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Computation and Modeling of Insect Flight

Z. Jane Wang

**Theoretical and Applied Mechanics, 212 Kimball Hall,
Cornell University, Ithaca, NY 14853
email: jane.wang@cornell.edu**

Interactions between dynamic boundaries and unsteady viscous flows occur in a wide range of physical, engineering, and biological systems, including fish swimming and insect flight. These problems pose formidable theoretical and computational challenges, due to the tight coupling between the dynamics of the boundary and the fluid, and the presence of multiple interacting time and length scales. On the other hand, Nature has been solving the same problem over millions of years. In a sense, insects are nature's Navier-Stokes solvers, and no doubt they have found some clever answers in the course of evolution. Therefore, studies of the unsteady aerodynamics of insect flight will advance our fundamental understanding of one of most challenging subjects in fluid dynamics.

In this talk I report our recent work on computing and modeling of insect flight. We compute unsteady viscous flows, governed by the Navier-Stokes equation, about a two dimensional flapping wing which mimics the motion of an insect wing. I will present two main results: the existence of a preferred frequency in forward flight and its physical origin, and 2) the vortex dynamics and forces in hovering dragonfly flight. If time permits, I will show the recent results on three dimensional flapping flight driven by muscles.