Revisit of axis-switching in low aspect-ratio rectangular jets

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Axis switching refers to the change in the orientation of the major axis of the jet from initial spanwise to lateral direction. This phenomenon is of interest both from fundamental physics and practical application points of view. This behavior is most noticeable in square and low aspect-ratio (AR) rectangular jet flows. It has been reported computationally that square jet (AR=1) and rectangular jet (AR=1.5) switch the major axis 45^0 and 90^0 respectively [1-2]. In this work we revisit the axis-switching phenomenon through direct numerical simulation using kinetic-based lattice Boltzmann method for a square jet and 4 rectangular jets with AR =1.5, 2, 2.5, and 3 respectively at Re=200. It is observed that larger AR jet develops longer characteristic decay (CD) region where jet decay and mixing depend on the jet AR. As all rectangular jets exhibit 90^0 axis-switching close to the end of the CD region as expected although the location varies with ARs, 45^0 axis-switching is discovered in each jet before the 90^0 axis-switching appears downstream. Quantitative examinations of the transition from 45^0 to 90^0 in rectangular jets are conducted to reveal the physical underlying mechanism of jet development and provide physical insights for practical application.

1. H. Yu and S. Girimaji, 17, physics of Fluids, 2005;
2. H. Yu, L-S. Luo, and S. Girimaji, 35, Computers & Fluids, 2006.