INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Lattice Boltzmann Simulation of Fluid Flows with Special Emphasis on Nanofluid Flow through Porous Structures: Development and Applications

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SHORT ABSTRACT

This thesis is concerned with the lattice-Boltzmann simulation of various fluid flow and heat transfer problems. The initial work of the thesis concentrates on developing Fortran codes based on single-phase, single-relaxation-time (SRT) and multiple-relaxation-time (MRT) lattice Boltzmann methods. The comparative study between MRT- and SRT-based LBM indicates that for most cases both the models provide comparable solutions for laminar flow regimes. However, the prime objective of the present thesis is to understand the heat transfer and flow behaviour of nanofluid, where nano-sized particles are suspended in a base fluid. In this regard, a new multiple-relaxation-time (MRT) based two-phase thermal lattice Boltzmann method is developed for a nanofluid flow which is the extension of a previously established single-relaxation-time (SRT) based two-phase lattice Boltzmann model. The two-phase model provides better insights into nanofluid flow than single-phase model, as it treats the base fluid and nanoparticles separately while considering different slip velocity mechanisms. Both these models (SRT and MRT) are then employed to carry out investigations on thermal cavity flow problems with a single-particle based nanofluid as well as a new kind of nanofluid, namely, hybrid nanofluid. The present thesis then extends both (SRT and MRT) two-phase nanofluid algorithms to the field of a nanofluid-saturated porous structure. The novel LBM models based on the SRT and MRT approaches incorporate Brinkman-Forchheimer-extended Darcy model for porous medium into the two-phase model for nanofluid by considering appropriate assumptions. Several validation tests are performed to establish the credibility of the developed codes which provide a close agreement between present LBM solutions with published results. To realise the applicability of the developed models, several natural and mixed convection cavity flow problems of practical relevance are investigated for a wide range of dimensionless parameters, namely, Rayleigh number, Richardson number, Prandtl number and Darcy number while keeping the volume fractions of nanoparticles less than equal to 3% to avoid their agglomeration in the base fluid. A detailed analysis of these flow problems is made based on both first and second law of thermodynamics to identify the optimal configuration with high energy efficiency, at which maximum heat transfer rate and minimum entropy generation prevail.