

FIG. 1. $Re=3700$.

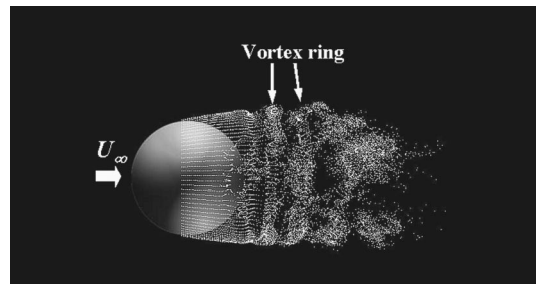


FIG. 2. $Re=10^4$.

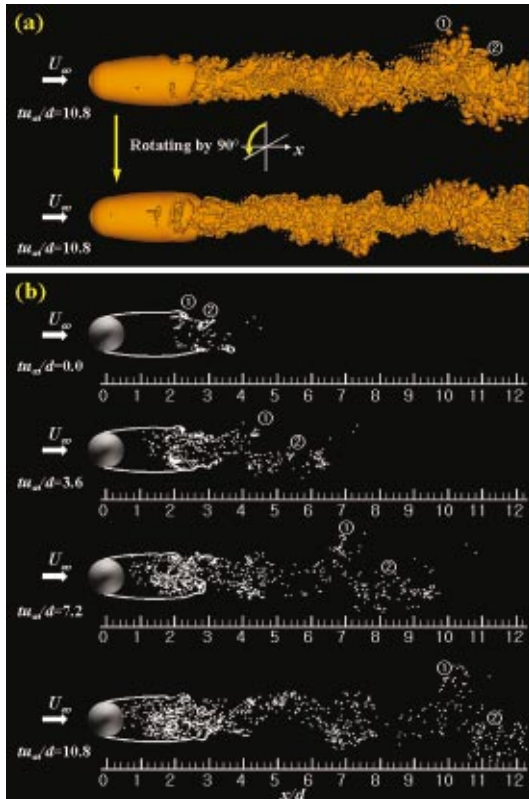


FIG. 3. $Re=3700$.

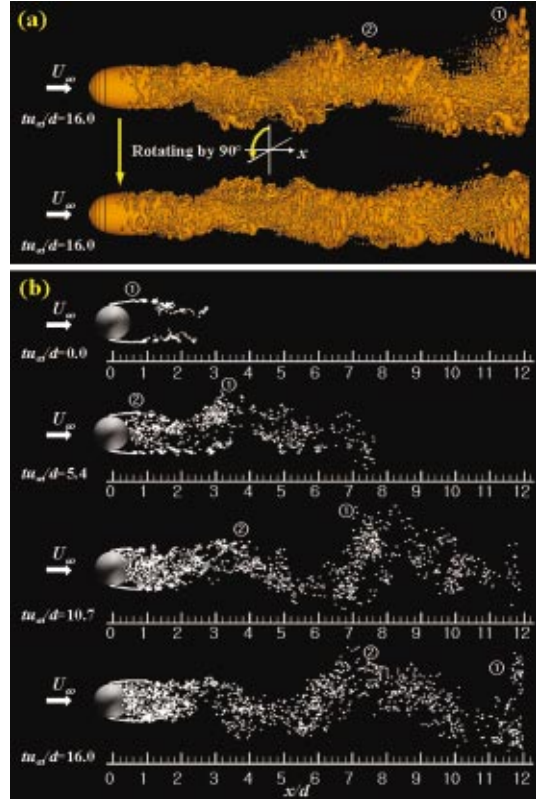


FIG. 4. $Re=10^4$.

Turbulent Flow past a Sphere at $Re=3700$ and 10^4

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Large eddy simulation of turbulent flow over a sphere is conducted at the Reynolds numbers of 3700 and 10^4 based on the freestream velocity u_∞ and the sphere diameter d using an immersed boundary method.¹ Vortical structures are represented by the particle tracing and vortex identification methods.²

Figures 1 and 2 show the vortex rollup in the shear layer at $Re=3700$ and 10^4 , respectively. For $Re=3700$, vortices roll up locally in the azimuthal direction near the end of the

shear layer, whereas vortex rings are formed right behind the sphere for $Re=10^4$.

Figures 3(a) and 4(a) show the instantaneous vortical structures, respectively, at $tu_\infty/d=10.8$ ($Re=3700$) and 16.0 ($Re=10^4$) using the vortex identification method.² One can clearly notice that at this instant alternating vortical structures exist in one plane but do not appear in the perpendicular plane. Time traces of vortical structures using the particle tracing [Figs. 3(b) and 4(b)] show that this wake waviness is closely associated with the shear-layer vortical evolution. That is, the vortices, ① and ②, that are generated by the shear-layer instability persist in the far-downstream locations, resulting in the waviness of the wake structure.

¹J. Kim, D. Kim, and H. Choi, *J. Comput. Phys.* **171**, 132 (2001).

²J. H. Jeong and F. Hussain, *J. Fluid Mech.* **285**, 69 (1995).