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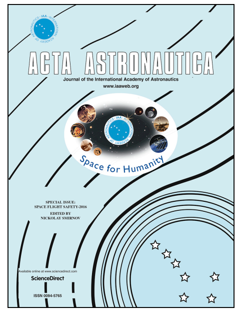

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Numerical Simulation of Liquid Droplet Breakup in Supersonic Flows

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Abstract: A five-equation model based on finite-difference frame was utilized to simulate liquid droplet breakup in supersonic flows. To enhance the interface-capturing quality, an anti-diffusion method was introduced as a correction of volume-fraction after each step of calculation to sharpen the interface. The robustness was guaranteed by the hybrid variable reconstruction in which the second-order and high-order method were respectively employed in discontinuous and continuous flow fields. According to the recent classification of droplet breakup regimes, the simulations lay in the shear induced entrainment regime. Comparing to the momentum of the high-speed air flows, surface tension and viscid force were negligible in both two-dimensional and three-dimensional simulations. The inflow conditions were set as Mach 1.2, 1.5 and 1.8 to reach different dynamic pressure with the liquid to gas density ratio being 1000 initially. According to the results of simulations, the breakup process was divided into three stages which were analyzed in details with the consideration of interactions between gas and liquid. The shear between the high-speed gas flow and the liquid droplet was found to be the sources of surface instabilities on windward, while the instabilities on the leeward side were originated by vortices. Movement of the liquid mass center was studied, and the unsteady acceleration was observed. In addition, the characteristic breakup time was around 1.0 based on the criterion of either droplet thickness or liquid volume fraction.

Keywords: five-equation model; liquid droplet breakup; supersonic flow; two-phase compressible flow