AN IMMERSED BOUNDARY METHOD EMBEDDED IN A PSEUDOSPECTRAL SCHEME

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ABSTRACT

In this work, the IMMERSPEC methodology (Mariano et al. 2010) is employed for the numerical simulation of flow past a rigid bluff body. According to methodology, Fourier pseudo-spectral approximation is combined with immersed boundary methods, for the numerical resolution of non-periodic flows through complex boundary geometries. The body boundaries are not aligned with Fourier collocation points, therefore, an bilinear interpolation scheme is used, to account for the presence of cut-cell boundaries (Mittal & Iaccarino 2005).

The model utilizes the two-dimensional, rotational, Navier-Stokes equations in Fourier space. The equations are spatially discretized by a finite amount of Fourier coefficients, while forwarding in time is achieved by a 3^{rd} order Runge-Kutta scheme. The boundary conditions are enforced by using additional source terms in the momentum equations. The source terms are initially calculated in the physical space, from velocity and pressure field, and are added to the right-hand side of momentum equations in the Fourier space.

The interpolation scheme's accuracy is evaluated by the simulation of flow past a square cylinder with cut-cell boundaries. Results of vorticity and Strouhal number at the vortex street ($Re = 100$) are compared with those of Mariano et al. (2010), where boundaries match with collocation points. It is deduced that the numerical scheme does not affect the evolution of the vortex street at the body's wake.

Two cases of flow past circular geometries are investigated: a) flow past a single circular cylinder and b) flow past an array (inline, staggered) of circular cylinders. Two different values of Reynolds number are considered ($Re = 100$ and 200) for each case. The boundary layer around the cylinder is laminar for both Reynolds numbers, while vortex shedding is considered to be laminar for $Re = 100$ and inside transition range for $Re = 200$. The resulting vortex street characteristics (Strouhal number, vortex spacing), for both cases, show satisfactory agreement with theoretical predictions.

REFERENCES

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