JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Weekly CEAFM Seminar: Fall 2012

Date: **Friday, September 7, 2012**

Time: 11:00 AM

Location: Gilman 50 (Marjorie M. Fisher Hall)

Speaker: **Prof. Gongxin Shen** (Beijing University of Aeronautics and Astronautics)

Title: *"3Dt-3c-DSPIV Study for Bio-Fluid Flows"*

Abstract

The locomotion of the swimming and flying creatures such as fish and insects has been a focus of research in bio-fluid dynamics for the past couple of decades. Although tremendous amount of data have been obtained, the three dimensional flow structures in these bio-fluid flows are still not quite clear. In this presentation, I will describe a specially designed 3Dt-3c-DSPIV (three-dimensional plus time, and three velocity component, digital stereo particle image velocimetry with multiple slices and phase-lock techniques) system for the study of the complex but periodic bio-fluid flows, which enables the elucidation of the 3D flow structures with the measured 3Dt-3c velocity distributions. With this system, we investigated two types of bio-fluid flows.

The first one is about the wake flow behind a flapping tail of a robotic fish model installed in a water channel. The entire tail of the model can make specified motions with two degrees of freedom, mainly in carangiform mode, by driving its after-body and lunate caudal fin respectively. The DSPIV system was set up to operate in a translational manner, measuring the velocity field in a series of parallel slices. Phase-locked measurements were repeated for a number of runs, allowing reconstruction of the phase-averaged flow field. This study reveals some new and complex three-dimensional flow structures in the wake of the fish, including the “reverse hairpin vortex” and the “reverse Karmam S-H vortex ring”. The mechanism of the fish locomotion as clarified by the phase history of the wake will also be discussed.

The second type of bio-fluid flows that we investigated is the leading edge vortex (LEV) on the insect flapping wings in hovering flight. Several robotic flapping wing models simulating fruit fly, butterfly and dragonfly wing motions were installed in a water tank. The unsteady 3D velocity fields of these wing motions were measured using the afore-mentioned DSPIV system. But during the measurements, the models were operated in a translational manner. Several new and complex three-dimensional flow structures, such as the second LEV structures for most of the insect flapping wings, the non-conical (non-spiral) but cylindrical LEV structures for the butterfly wing, and the interactions of the flow structures between the two flapping wings of the dragonfly, were identified. The mechanism for the locomotion of the insect flight will be discussed based on the measured phase histories of the LEV and the wake.