

Abstract Submitted  
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**Lessons from dragonfly flight** Z. JANE WANG, Cornell University — I will describe two lessons we learned from analyzing dragonfly flight using computers and table-top experiments. Part I: The role of drag in insect flight. Airplanes and helicopters are airborne via aerodynamic lift, not drag. However, it is not a priori clear that insects use only lift to fly. We find that dragonfly uses mainly drag to hover, which explains an anomalous factor of four in previous estimates of dragonfly lift coefficients, where drag was assumed to be negligible. Moreover, we show that the use of drag for flight is efficient at insect size. This suggests a re-consideration of the hovering efficiency of flapping flight, which is no longer described by the lift to drag ratio. Part II. Fore-hind wing interaction in dragonfly flight. A distinctive feature of dragonflies is their use of two pairs of wings which are driven by separate direct muscles. Dragonflies can actively modulate the phase delay between fore-hind wings during different maneuver. We compute the Navier-Stokes equation around two wings following the motion measured from our tethered dragonfly experiments, and find an explanation of the advantage of counter-stroking during hovering.

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