Unconditionally Stable Explicit CFD Scheme Based on Boltzmann Equation: the Cell-Boltzmann Method

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We propose a new class of time explicit CFD scheme, which is not restricted by the CFL condition. Space is divided into cells, which is filled by gas molecules having Maxwellian velocity distribution at each time step t^n. These molecules fly freely without collisions for Δt, and they relax into a new local thermodynamic equilibrium state at a new time t^{n+1}. We effectively solve the Boltzmann equation, rather than hydrodynamic equations to simulate continuum flow, by setting the mean free time of molecular particles to Δt. We term the scheme the Cell-Boltzmann method (CB). The time step in the CB is not restricted by the CFL condition. Only a penalty using a time step longer than the CFL time is a gradual degrading of a solution. The CB scheme is very robust and can handle flow with infinitely large Mach number. We show numerical examples of shock tube problems and Sjoegreen problems.