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Lattice Boltzmann simulation of dynamics of plunge and pitch of 3D flexible wing[1] DEWEI QI, Western Michigan University, WEI SHYY, University of Michigan — The method of lattice Boltzmann (LB) simulation has been used to simulate fluid structures and motion of a flexible insect wing in a 3D space. In the method, a beam has been discretized into a chain of rigid segments. Each segment is connected through ball and socket joints at its ends. One segment may be bent and twisted with its neighboring segment. A constraint force is applied to each joint to ensure the solid structure moving as a whole flexible elastic body.We have demonstrated that the LB method is suitable for modeling of aerodynamics of insects flight at low Reynolds numbers. First, a simulation of plunging and pitching of a rigid wing is performed at $Re = 75$ in a 2D space and the results of lift forces and flow structures are in excellent agreement with the previous results. Second, plunging and pitching of a flexible wing in span-wise direction is simulated at $Re = 136$ in a 3D space. We found that when twisting elasticity is large enough the twisting angle could be controlled at a level of smaller than 0.2 degree. It is shown that as bending and twisting elasticity is large enough, the motion of flexible wing approaches that of a rigid membrane wing. The simulation results show that the optimization of flexibility in span-wise direction will benefit thrust and an intermediate level is favorable. The results are consistent with experimental finding.

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