Simulation of Multiphase Flows through Kinetic Approach

The Lattice Boltzmann Method (LBM) introduced at the turn of 1980s has recently become an alternative numerical technique to solve fluid dynamic problems. In the computational approach, this method consists of a first order upwind discretization of the lattice Boltzmann equation on a square lattice spacing. In order to solve the macroscopic fluid dynamics through a microscopic kinetic approach, trying to mathematically describe movements and interactions of the small particles that constitute the flow, a regular lattice is defined and the velocity space is drastically reduced to only a few discrete points by assuming that at each site the particles can only move along a finite number of directions. By this approximation it is possible to evaluate the macroscopic variables knowing the mesoscopic characteristics of the fluid in the directions defined by the specific problem.

Moreover, due to the intrinsic simplicity of the model, a large number of multiphase models have developed in order to simulate the complex phenomena, which occur at the interface between two or more phases. One of the most used is the Shan-Chen one, which models an interaction potential in a simple way but it introduces some numerical issues which lead to the generation of some artificial velocities around the interface, commonly known as spurious currents. This is the reason why many models try to avoid this numerical artefact. Between them, one of the most appealing ones in terms of density ratio and reduction of unwanted velocities seems to be the model developed by T. Lee (City College University of New York).

The aim of this talk is to deeply analyze which are the capabilities of this model. The test case chosen are the primary and secondary break-up (liquid jet and droplet respectively). Both the applications will be compared with some data available in the literature. However, before studying these test-cases a direct comparison of the implemented method with the Shan-Chen one will be carried out in order to point out which are the big advantages in using it.

In the last section some possible developments will be presented in order to point out where the main issues should be addressed. One of the possible ways of development is the extension of the model to an axisymmetric formulation in order to reduce drastically the computational time required by the three-dimensional simulations. Another important way of development is for sure the implementation of a multi-relaxation-time method which could give significant improvements in terms of stability.