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Oscillatory Counter-Centrifugation: Effects of History and Lift Forces

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This work is co-authored with my doctoral student Shujing Xu and is dedicated to the memory of my doctoral advisor Howard Brenner who enjoyed thought experiments related to rotating systems. Oscillatory Counter-Centrifugation refers to our theoretical discovery that within a liquid-filled container that rotates in an oscillatory manner about a fixed axis as a rigid body, a suspended particle can be made to migrate on average in the direction opposite to that of ordinary centrifugation. That is, a heavy (or light) particle can move toward (or away from) the rotation axis, when the frequency of oscillations is high enough. In this work we analyze the effects of the Basset history force and the Saffman lift force on particle trajectories and find that the counter-centrifugation phenomenon persists even when these forces are active.