Special Program in Applied Mathematics and Applied Mechanics

Development of a Near-Wall second-moment turbulence closure based on Direct Numerical Simulation data analysis

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15:00 - 17:00
308, Mathematics Research Center Building (ori. New Math. Bldg.)

This study aims at the development and validation of a near-wall wall-normal-free Reynolds Stress Model. This model was developed from the model proposed by Gerolymos and Vallet in 2001. This new closure includes a new model for pressure diffusion, the redistribution term, and the dissipation tensor. In particular, the slow part of the redistribution term and the anisotropic part of the dissipation rate tensor of the Reynolds stress transport equation are decoupled, contrary to the Gerolymos and Vallet model. The validation of this model has been assessed on a wide range of configurations : quasi-incompressible and compressible 1-D plane channel flow, 2-D subsonic flow on a flat plate, shock-wave/turbulent boundary layer interaction in a supersonic 2-D flow with separation, 2-D subsonic flow in an asymmetric plane diffuser with large recirculation zone, 3-D flow in a S shaped canal. The results are satisfactory and improve those obtained with the Gerolymos and Vallet model, particularly concerning the prediction of the detachment and reattachment of the boundary layer and the pressure coefficient. A detailed study of the terms of the Reynolds stress transport equation by a priori calculations has been thoroughly carried out. This analysis was possible thanks to the direct numerical simulation database of a quasi-incompressible flow in a 1-D plane channel developed during the PhD thesis of Dorothée Sénéchal in 2009. It provides access to all the triple velocity correlations involved in the calculation of the pressure-velocity correlation and to the decomposition in, slow and fast, homogeneous and inhomogeneous, parts proposed by Chou, of all the correlations involving the fluctuating pressure in the Reynolds stress transport equation. This research shows that the prediction of the dissipation rate transport equation of the turbulent kinetic energy does not influence the near-wall prediction of the Reynolds stresses. The conclusion of this study is that the modeling of a transport equation for the tensor dissipation must be considered to accurately predict the behavior of the near-wall turbulence.