FLOW FIELD around a Vertically SALTATING SPHERE

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ABSTRACT
We conducted experiments to characterize liquid motions around an immersed solid sphere in free fall near a wall. During its descent, the sphere repeatedly bounces off the vertical wall, much like a sediment particle saltating along a horizontal stream bed. To measure the flow around the sphere, we use refractive-index-matched materials and laser-illuminated tracer. We observe vortex rings released by the saltating sphere, and interpret the lateral sphere motions as the result of an attractive force between the sphere and the wall.

Pathlines of liquid and sphere
By processing the sequence of gray-scale images captured by the high-speed camera, we can superimpose the data to form an impressive image of the sphere and its impact trajectory. These reveal the nature of the flow pattern emerging along the sphere path and the complex effects of its velocity, forming toroidal patterns.

Multiple-exposure video image
Taking the wall, the saltating sphere (state of measurement) will be released from somewhere near the upper surface of the liquid near the center of the sphere vertically. Interestingly, the sphere does not fall along a straight line but a curve similar to the curve leading to the vertical impact.

Refraction index matching
Refractive index matching in the way that light propagates through transparent solid-liquid media. When water is not (left), the acryllic spheres are visible both above and below the liquid's free surface, while a white rectangle. When immersed in the liquid phase system, is the acryllic sphere become invisible (right). This is because the water-paer system has the same index of refraction as acryllic.

Shadows and caustics
Shadows and caustics are produced by the sphere moving through the light under a laser beam. These patterns are produced by light rays, which are refracted upon entering the liquid and refracted away from the liquid.

Sphere-wall attraction
By symmetry, the liquid-particle circulation in the liquid sphere can be approximated by a planar scheme, which can be seen by looking through the wall. The observed flow behavior of this two-phase system demonstrates the existence of a coherent vortex in the liquid sphere, forming a conical edge from the sphere. An attractive force associated with the vortex shows the sphere. This might be due to the flow of the liquid sphere as it moves along the sphere path and the complex effects of its velocity, forming toroidal patterns.

Velocity and vorticity maps
The velocity and vorticity maps demonstrate the success of the liquid flow around the saltating sphere. The main flow is produced by a high-speed jet and a lower speed along the wall. The vorticity is zero near the wall and increases near the wall. The sphere motion is characterized by a strong vortex along the upper and lower sides. The vortex ring is generated by the movement of the sphere, and its movement is similar to a vortex ring emerging from a sphere in a liquid.