

Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Interaction of multiple co-axial co-rotating vortex rings¹ SUYANG QIN, HONG LIU, XIAOYU LIU, YANG XIANG, Shanghai Jiao Tong Univ — Fish and birds gain hydrodynamic force from a wake of discrete or linked vortex chain, which is the existence form of vortex rings in nature. Vortex rings with the same formation time are generated successively with different time interval by a piston-cylinder arrangement, and the velocity fields are measured using DPIV. The motion of multiple interacting vortex rings is first reported in laboratorial experiments. Besides the most attracting leapfrogging phenomenon, two other phenomena, suction and weak influence, are also clearly presented using the method of Lagrangian coherent structures. Due to the induced effect of wake vortex rings, the formation process of the forming vortex rings is different from that of a single isolated vortex ring, indicating that another distinct timescale exists, together with formation number proposed by Gharib (1998 JFM), determining the mechanisms of vortex rings. When the rear vortex ring leapfrogs, the limiting case is that the rear contracting ring is axis-touching. If an axis-touching ring is further squeezed by the wake vortex, the vortex structure will collapse, which can be explained by Kelvin-Benjamin variational principle. According to this principle, it is impossible for two optimal formed vortex rings to leapfrog.

¹Financial support from the State Key Development Program of Basic Research of China (2014CB744802) is gratefully acknowledged.

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Date submitted: 27 Jul 2015

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