The optics- chemistry link of dark matter; investigating mass absorption cross sections of soot particles from two combustion sources

Benjamin Brem[1], Miriam Elser[1], Michael Arndt[2], Andrea Fischer[1],Lukas Durdina[1], David Schönenberger[1]

[1]Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland [2]AVL List GmbH, Graz Austria

Context

- "Soot" is a weakly defined term for particulate matter that mainly consists of elemental and organic carbon (EC, OC)
- Soot is not created equal; its intrinsic and extrinsic properties are affected by the type of combustion source and process
- The grade of carbon graphitization, *i.e.* sp2 bonds, results in a mass specific optical absorption coefficient (MAC, $m^2\ g^{-1}$)
- The MAC is one key property for predicting the climate forcing of soot and is essential in the standardized calibration of real time instrumentation (*i.e.* photo acoustic (PAS) types)
- The quasi-standard for determining the EC mass is the thermal-optical transmittance (TOT) method
- For the accurate real-time determination of soot mass the variability of MAC values referenced to the TOT EC mass needs to be understood

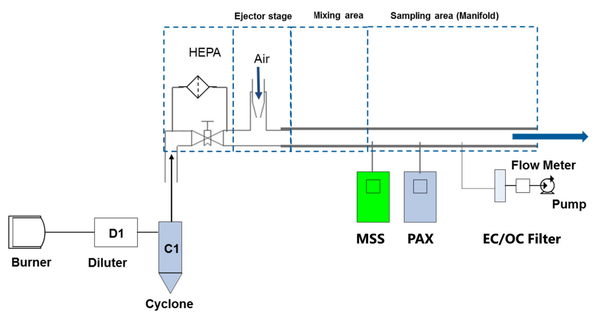
Objective

- Investigate the variability of MAC values referenced to TOT EC mass for soot generated by a diffusion flame burner and an aircraft engine

Methods

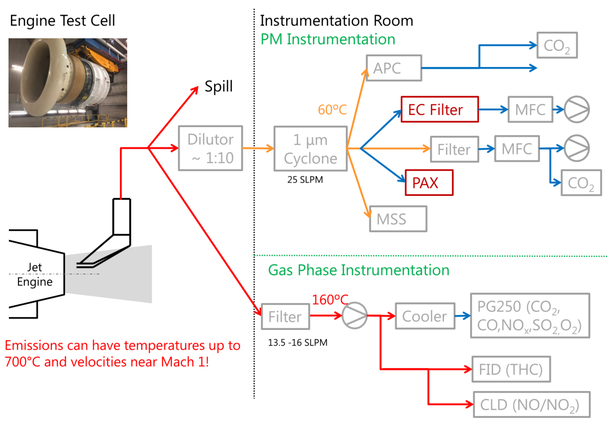
Diffusion Flame Experiments

- Soot source: Matter CAST
- EC content > 80%
- Soot concentration set with a dilution bridge and ejector dilutor
- Setup has calibrated over 2000 AVL Micro Soot Sensor (MSS) units



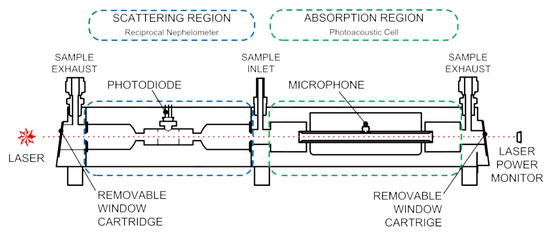
Aircraft Engine Experiments

- Soot source: CFM56-7B26
- Thrust settings covering the landing and take-off cycle
- Sampling system according to ICAO *Annex* 16, App. 7
- Equipment connected to the diluted "PM Line"



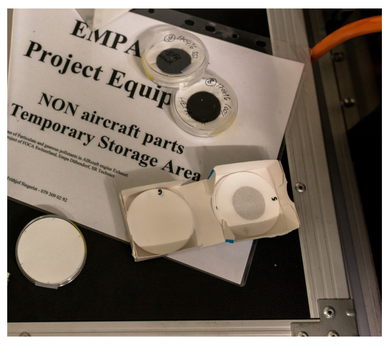
Light Absorption Coefficient

- The Photoacoustic Extinctiometer (PAX, Droplet Measurement Technologies) provided the absorption and light scattering coefficients in real-time and *in situ* at a wavelength of 870 nm



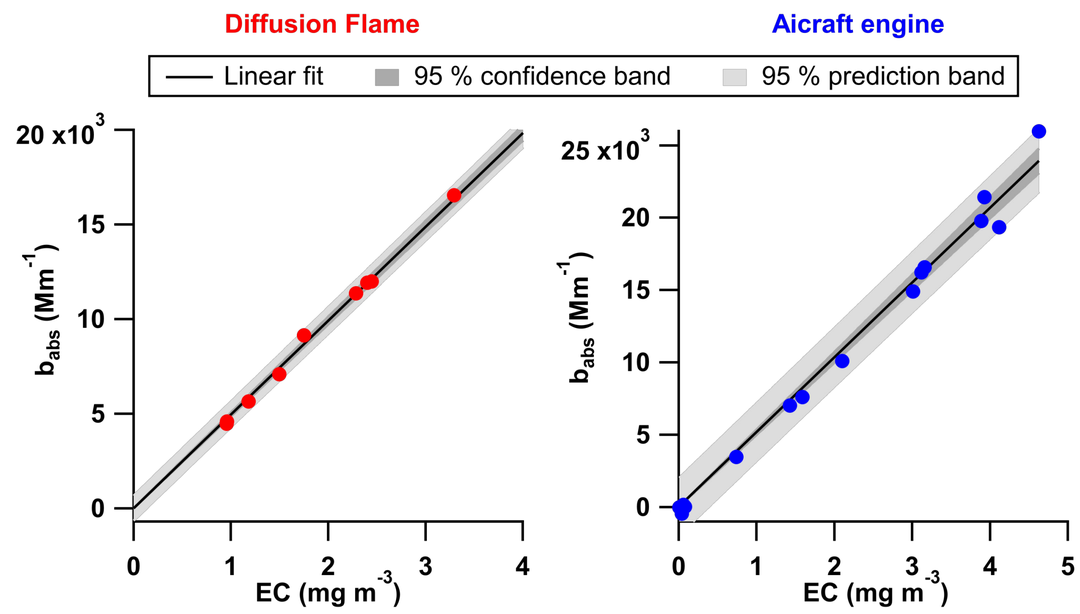
Elemental Carbon Mass

- Filter integration times of up to 1 hr. for low concentration/ engine thrust levels
- Analysis performed according to NIOSH 5040
- Manual OC/EC split at 540s was used for the aircraft filters



Results and Discussion

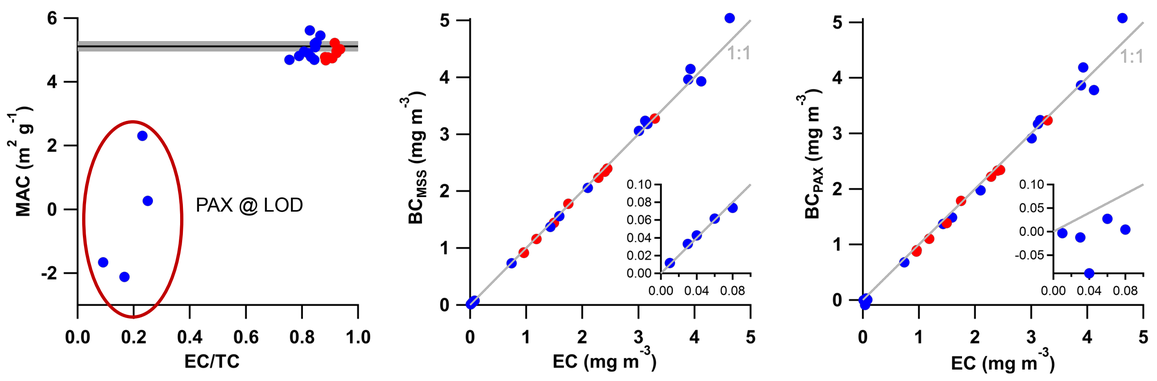
MAC values



- Very good linearity
- Difference not statistically significant
- Higher MAC value of aircraft soot might be caused by its more graphitized internal structure
- Fairly good agreement with the value from Bond et al. (2007)

Source	MAC ± SE ($m^2\ g^{-1}$)	R^2
Diffusion flame	4.96 ± 0.10	0.93
Aircraft engine	5.17 ± 0.18	0.94
All data	5.12 ± 0.13	0.93
Bond (2007)	4.74	N.A.

Influence of OC content



- Aircraft PM contains up to 90% OC at thrust levels near idle
- Low and negative MACs at high OC levels are caused by the limit of detection (LOD) of the PAX instrument and not the OC content
- The MSS shows a good agreement with EC values down to concentration levels of 10 µg m^{-3}

Conclusions and Outlook

- Diffusion flame sources can be used for calibrating real time photoacoustic soot mass instruments operating in the near IR spectrum i.e. for aircraft emission measurements
- The potential influence of OC content on MAC values (e.g. lensing effects) requires further investigation with a high resolution PAS instrument, but the influence in the near IR region is expected to be minimal
- Investigation on the radiative relevance of nascent aircraft soot particles is ongoing (See Poster 19)

References

Tami C. Bond & Robert W. Bergstrom (2007) Light Absorption by Carbonaceous Particles: An Investigative Review, *Aerosol Science and Technology*, 40:1, 27-67, DOI: 10.1080/02786820500421521 .

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benjamin.brem@empa.ch

Empa
Materials Science and Technology