

Unsteady elastic force-fluid shear stress interaction in a micro structure with membrane

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ABSTRACT

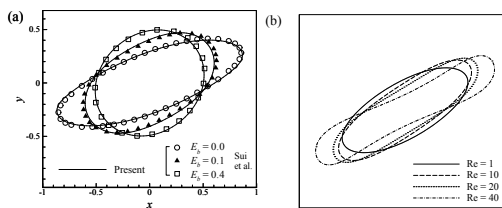
We have numerically solved the unsteady fluid-structure interaction of a 2D micro capsule subject to a sudden shear force in the viscous flows. The immersed boundary method is used to solve the coupled Navier Stokes equations and the structural equation of motion. Capsule deformation has showed an initial overshoot followed by oscillatory damping to a steady/quasi-steady state.

I. INTRODUCTION

Some blood cells with elastic membranes deform as they move through the micro vasculature or arteries pulsating with the heart beat. The mechanical stimulation they receive through the time-dependent or periodic deformation can be important for the cell physiology or particular cellular functions. We numerically investigate the unsteady deformation of a micro capsule having a thin membrane in the unsteady flows. The involved parameters are the Reynolds number Re and the Capillary number G . We use the immersed boundary method to solve the governing equations.

II. FLUID-STRUCTURE INTERACTION

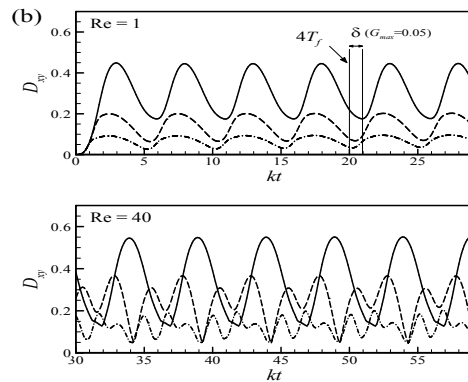
A. Simple Shear Flow (Fig.1)



A circular capsule is subject to a sudden acceleration at $t=0$ at the center of a simple shear flow. The steady form of the capsule appears as above. Left is the capsule shape dependent on bending rigidity E_b for a fixed $Re=0.05$. Right is that dependent on Re up to 40 for a fixed $G=0.05$. Here the circular capsule shows severe distortions.

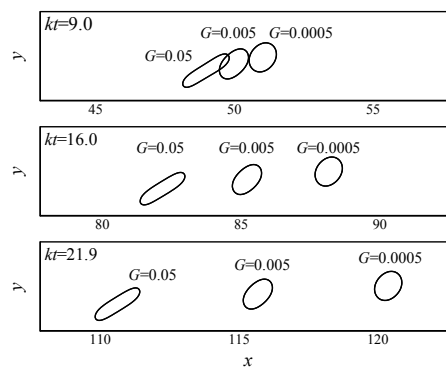
B. Pulsating Shear Flow (Fig.2)

The quasi-steady deformation parameter (i.e., the ratio of the short axis to the long axis) D_{xy} of the capsule in the pulsating shear flow is showed below. Different amount of phase shift and subharmonics appear that depend on Re and G .



C. Couette Flow (Fig.3)

The circular capsules with different capillary number G take different trajectories in a Couette flow. The capsule positions and shapes are shown below for three different time instants at $Re=20$.



REFERENCES

1. C. Song, "Dynamic Fluid-Structure Interaction of an Elastic Capsule in the Viscous Flow," Ph. D. thesis, KAIST, Aug. 2010.