INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: COMPACT HIGH ORDER COMPUTATION OF COMPLEX HEAT AND MASS TRANSFER PROBLEMS ON NONUNIFORM GRIDS

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SHORT ABSTRACT

This work is concerned with the application of compact and higher order compact (HOC) finite difference schemes to complex heat and mass transfer problems on nonuniform grids, which have been used overwhelmingly for fluid flow problems, and the handful of works dealing with heat and mass transfer problems have used grid transformation when dealing with non-rectangular geometries, which in turn leads to increased computational time and complexity, and numerical errors.This work uses a combination of two recently developed schemes for the streamfunction-velocity (ψ-v) form of the Navier-Stokes (N-S) equations, and existing HOC schemes for the temperature equation, in addition to using body fitted Cartesian grids when dealing with non-rectangular geometries. Using this approach four different problems of heat and mass transfer have been tackled viz. natural convection around heated bodies (a circular, and a diamond cylinder respectively) placed in a square enclosure, double diffusive natural convection in a porous annulus, conjugate heat transfer (CHT) in suddenly expanding flow, and forced convection over a heated diamond cylinder in uniform flow. The numerical approach has been shown to work remarkably well for the range of Rayleigh numbers ($10^3 \leq Ra \leq 10^7$) considered. A comprehensive analysis of flow physics has been provided, and for the first time, secondary corner vortices have been shown to exist for certain parameters. A reconstructed HOC scheme was applied to study the double diffusive natural convection in a porous annulus. This study was focused on teasing out general heat and mass transfer characteristics for all the parameters considered, and studying transient flow behavior for a particular set of parameters. While investigating CHT in suddenly expanding flows, new benchmark results have been provided for the backward facing step (BFS) geometry, and new insights into the heat transfer phenomena have been provided for flow in a suddenly expanding channel with large expansion ratios. Finally, comprehensive computations were carried out to investigate forced convection over a heated diamond cylinder in uniform flow. The use of body fitted Cartesian grids was demonstrated again, and an insightful picture of the heat transfer phenomena was provided. In all the cases, present numerical results are in excellent agreement with well established results in the literature.