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Resolving the unsteady deceleration and forces after water entry by low mass-ratio spheres B.P. EPPS, MIT, T.T. TRUSCOTT, Naval Undersea Warfare Center, R.R. LAFOY, A.H. TECHET, MIT — The dynamics of water entry are significantly affected by surface coating and mass ratio, over a range of moderate impact velocities and sphere diameters. A hydrophobic sphere creates a sub-surface vapor cavity whereas a hydrophilic sphere does not, and the forces acting on the sphere after entry depend upon whether or not this cavity is formed. Using high speed-video, sub-pixel-accurate image processing techniques, and a smoothing spline method to find the derivatives of position data, we find the unsteady forces acting on spheres during the water entry event. Our data reveals that as mass ratio decreases from O(10 to 1), the sphere's deceleration becomes highly non-linear, since inertial forces cease to dominate over hydrodynamic forces. The unsteady deceleration is affected by vortex shedding in the no-cavity case, whereas in the cavity forming case, forces are affected by cavity growth and collapse, and vortex shedding is inhibited until after pinch-off. PIV sequences taken in both cavity-forming and non-cavity-forming impact cases highlight the vortex shedding onset and can be used to gain further insight into the sphere dynamics. Ultimately, this work emphasizes the need to accurately account for unsteady effects in modeling the post impact dynamics of spheres, especially as mass ratios approach unity.

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