On Axisymmetry of Vortex Rings

AHMAD FALAHATPISHEH, ARASH KHERADVAR, Univ of California - Irvine — The shape of vortex rings can be an indication of the axisymmetry of propulsion or transient jet flows. There are many conditions that vortex rings deviate from axisymmetry. For the first time, we introduce a metric, called axisymmetry index, $\xi$, that measures the axisymmetry of vortex rings with a single value. Axisymmetry index examines the spectrum of the impulse of the ring in azimuthal planes and reports the degree by which the ring deviates from axisymmetry. The index is systematically investigated in analytical and numerical cases. A perfect axisymmetric ring is associated with $\xi = 1$. It is validated in Gaussian vortex ring and Hill’s spherical vortex, where the computed indices are found to be in agreement with $\xi = 1$. A family of non-axisymmetric vortex rings are parametrically generated to study the relation of the index with the ratio of the maximum of circulation to the minimum of circulation of the ring. The results show that as the second moment of vorticity on one side increases compared to the other side, the deviation of the ring from axisymmetry increases, hence, a decrease in the index from unity. We also present results of numerically investigating the axisymmetry of a non-axisymmetric vortex ring that forms downstream of an oval-shaped nozzle.

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Date submitted: 01 Aug 2014

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