Hydrodynamics of Diatom Chains and Semiflexible Fibres

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Abstract: We study the dynamics of flexible fibres as models, in part, for diatom chains. Diatoms are non-motile, unicellular phytoplankton that have the ability to form colonies in the form of chains. Depending upon the species of diatoms and the linking structures that hold the cells together, these chains can be quite stiff or very flexible. Recently, the bending rigidities of some species of diatom chains have been quantified. In an effort to understand the role of flexibility in nutrient uptake and aggregate formation, we begin by developing a three-dimensional model of the coupled elastic-hydrodynamic system of a diatom chain moving in an incompressible fluid. We find that simple beam theory does a good job describing diatom chain deformation in a parabolic flow when its ends are tethered, but does not tell the whole story of chain deformations when they are subjected to compressive stresses in shear. While motivated by the fluid dynamics of diatom chains, our computational model of semiflexible fibres illustrates features that apply widely to other systems. The use of an adaptive immersed boundary framework allows us to capture complicated buckling and recovery dynamics of long, semiflexible fibres in shear. From this study, we want to examine the effects of varying background flows on these models as a function of their flexibilities.

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