Comparison of continuous-wave LII ("SP2") and pulsed-shot LII response to rBC measurement

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Keywords: SP2, LII, rBC, black carbon
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To date, two commercial approaches to Laser Induced Incandescence (LII) measurement of refractory black carbon (rBC) have been developed: the SP2 and the Auto-Compensating LII (AC-LII; "AC" refers to online corrections for fluctuations in variables such as temperature and laser power). The primary difference between the two instruments is the laser heating method, or equivalently the physical state of the heated rBC during measurement.

In the SP2 (Droplet Measurement Technologies, CO, USA), particles are introduced into a 1064 nm continuous-wave laser cavity and eventually heated to incandescence in the presence of rBC (Schwarz et al., 2006). The peak incandescence point (~4000 K), occurring before rBC sublimation, is calibrated to single-particle rBC mass using reference materials. Radiative particle cooling is not relevant for typical rBC particle sizes (Moteki and Kondo, 2010). In the AC-LII (Artium Inc., CA, USA) rBC particles are heated by a pulsed 1064 nm laser to ~3000 K (Artium Inc, 2015). The total mass of rBC in all particles residing within the optical cavity can be calculated with the resulting incandescent radiation at a single wavelength and the corresponding soot surface temperature, which is determined by two-color pyrometry. The limit of quantification of the AC-LII has recently been pushed down to atmospherically-relevant levels. The usefulness of this sensitivity has been demonstrated by Liggio et al. (2012) for on-road vehicles.

This study was motivated by the physical differences between the SP2 and AC-LII measurement processes, and the possibility of long term sampling by AC-LII; the goal was to establish the degree of consistency between the two using well-characterized samples. We therefore performed laboratory measurements of reference rBC materials (CAST soot, carbon blacks, graphitic nanoparticles) to explore the discrepancy in ambient measurement with these two instruments. These results will be discussed in reference to the High-Sensitivity mode of the AC-LII, in which the temperature of incandescing rBC is not directly measured.

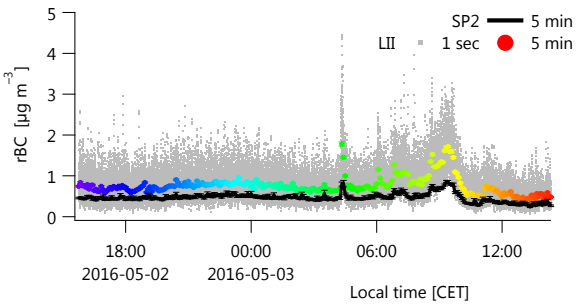

Figure 1: Time series of ambient rBC measurement.

Acknowledgements: This work was supported ERC Starting Grant "BLACARAT".

Artium Inc., CA, USA, AC-LII Manual, 2015.

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