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Department Seminar

Topic: **Dynamic flight stability and control of hovering insects**

Speaker: **Dr Sun Mao**
Professor of Institute of Fluid Mechanics
Beijing University of Aeronautics and Astronautics (BUAA)

Date: **Thursday, 20 December 2012**

Time: **10.00am to 11.00am**

Venue: **EA-06-07** (map of NUS can be found at <http://map.nus.edu.sg/>)

Abstract

We made high-speed film of a hovering donefly, which showed that the insect could be treated as a three-segment body (body with two-wings rotating about the wing-roots). The equations of motion of the insect were derived.

Froquet theory and average-model theory were developed to solve the equations. The theories showed that there is an unstable oscillatory mode (longitudinal) and an unstable slow divergence mode (lateral). Due to the unstable modes, the hovering flight of the insect is dynamically unstable. However, the instability might not be a great problem to the insect that tries to stay hovering. The time for the initial disturbances to double is more than 8-10 times the wingbeat period and the insect has plenty of time to adjust its wing motion before the disturbances grow large. Approximate analytical expressions of the eigenvalues, which give physical insight into the genesis of the natural modes of motion, were derived. The expressions identify the speed derivative μ and the forward-and-backward tilting of the vertical force as the primary source of the longitudinal unstable oscillatory mode and the side-speed derivative L_v and the side tilting of the vertical force as the primary sources of the unstable divergence mode. The flight is numerically simulated by coupling the full equations of motion with Navier-Stokes equations. The validity of the linear theories was tested using the solution of the full equations. Controllability analysis shows that although unstable, the flight is controllable.

About the Speaker

Dr. Sun Mao, Professor of the Institute of Fluid Mechanics at Beijing University of Aeronautics and Astronautics (BUAA). Sun graduated from BUAA in 1978; received his M.A. (1981) and Ph.D. (1983) in aeronautical engineering from Princeton University; and did post-doctorate research in University of Maryland (1983-85). Since 1986, he has taught and conducted research at BUAA. Sun's research aims to identify, investigate, and discover new phenomena in a broad range of physical and biological systems. One of his current interests is to understand the intricacies of unsteady aerodynamics and animal flight dynamics through insect flight. Other themes of his research include computational fluid dynamics, dynamical and compliant boundary problems in fluid flows and nonlinear dynamics in complex system.

**** Admission is free. All are welcome to attend. ****