ELS-XV-2015 Abstracts
ELS-XV-2015-40
Electromagnetic & Light Scattering XV 2015, Leipzig

Scattering Measurements Characterizing Single Aerosol Particle Environmental Response

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Understanding how aerosols evolve in ambient environments is an important factor for both improved fundamental understanding of ambient aerosol behavior, and also hazard assessment and defense development for potentially harmful materials released into the air either deliberately or accidentally. This presentation describes an experimental system that permits long-term study of aerosol particles in controlled environments. By using non-contact optical interrogation, physical and compositional changes in individual aerosol particles, can be directly measured, and the resulting data can be applied to develop and validate predictive models over a wide range of environmental conditions.

Since specific rates of evaporation, condensation and reaction will depend on particle size and composition as well as environmental conditions, our approach is to trap and maintain individual suspended particles with known initial conditions in an enclosed gas flow system for which temperature, humidity and gas phase composition can be controlled. The use of an Electrodynamic Quadrupole (EQ) field for confining a charged particle at a spatially fixed point has a very long history [e.g. Refs 1, 2]. However, all earlier configurations require an imprecise and/or time-intensive procedure for introducing and capturing a particle due to low capture efficiency, which was an impediment to high throughput analysis needed for systematic exploration of experimental parameters. Recently, we have developed and refined an electrode geometry, described as a Linear EQ (LEQ) trap, that permits relatively easy and reliable (even automated) particle introduction and capture. This capability is necessary for developing large and statistically robust databases to support model development, model validation, and ultimately broader understanding of anthropogenic aerosol fate.

The LEQ experimental arrangement provides good visibility/optical access for long-term, non-contact interrogation of trapped particles. We have so far exploited optical measurement techniques of direct imaging, elastic scattering, and visible spectral scattering to obtain information on particle size, particle composition and the dependence of differential spectral scattering on particle shape. Combining imaging with resonance elastic scatter tracking provides accurate and precise droplet size data, from which evaporation rates are determined. These experimental results are compared to computational models based on bulk properties of the particle material for a range of environmental conditions. Additionally, the spectral dependence of scattering due to the presence or absence of particle material absorption has been investigated, and the affect of highly irregular shapes on mean values of those spectral signatures has been explored. Soon, we will implement acquisition of two additional optical diagnostic methods: continuum spectral IR scatter, and Raman spectroscopy (both spontaneous and enhanced).

References

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2. J.D. Eversole and H-B. Lin, Rev. Sci. Instrum., 58, 1190 (1987); doi: 10.1063/1.1139438