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A fast integrated mobility spectrometer for rapid measurement of sub-micrometer aerosol size distribution, Part I: design and model evaluation

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Abstract

A fast integrated mobility spectrometer (FIMS) was previously developed to characterize submicron aerosol size distributions at a frequency of 1Hz and with high size resolution and counting statistics (Kulkarni & Wang, 2006a, 2006b; Olfert, Kulkarni, & Wang, 2008). However, the dynamic size range of the FIMS was limited to one decade in particle electrical mobility. It was proposed that the FIMS dynamic size range can be greatly increased by using a spatially varying electric field (J. Wang, 2009). This electric field creates regions with drastically different field strengths in the separator, such that particles of a wide diameter range can be simultaneously classified and subsequently measured. A FIMS incorporating this spatially varying electric field is developed. This paper describes the theoretical frame work and numerical simulations of the FIMS with extended dynamic size range, including the spatially varying electric field, particle trajectories, activation of separated particles in the condenser, and the transfer function, transmission efficiency, and mobility resolution. The influences of the particle Brownian motion on FIMS transfer function and mobility resolution are examined. The simulation results indicate that the FIMS incorporating the spatially varying electric field is capable of measuring aerosol size distribution from 8 to 600 nm with high time resolution. The experimental characterization of the FIMS is presented in an accompanying paper.

Keywords: Fast Integrated Mobility Spectrometer; Aerosol size distribution; High time resolution; dynamic size range; Electrical mobility; Mobility resolution.

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