Benchmark computations of normal and oblique dipole-wall collisions with a no-slip wall

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Benchmark results are reported of two separate sets of numerical experiments on the collision of a dipole with a no-slip boundary at several Reynolds numbers. One set of numerical simulations is performed with a finite differences code while the other set concerns simulations conducted with a Chebyshev pseudospectral code. Well-defined initial and boundary conditions are used and the accuracy and convergence of the numerical solutions have been investigated by inspection of several global quantities like the total kinetic energy, the enstrophy and the total angular momentum of the flow, and the vorticity distribution at the no-slip boundaries. It is found that the collision of the dipole with the no-slip wall and the subsequent flow evolution is dramatically influenced by small-scale vorticity produced during and after the collision process. The trajectories of several coherent vortices are tracked during the simulation and show that in particular underresolved high-amplitude vorticity patches near the no-slip walls are potentially responsible for deteriorating accuracy of the computations.

Our numerical simulations clearly indicate that it is extremely difficult to obtain mode or grid convergence for this seemingly rather simple two-dimensional vortex-wall interaction problem.