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Added-mass-induced beating between a submerged pendulum and a free surface wave mode TIMOTHY T. K. CHAN, Physics of Fluids Group, University of Twente, 7500 AE Enschede, The Netherlands, VARGHESE MATHAI, Department of Physics, University of Massachusetts, Amherst, Massachusetts 01003, USA, SANDER WILDEMAN, University of Twente, 7500 AE Enschede, The Netherlands — One would expect a pendulum released inside a tank of quiescent liquid to oscillate with a monotonically decreasing amplitude until it finally comes to rest. Here we present a surprising observation where a submerged heavy pendulum starts up again after coming to a halt. We demonstrate that this effect arises from the two-way coupled interactions between the pendulum and the sloshing wave mode generated in the tank of liquid. A strong coupling is observed when the pendulums natural frequency matches that of the wave mode. We model this behavior using a lumped variational approach that treats the pendulum and the wave mode on equal footing. The beating behavior is shown to resemble that of the well-known physics demonstration of two oscillating pendula coupled by a weak spring. While it is not immediately obvious how such an interaction arises inside a liquid, where there are no springs or other elastic forces, we show that the coupling between the pendulum and the liquid originates from pure added mass effects. Our work demonstrates how acceleration-induced forces such as kinetic buoyancy (known from e.g. the pioneering work of Bjerknes) – commonly used to describe the behavior of submerged bodies – can strongly influence the motion of the bulk surrounding fluid.

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