AM5545 Introduction to Multiphase flows

Assignment – 04

Note: Use of Chat GPT and Other AI tools are not just permissible but encouraged!

[Due Date: 06/11/2025 EOD]

Problem Description

A cubic domain of side length L contains $N = 1000$ liquid droplets. Initially the droplet radii are all identical, R (monodisperse). The initial positions of the droplets are assigned randomly without any overlap, and periodic boundary conditions are applied in all three spatial directions.

Each droplet is initialized with a velocity sampled from a zero-mean distribution such that the ensemble-average velocity of the system is zero. The droplets move inside the domain and undergo binary collisions. The collision outcomes follow hydrodynamic interaction rules based on the Weber number (We) and the impact geometry.

Evaporation and mass loss are neglected for this study. After collision, a pair of droplets may undergo coalescence, bouncing or separation. Ensure that momentum is conserved in each collision.

A simplified collision-outcome nomogram is provided to determine the post-collision behavior based on the pair Weber number(We) and the impact parameter(B), Where $B = 2b/(D1 + D2)$, ($D1$ and $D2$ are the diameters of small and large droplets and b is defined as the projection of the two liquid droplets' centerline perpendicular to the relative velocity). The system is simulated until a statistically steady state is achieved. The final objective is to report the following,

1. Starting from 1, vary the variance by factor of 10 and 100 of the velocity distribution and explore the effect.

2. Do the initial condition have an effect?

3. In all cases, plot the final (steady-state) drop size distribution.

For higher Weber numbers, distinct droplet collision regimes—including reflective separation, stretching separation, finger-type breakup, and splashing—can be observed. The regime boundaries and transitions may be referred from the regime chart provided in the attached research paper.

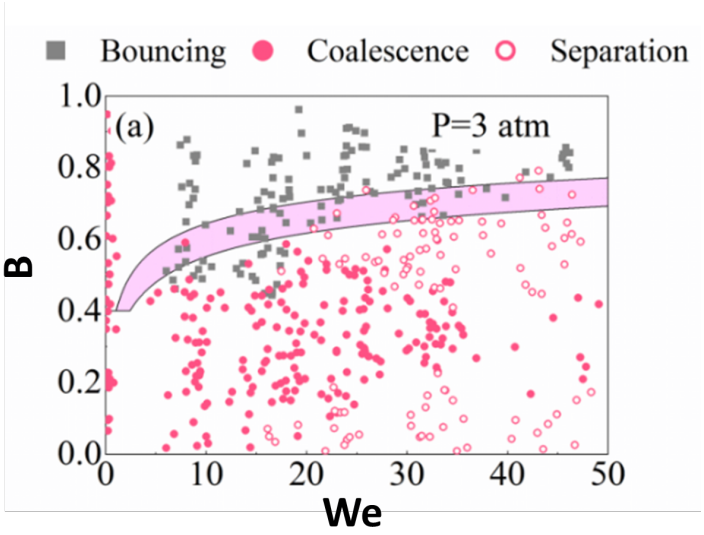

Figure 1: $We - B$ Nomogram of droplet collision