Development and analysis of high-quality numerical methods and simulation for flow problems

Masahisa TABATA
(Professor, Faculty of Mathematics, Kyushu University)

【 Outline of survey 】

(1)We develop and analyze high-quality numerical schemes for incompressible flow problems and carry out numerical simulation of the density dependent Navier-Stokes equations, the heat convection equation and so on. We use a characteristic finite element method of second order in time increment, which has been recently developed by our group. This method has some nice properties for numerical solution of flow problems, and the advantage has been shown for the convection-diffusion problems

. (2)We develop and analyze numerical schemes for moving boundary problems and perform numerical simulation for problems such as mean curvature flow and two-layer flow. We introduce the signed distance function, which has a good affinity for the finite element method. Our schemes are constructed from the points of mathematical justification as well as effectiveness in practical computation.

(3)We develop numerical schemes with validated computation for flow problems to find the exact solutions from numerical computation results. Caused by additional computational quantity, validated computation is not yet popular in computational fluid dynamics. We are aiming to expand the applicability to flow problems by reducing the additional cost.

【 Expected results 】

(1)In the field of computational fluid dynamics we present numerical methods with high-quality and mathematical justification. More reliable numerical results can be obtained by these methods than conventional ones.

(2)Our investigation is not limited to theoretical analysis but construct practical codes to perform numerical simulation of flow problems. Our results, therefore, can be applied right away in practical computation .

(3)Validated computation produces a perfect a posteriori error estimate, which enables us to get , for example, critical Rayleigh numbers for heat convection problems and the exact solutions of flow problems via a computer-aided proof. As a byproduct we can present bench mark problems for flow simulation code.

【 References by the principal researcher 】

[1] Rui, H. and Tabata, M., A second order characteristic finite element scheme for convection-diffusion problems, Numerische Mathematik, 92(2002), 161-177.

[2] Tabata, M., Uniform solvability of finite element solutions in approximate domains, Japan Journal of Industrial and Applied Mathematics, 18(2001), 567-585.

[3] Tabata, M. and Suzuki, A., A stabilized finite element method for the Rayleigh-B e nard equations with infinite Prandtl number in a spherical shell, Computer Methods in Applied Mechanics and Engineering, 190(2000), 387-402.

【 Term of project 】 ＦＹ 2004 — 2008	**【 Budget allocation 】** 60,800,000 yen
【 Homepage address 】 Under construction	