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Numerical Simulation of Particle-Laden Underexpanded Jets[1]

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Numerical simulations of inertial particles in underexpanded jets are performed to isolate gas phase compressibility effects on particle velocity statistics. High-speed compressible particle-laden flows can be observed in a number of practical applications, from the interaction of rocket exhaust plumes with planetary and lunar surfaces to coal dust explosions. Unlike low-speed gas-solid flows where unsteady forces acting on particles can be neglected due to the large density ratio, in the high-speed flows considered here such forces can have order-one effects due to large relative acceleration between the phases. The focus of present work is to assess the ability of existing drag laws to reproduce velocity statistics in a three dimensional Eulerian-Lagrangian framework. The gas-phase equations are solved using a class of high-order, energy-stable finite difference operators, and a nozzle geometry is modeled using a ghost-point/direct-forcing immersed boundary method. We also present effects of two-way coupling on the structure of the jet. Results are compared with experiments performed at Johns Hopkins University. Further details on the experiments can be found in our companion presentation, "Experimental Investigation of Two-Way Coupling in Particle-Laden Compressible Flows".

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