

Structure-preserving discretization of fluid flow equations

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Abstract :

In the context of numerical simulation of multiscale fluid dynamics problems, as in the case of Direct or Large Eddy Simulations of turbulent flows, an important topic is the design of robust and accurate numerical methods, that can efficiently handle high Reynolds number and/or under resolved simulations, for which nonlinear instabilities are a major issue. To this aim, modern numerical methods are usually required to satisfy some symmetries of the continuous governing equations, which typically amount to the discrete enforcement of the induced balance of suitably selected secondary quantities. The resulting discretizations have shown increased robustness and reliability, and are usually referred to as structure-preserving or physics-compatible methods. In this talk, the design and applications of structure-preserving methods in Computational Fluid Dynamics are reviewed from the founding ideas up to recent developments. Kinetic Energy Preserving (KEP) schemes, which are the most established and used among them, are illustrated for both incompressible and compressible flows, and with reference to temporal and spatial discretizations. More recent developments in the context of compressible flows are also considered. Entropy Conservative (EC) methods, which guarantee a correct discrete balance of entropy, and Pressure Equilibrium Preserving (PEP) schemes, which are able to discretely reproduce the correct evolution of density waves, are illustrated. Finally, some implementation issues of these classes of schemes on High-Performance Computing architectures are analyzed.