EN 61010-020:2006

*Note that, as with all particle instrumentation, at smaller particle sizes some diffusion loss is inevitable.

Reference list

A full list of publications which make use of the CPMA can be found at: **www.cambustion.com/publications/cpma**

For more information, a quotation or to see an animation of the CPMA, please visit or contact:

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