Interaction of multiple flapping filaments for cylinder wake modification using the Lattice Boltzmann Method

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Abstract: This paper introduces the recent work undertaken on the development of a code based on the combination of the Lattice Boltzmann Method (LBM) with a recent version of the Immersed Boundary Method (IBM). The code is first validated against existing results, before being applied to investigate the different modes of flapping behaviour for single and multiple filaments at various separation distances. The work proceeds to investigate the cylinder wake modification for moderate Reynolds number when groups of said filaments are attached to the ley-side of a circular cylinder.

Keywords: Lattice Boltzmann Method, Fluid Structure Interactions, Immersed Boundary Method, Biofluids.

1 Introduction

The recent growth in popularity of the Lattice Boltzmann Method is due in equal measure to its low cost algorithm, its scalability and its applicability to complex physics problems. In particular a number of interesting biofluid problems have been investigated using LBM, where the high Reynolds number limitation of the standard BGK implementation is not breached and many aspects of multi-physics many be addressed; i.e. deformable elastic membranes, convected objects, objects attaching and detaching, porous objects etc.

Recent studies examining IBM in LBM framework have started to investigate the complex motion of a flexible filament in a mean flow at various configurations (e.g. [1] and [2]) using standard direct forcing implementations of immersed boundary method. The work of [3] introduced a novel implementation of IBM which is able to conserve integrals of the force field and of its moment on the grid, using the Reproducing Kernel Particle Method (RKPM). This method is expected to yield more accuarate integral values, of particular benefit for example when one requires global values of lift and drag. The current in-house code is running in 2D only but the LBM implementation enables near real-time simulations to be conducted.

2 Problem Statement and Future Work

The recent work of [4] provides an extensive discussion of the multiple behaviour modes of a single filament, while the earlier work of [5] reports very useful experimental results for the dependence of two filaments upon their separation distance. Both studies, amongst others,

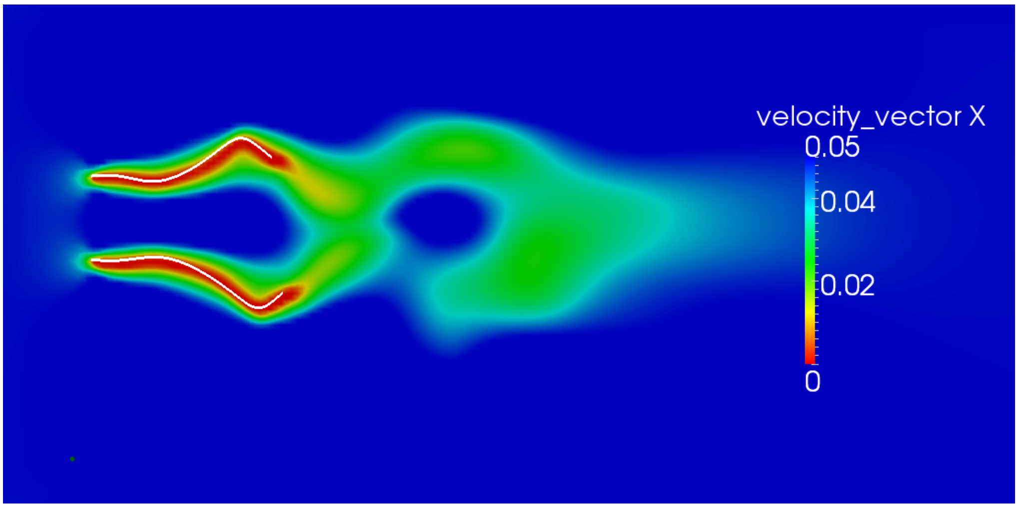

Figure 1: Two filaments flapping in antiphase and surrounding velocity field (scale indicates lattice velocity.)

demonstrate a complex multi-modal behavioural map for flexible filaments. Both will be used to first validate the current work to an acceptable level of accuracy. A snapshot of the flow around two filaments is shown in Figure 1 for a Reynolds number of 20,000 based on freestream velocity and filament length.

Once the current implementation has been validated we will investigate configurations of multiple filaments; varying key parameters such as stiffness, filament length, and spacing. We will then proceed to investigate the cylinder wake modification of flow around using a single/multi elastic filament(s); a problem with many interesting applications in areas of flow control and drag reduction.

References

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