

Lateral dynamic flight stability of hovering insects: theory vs. numerical simulation

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Abstract

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Abstract In the present paper, the lateral dynamic flight stability properties of two hovering model insects are predicted by an approximate theory based on the averaged model, and computed by numerical simulation that solves the complete equations of motion coupled with the Navier--Stokes equations. Comparison between the theoretical and simulational results provides a test to the validity of the assumptions made in the theory. One of the insects is a model dronefly which has relatively high wingbeat frequency (164Hz) and the other is a model hawkmoth which has relatively low wingbeat frequency (26Hz). The following conclusion has been drawn. The theory based on the averaged model works well for the lateral motion of the dronefly. For the hawkmoth, relatively large quantitative differences exist between theory and simulation. This is because the lateral non-dimensional eigenvalues of the hawkmoth are not very small compared with the non-dimensional flapping frequency (the largest lateral non-dimensional eigenvalue is only about 10% smaller than the non-dimensional flapping frequency). Nevertheless, the theory can still correctly predict variational trends of the dynamic properties of the hawkmoth's lateral motion.

Keywords: Insect Hovering Lateral dynamic flight stability Averaged model Equations-of-motion Navier--Stokes simulation

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