TR-PIV3D-3C measurements around a flapping wing

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Flapping wings have been of interest to biologists for years, and are currently under much consideration by the aeronautical community, due to the recent advent of Micro-Air Vehicles. The problematic associated with such wing concept relies on the comprehension of low Reynolds number unsteady aerodynamic phenomena. Previous studies revealed that mechanisms such as the presence of a Leading Edge Vortex (LEV), the Kramer effect or the wing/wake interactions are responsible for the generation of a strong lifting force (Dickinson et al. 1999).

Despite the fact that two-dimensional configurations bring interesting insight into the aerodynamics of flapping wings (Wang 2000, Kurtulus et al. 2008, Bos et al. 2008, Jardin et al., 2009), the latter is particularly sensitive to the presence of a three-dimensional component. Extended works (Maxworthy 1979, van den Berg & Ellington 1997, Poelma et al. 2006) suggested that spanwise velocities might effectively have an effect on the stability of the LEV. Nevertheless, most researches focused on revolving wing configurations for which the distinction between the effects due to the inertial forces (Coriolis and centrifugal) and that due to the wing tip vortex is delicate. In this paper, we focus on a configuration for which the translation phase is rectilinear, which allows isolating the role of the tip vortex on global flow dynamics.

A high frequency scanning of the high speed laser sheet by an oscillating mirror is used to illuminate a volume of the flow. Different volumes of particles at different times are recorded by means of a high speed camera. 3D iterative correlation by shift windowing and sub pixel accuracy is proposed for the evaluation of the three components of the displacement in the volume. The time interval (Δt=100 ms) is sufficiently short to obtain, for this application, time resolved velocity measurements.

Schemes of the experimental setups and of the time table are presented to validate the recording of these large volumes. Influence of the magnification in depth, of cylindrical lenses on the laser sheet location will be raised. Concerning the flow, comparison with the 2D flow will be proposed. Finally, interaction of the Leading Edge Vortex, the Tip Vortex, and the Starting Vortex are examined with the wing motion.

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