Fluid Mechanics Group
Mechanical Engineering

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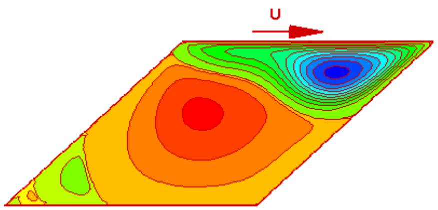
CFD in Heat & Fluid Flows in Enclosures

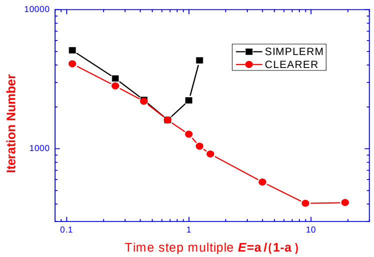
In Computational Fluid Dynamics (CFD) the efficient and robust algorithm is very necessary in order to get insight into the heat & fluid flows in complex enclosures, especially when the gridlines in those geometries are highly non-orthogonal.

Since SIMPLE (Semi-Implicit Method for Pressure Linked Equation) was proposed by Patankar and Spalding in 1972, many variants have been proposed, but few of them can work well in non-orthogonal curvilinear coordinate. In our research an algorithm named CLEARER (Coupled and Linked Equations Algorithm Revised ER) is formulated to overcome the previous disadvantages.

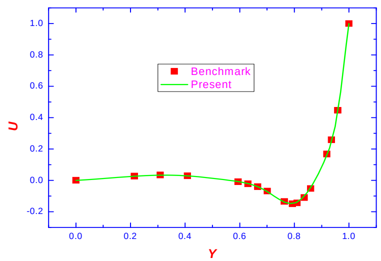
Lid-driven cavity flow at Re=1000

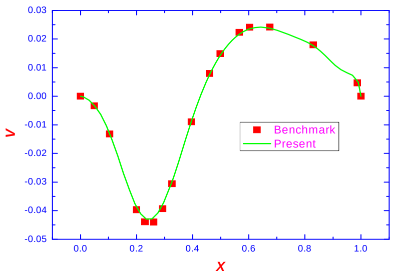


Streamlines in the inclined cavity at $\theta = 45^0$

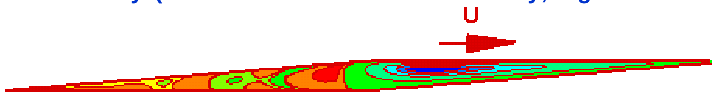


Comparison of efficiency and robustness





Comparison of accuracy. (Left: Centerline horizontal velocity; Right: Centerline vertical velocity)



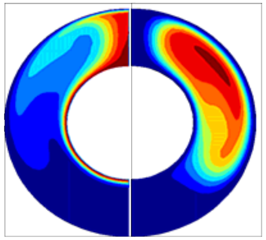
Streamlines in the inclined cavity at $\theta = 5^0$

From the above figures it can be seen that the CLEARER algorithm can predict the numerical results accurately, improve the efficiency and robustness greatly, meanwhile it can also overcome the very severe grid non-orthogonality.

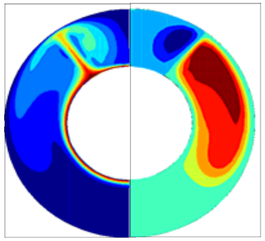
Natural convection heat transfer between concentric spheres

Natural convection heat transfer from a body to its finite enclosure can be found in various engineering applications: gyroscope, nuclear reactor design and many other practical situations. In these applications, the accurate prediction of heat transfer rates from initial state to steady state is very important.

The finite difference method is used to investigate the natural convection heat transfer between two concentric spheres, the inner sphere is hotter. For the same flow parameters (Prandtl number (Pr), Rayleigh number (Ra) and Radius ratio (R*)), two steady solutions can be obtained, depending on the initial values.

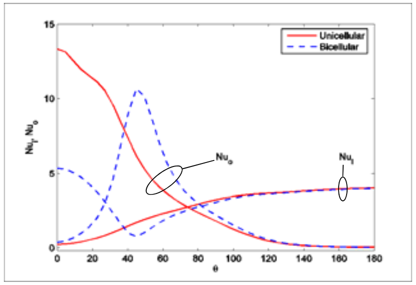


(a)

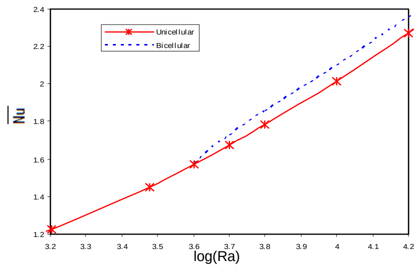


(b)

Isotherms (left) and streamlines (right) in steady unicellular flow (a) and steady bicellular flow (b), for Pr=0.7, Ra=2.5x10^5, R*=2.0



Local Nusselt numbers along inner and outer spheres in steady unicellular and bicellular flows



Effect of flow structure on average Nusselt number

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