Chaotic motion of light particles in an unsteady three dimensional vortex: experiment and simulation

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We simulate the motion of a small rigid sphere, lighter than the fluid in a rotating, three dimensional and periodically time dependent flow (vortex). The motivation of this work is an experiment. In the experiment a rotating magnetic stirrer generates a vortrex in a cylindrical container [1]. The core of the flow is able to keep a light particle near the axis moving up and down. Experiment shows that the smoothed out hydrodynamics of the flow is periodic but the motion of the particle is highly non-periodic.

Our model is a generalization of the Burgers vortex and describes the flow around the axis. The equations of motion of the particle are a modified semi-empirical Maxey-Riley equations. The dynamical mechanism underlying the particle's chaotic-like motion is the coexistence of a fixed point attractor and a limit cycle about the vortex axis in the time-independent flow. Time dependence might combine these regular attractors into a single chaotic attractor.

Reference:
[1] G. Halasz et al., *American Journal of Physics* **2007**, *75*, 1092-1098.