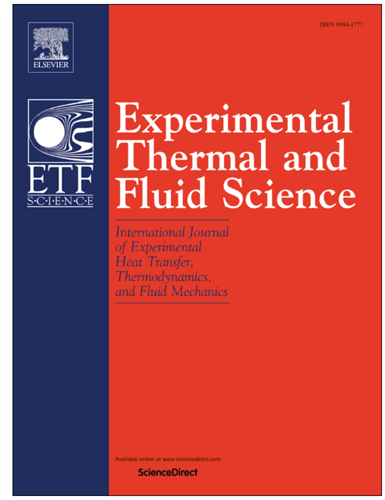
Accepted Manuscript



Quantitative analysis of vortex added-mass and impulse generation during vortex ring formation based on elliptic Lagrangian coherent structures

Yang Xiang, Haiyan Lin, Bin Zhang, Hong Liu

PII: S0894-1777(18)30225-5
DOI: https://doi.org/10.1016/j.expthermflusci.2018.02.018
Reference: ETF 9379

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 17 May 2017
Accepted Date: 13 February 2018

Quantitative analysis of vortex added-mass and impulse generation during vortex ring formation based on elliptic Lagrangian coherent structures

Yang Xiang[a], Haiyan Lin[a], Bin Zhang[a], Hong Liu[a,*]

[a] *J.C.Wu Center for Aerodynamics, School of Aeronautics and Astronautics, Shanghai Jiao Tong University, Shanghai, 200240, China*

Abstract

In many propulsive systems operating with the generation of large-scale vortices, the enhanced performance is achieved and closely related with the effects of vortex added-mass. However, quantitatively analysing vortex added-mass is difficult, particularly when the vortex is significantly deforming, because identifying a physical vortex boundary is difficult. Recently, a physical vortex boundary is defined by the elliptic Lagrangian coherent structures (LCSs), which are sought as closed stationary curves of the averaged Lagrangian strain. In this study, a canonical vortex-ring flow is investigated to analyze the evolution of vortex added-mass by examining the evolution of elliptic LCSs. A vortex ring is produced experimentally by employing a piston-cylinder apparatus, and the time-dependent flow fields are recorded by particle image velocimetry technique. Elliptic LCSs are computed with high-precision algorithms. Compared with the streamline pattern and ridges of the finite-time Lyapunov exponent, elliptic LCSs can more precisely and quantitatively determine a vortex boundary that acts as a material surface in fluids. In terms of elliptic LCSs, vortex added-mass coefficient is computed and demonstrates a decreasing tendency from approximately 1.3 to 0.88 during vortex ring formation. Correspondingly, the overpressure contribution to the vortex impulse exhibits the same decreasing tendency

*Corresponding author
Email address: hongliu@sjtu.edu.cn (Hong Liu)