Aggregate Dynamics in the Transition Regime: a two Knudsen Number Problem

Prof. Christopher J. Hogan Jr.
Department of Mechanical Engineering, University of Minnesota

The production of particles at sufficiently high concentration in the gas phase invariably leads to the formation of agglomerates/aggregates, i.e. condensed phase entities composed of spherical or near spherical primary units in contact with one another. Aggregates are frequently produced in high temperature combustion and gas phase materials synthesis reactors, hence aggregate formation, growth, and measurement has garnered considerable interest. In large part, efforts in aggregate analysis have been devoted to inference of aggregate structure, including primary particle diameter, as well as the scaling between the number of primary particles per aggregate and the aggregate radius of gyration (i.e. the fractal dimension). However, a series of experimental and theoretical studies reveal that it is not these structural properties which govern aggregate transport in aerosols including aggregate mobilities/diffusion coefficients, ion attachment (charging) rates, and aggregate-aggregate collision rates. On the contrary, aggregate transport properties are determined by appropriately defined aggregate continuum radii and projected areas, which are measures of overall aggregate architecture. In this talk, an overview of the transport properties of aggregates in aerosols will be provided, including specific methods to calculate aggregate mobilities and collision rates at all background gas temperatures and pressures. These methods are based upon a series of Monte Carlo and Brownian Dynamics calculations, and experimental evidence supporting use of the developed equations will be provided. Emphasized in the presented methods will be the need to consider two Knudsen numbers in quantifying aggregate transport; the traditional Knudsen number, which governs aggregate mobility, and the diffusive Knudsen number, the parameter governing aggregate-ion and aggregate-aggregate collisions.