SUMMARY OF Ph.D. DISSERTATION

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Title

Validation of Vortex Methods as a Direct Numerical Simulation of Turbulence

Vortex methods have made remarkable advancements in the past decade, and now offer an interesting alternative to finite difference and spectral methods for the numerical simulation of turbulence, especially for external flows involving unsteady vortical motion. However, the lack of validation in simple flows has left many fundamental questions unanswered. The aim of this thesis is to provide a concrete answer to these fundamental questions by systematically benchmarking the vortex method for turbulent flows.

In chapter 1, the background and objective of the present thesis is explained. In chapter 2, the governing equations and their discretized form are shown.

In chapter 3, the viscous diffusion schemes are validated in the absence of mean shear and near wall effects by calculating the homogeneous isotropic turbulence. The match of the decay rate of kinetic energy and the energy spectra in the homogeneous isotropic turbulence calculation exemplifies the high accuracy of the present viscous diffusion scheme.

In chapter 4, the homogeneous shear flow was calculated to check the ability of the vortex method to handle strongly sheared turbulence. The match of the growth rate of the anisotropy and time evolution of the joint probability density functions of velocity in the homogeneous shear flow shows the soundness of our stretching calculation.

In chapter 5, the ability of the vortex method to handle near wall flows is examined by calculating the channel flow. The ability of the present method to reproduce the Poiseuille velocity profile is an indicator of the soundness of the present wall vorticity boundary condition. Furthermore, the agreement of the mean velocity profile and Reynolds stress in the turbulent channel flow indicates the overall soundness of our vortex method.

In chapter 6, the overall conclusions are given along with some proposals of future work that can be done to supplement this thesis.