LATTICE BOLTZMANN METHOD FOR SPACECRAFT PROPELLANT SLOSH SIMULATION

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A scalable computational approach to the simulation of propellant tank sloshing dynamics in microgravity is presented. In this work, we use the lattice Boltzmann equation (LBE) to approximate the behavior of two-phase, single-component isothermal flows at very low Bond numbers. Through the use of a non-ideal gas equation of state and a modified multiple relaxation time (MRT) collision operator, the proposed method can simulate thermodynamically consistent phase transitions at temperatures and density ratios consistent with typical spacecraft cryogenic propellants, for example, liquid oxygen. Determination of the tank forces and moments is based upon a novel approach that relies on the global momentum conservation of the closed fluid domain, and a parametric wall wetting model allows tuning of the free surface contact angle. Development of the interface is implicit and no interface tracking approach is required. A numerical example illustrates the method's application to prediction of bulk fluid behavior during a spacecraft ullage settling maneuver.

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