# A low dissipation finite element scheme for the large eddy simulation on complex geometries

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## ABSTRACT

A low dissipation finite element discretisation compatible with physical based sub-grid scale (SGS) modelling is presented in this paper. The same principles followed by R. Verstappen and A. Veldman and after generalised for unstructured finite volumes by Jofre et al. and Trias et al., is extended here to finite element (FE) schemes. The basic idea behind this approach remains the same: to mimic the fundamental symmetry properties of the underlying differential operators, i.e., the convective operator is approximated by a skew-symmetric matrix and the diffusive operator by a symmetric, positive-definite matrix. The final set of equations is time integrated using an explicit third order Adams-Bashforth method. The pressure stabilisation is achieved by means of a non-incremental fractional step (see Codina). In addition, turbulence modelling is introduced by means of the Vreman SGS model optimal for complex geometries. Finally, the proposed discretization method is successfully tested for linear and quadratic elements in three different cases. The first benchmark is a turbulent channel flow at $Re_\tau = 180$ (Kim et al.). The second selected case is the flow over a sphere at subcritical Reynolds number (Rodriguez et al.). And last but not the least, the flow over an Ahmed car at high Reynolds number is presented (Aljure et al.). To conclude, in all the presented cases the proposed low dissipation FE scheme presents good accuracy compared to other low dissipation finite volume and finite difference methods with the advantage of being able to increase the order of accuracy at will without breaking the fundamental symmetry properties of the discrete operators.

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