PROBING STRUCTURE AND CHEMICAL PROPERTIES OF FREE-STANDING CLUSTERS WITH SYNCHROTRON RADIATION

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Despite intensive laboratory and field measurements, dating back over a century ago, molecular details of formation and growth of new atmospheric particles remain elusive. As changes in new particle formation and growth rates can affect global concentrations of cloud condensation nuclei, thus contributing to anthropogenic radiative forcing (Merikanto et al., 2009), a mechanistic understanding of these processes, including phase and surface properties of newly formed particles, is vital for reducing uncertainties in climate forecasts. Deductions based on indirect measurements have proven inconclusive (Kupiainen-Määttä et al., 2014), and recently there has been a surge towards measurements setups yielding molecular-level resolution of cluster properties.

Surfaces in particular are currently moving into the spotlight of the atmospheric science community. A suite of novel developments in methods originating from materials science now allow for highly surface sensitive chemical characterization of systems with increasing resemblance to atmospheric aerosols. Here, we present the custom-built experimental setup Multiuse Setup for Clusters Emission (MUSCLE) for producing freestanding multicomponent nanoparticles with well-defined composition, and directly characterizing their chemical, structural, and phase-state properties using synchrotron radiation based spectroscopy at the gas-phase endstation of the FinEstBeaMS beamline, MAX IV Laboratory. The unsurpassed brightness of the new MAX IV synchrotron light source has made feasible the use of powerful surface sensitive photoelectron spectroscopy techniques for samples of relatively low density, and in particular freestanding cluster beams of atmospherically relevant trace components.

MUSCLE is our next generation cluster source based on the proven basic design of the Exchange Metal Cluster (EXMEC) source (Huttula et al., 2010). Both setups generate a continuously renewed beam of neutral clusters comprising a wide range of atomic, molecular or ionic components. Using this setup, we have generated clusters of e.g. aqueous alkali halides with controlled composition (Hautala et al., 2016) and semi-volatile atmospheric organics, like stearic acid (unpublished data). With synchrotron based photoelectron spectroscopy we have e.g. observed size-dependent structural phase transitions for CsBr clusters (Hautala et al., 2016).

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[4] Hautala, L. *et al.* (2016). *Phys. Rev. B*, **95**, 45402.