

PROCEEDINGS

Influence of Active Tension Magnitude and Spatial Distribution on Vortex Dynamics and Propulsive Performance of a Bioinspired Jellyfish

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ABSTRACT

Jet propulsion in jellyfish relies on spatially distributed active tension along the bell margin to generate vortex rings and produce thrust. Although vortex-mediated propulsion has been widely investigated, how the magnitude and spatial distribution of active tension regulate vortex dynamics and propulsive performance remains poorly understood. Here, we employ a three-dimensional lattice Boltzmann-immersed boundary method to systematically investigate the influence of active tension magnitude and spatial parametrization on the swimming behavior of a bioinspired jellyfish. We vary (i) the applied tension magnitude, (ii) the spatial parametrization coefficient, and (iii) the functional distribution pattern along the bell margin, including uniform and linearly varying profiles. By quantifying vortex ring strength, circulation, and kinematic performance metrics such as swimming speed and displacement, we reveal how active tension distribution governs vortex interaction and thrust generation. Our results demonstrate that not only the magnitude but also the spatial organization of active tension critically modulates vortex ring formation and momentum transfer, leading to distinct propulsion efficiencies. These findings provide mechanistic insight into tension-driven vortex control in jellyfish locomotion and offer theoretical guidance for the design of high-performance jellyfish-like soft robotic swimmers.

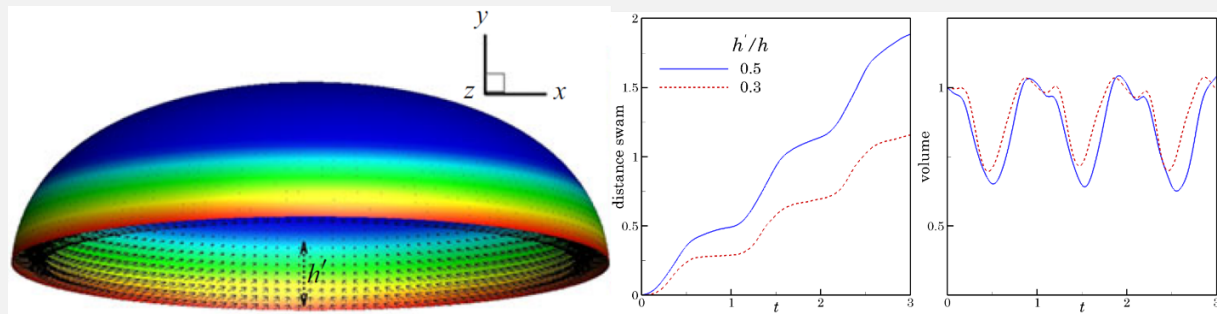


Fig.1. Active tension of jellyfish, the distance swam and the volume variation in three cycles

KEYWORDS

Jellyfish propulsion; active tension; bioinspired locomotion

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