Usage Report for Fiscal Year 2021

Project Title:

Multiscale modeling of ultrasonic-controlled drug delivery system processing

Name:
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1．Background and purpose of the project, relationship of the project with other projects

We consider an oscillatory spherical bubble travelling in shear-thinning power-law fluid and investigate the effects of the oscillatory frequency on the fluid behaviors induced by the oscillatory spherical bubble. Our results shed light on the dynamics of bubbles in shear-thinning fluid with occurrence of ultrasonic irradiation.

2．Specific usage status of the system and calculation method

(1) Specific usage status of the system

Numerical simulations of the shear-thinning fluid flow induced by an oscillatory spherical bubble

(2) Calculation method

The numerical simulation predicts the fluid behaviors of the flow induce by a translational oscillatory spherical bubble and the viscosity of the fluid is constrained by power-law model. To exactly impose the boundary condition and to exactly evaluate the fluid force acting on the bubble, the governing equations are described by a spherical coordinate system, and discretized in a finite-difference scheme. Thread parallelization (OpenMP) is applied to all the loop operations over the entire grid points in the code.

3．Result

(1) For the instantaneous vorticity distribution of the flow induced by the oscillatory spherical bubble, with the increase of the oscillation angular frequency, the magnitude of the total vorticity basically remains unchanged and the vorticity confined in the bubble wall is slightly increased; while, the vorticity in the bulk of the flow has been visibly reduced, as shown in Figure 1.

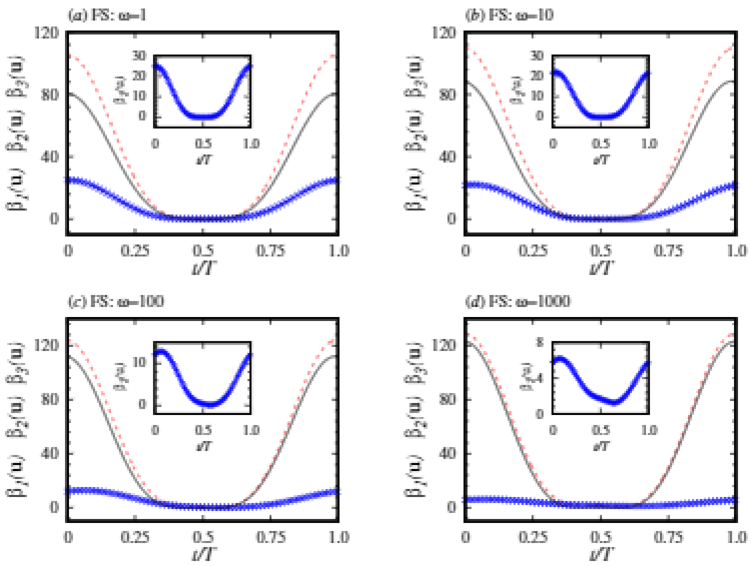

Figure 1 The instantaneous change of the vorticity distribution

(2) For the time-averaged vorticity distribution of the flow induced by the oscillatory spherical bubble in Figure 2, for the strongly shear-thinning fluid flow (small *n*), the magnitude of the total time-averaged vorticity and the vorticity confined within the bubble wall tend to be larger compared with that in the slightly shear-thinning fluid flow (large *n*). The oscillation also enhances the generation of the vorticity and hinders the transfer of the vorticity from the bubble wall to the bulk of the flow.

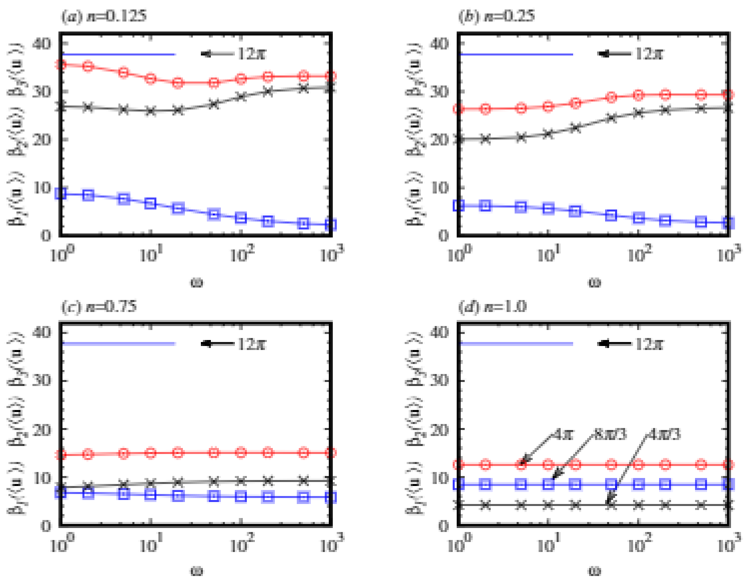

Figure 2 The time-averaged change of the vorticity distribution

4． Conclusion

In the shear-thinning fluid flow induced by the motion of the oscillatory spherical bubble, the change of the generation of the vorticity and the transfer of the vorticity from the bubble wall to the bulk of the flow is the result of the joint effects of the shear-thinning effect of the fluid and the oscillation of the bubble. Small power-law index and the large oscillation angular frequency help the vorticity confined within the bubble wall.

５． Schedule and prospect for the future

The future plan for FY2022: We will investigate the drag reduction effect of ultrasonic irradiation on a sphere freely falling in shear-thinning fluid in FY2022.