Supersonic Beams at High Particle Densities

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Chemical Physics beyond the Ideal Gas Approximation

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Supersonic molecular beams continue to constitute a versatile and popular tool in science and technology. In physical chemistry, jet expansions from dense gases are routinely used to grow clusters and nanoparticles. Surprisingly, the real gas behavior of those jet expansions has not been studied in much detail. Until now, supersonic beams are mostly treated in the ideal gas approximation, where particle associations and cluster formation are completely ignored. Attempting to improve this situation we investigate — both experimentally and theoretically — the influence of source pressure, temperature, and aggregation state on cluster size and beam velocity. We present a facile yet consistent approach that is capable to predict experimental flow velocities even at the liquid-vapor phase boundary and the critical point. In addition, the model is capable to explain the bifurcation of beam velocities with a condensation within the expansion nozzle. The calculations are complemented by an extensive set of experimental data on CO_2, C_2H_4, and C_3H_8, exhibiting surprising results in the close vicinity of the critical point.