Single vs Multiple Bouncing Balls on a Vibrating Fluid Surface: Differences in Translational and Rotational Dynamics

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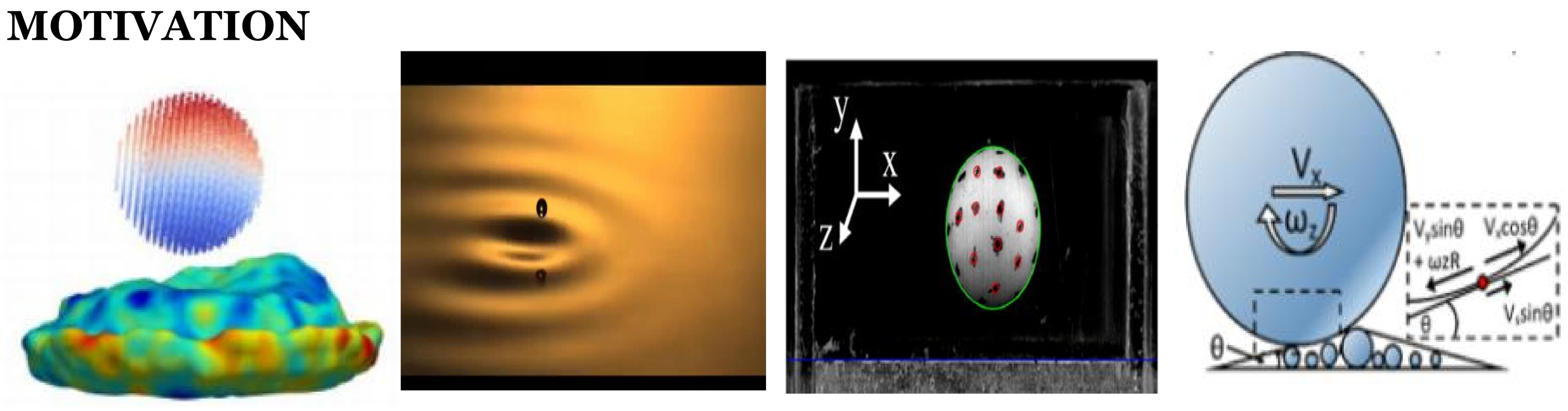
INTRODUCTION

MOTIVATION



The phenomenon of bouncing balls and 'walking droplets' on vibration-energized surfaces has gained widespread attention over the years due to the wealth of complex behaviors manifested by such systems and more recently, due to its possible analogy with quantum mechanics behavior.

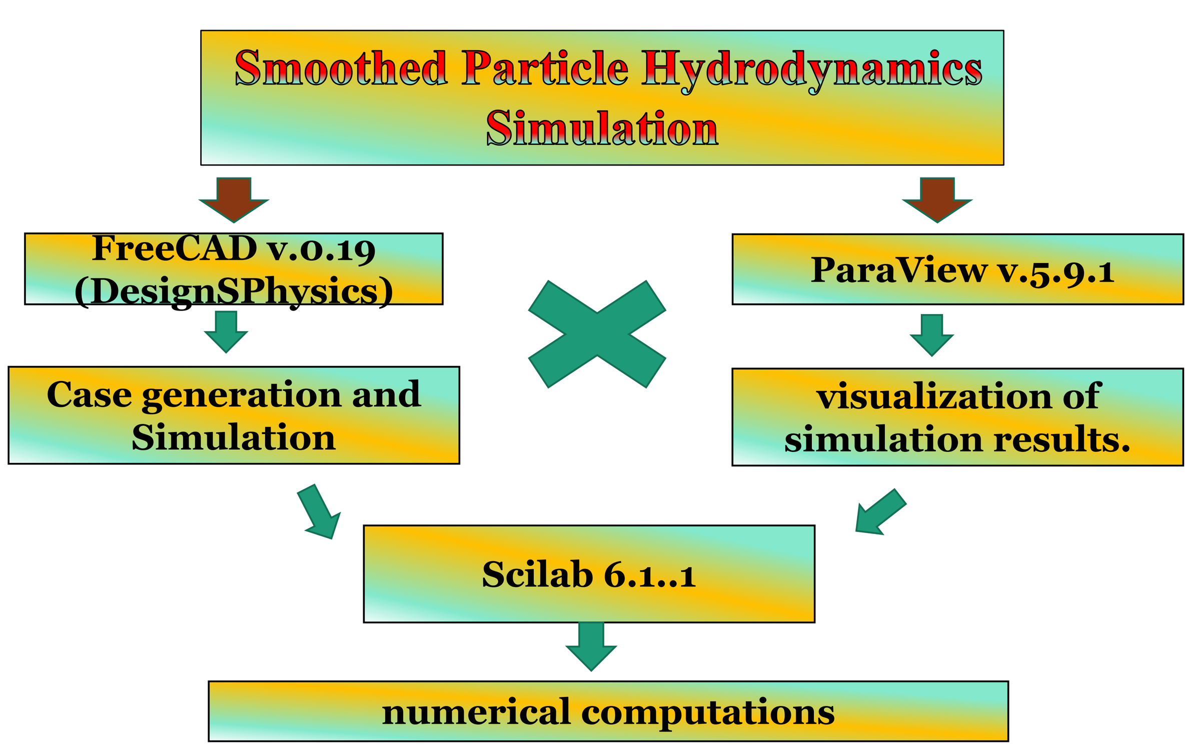
ISSUE

While most numerical simulations of bouncing balls employ discrete element methods, molecular dynamics, and finite element analysis, it has been shown that the computational fluid dynamics simulations, particularly the smoothed particle hydrodynamics (SPH) method is effective in simulating oil droplets walking pn viscous vibrating liquid.

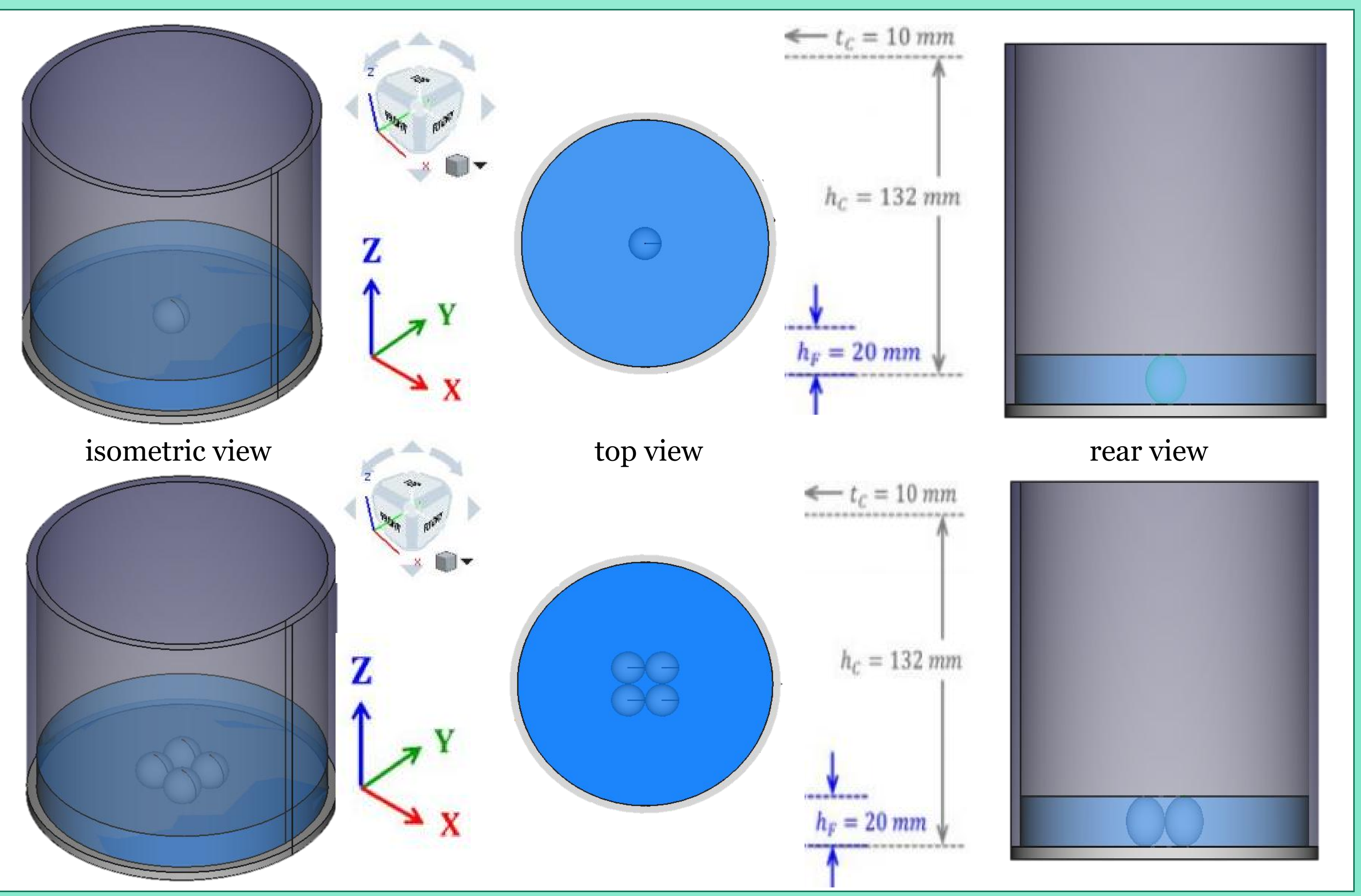
OBJECTIVES

This study aims to investigate the similarities and/or differences in the translaational and rotational motions of the bouncing balls in a single-ball (Case1) and a multiple ball (Case 2) system.

METHODOLOGY



SIMULATION SET-UP



RESULTS AND DISCUSSIONS

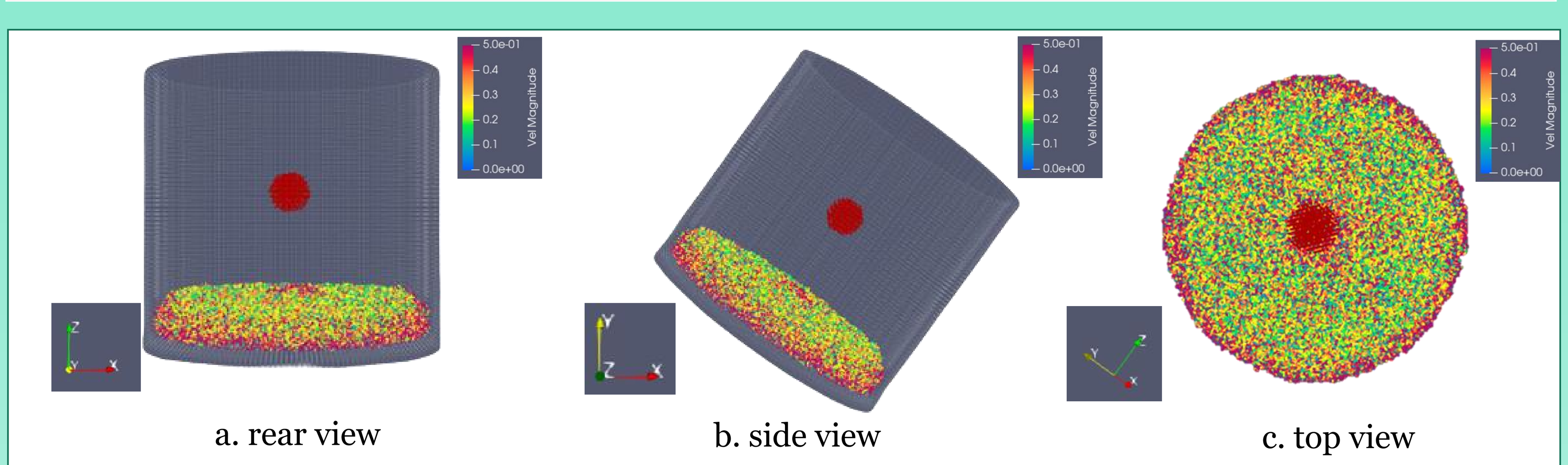


Fig. 1. Display sample screenshots for simulated single-ball system at 30 seconds.

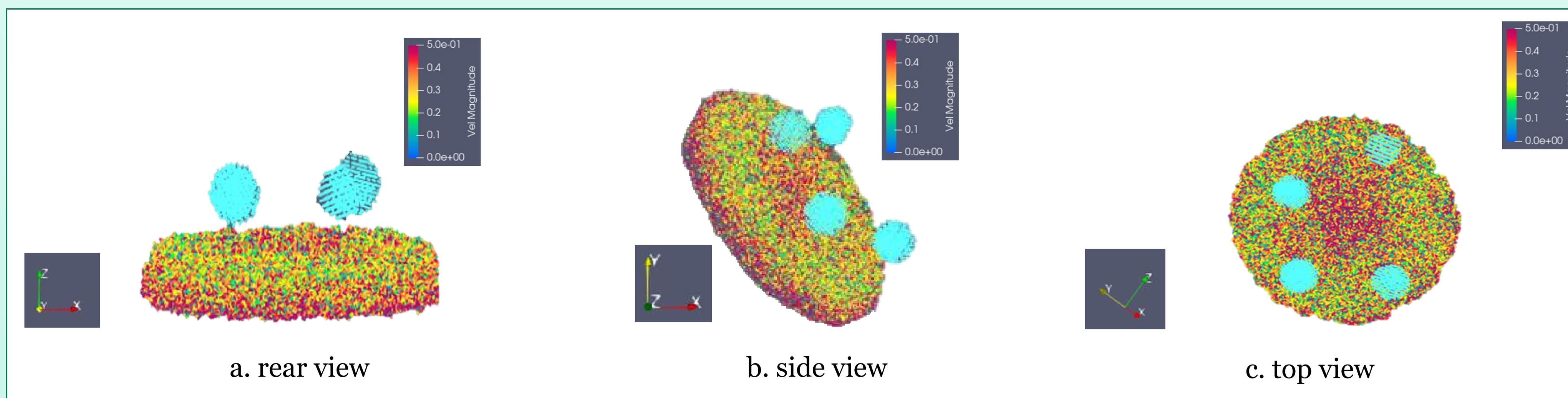


Fig. 2. Display sample screenshots for simulated multiple-ball system @ 30 seconds.

The difference between the translational velocity of a single ball vs multiple balls

	Vx		Vy		Vz	
	(0-2 s)	(2-5 s)	(0-2 s)	(2-5 s)	(0-2 s)	(2-5 s)
ball = 1	0.152	0.043	0.078	0.051	0.252	0.134
ball = 4	0.094	0.070	0.132	0.072	0.177	0.140

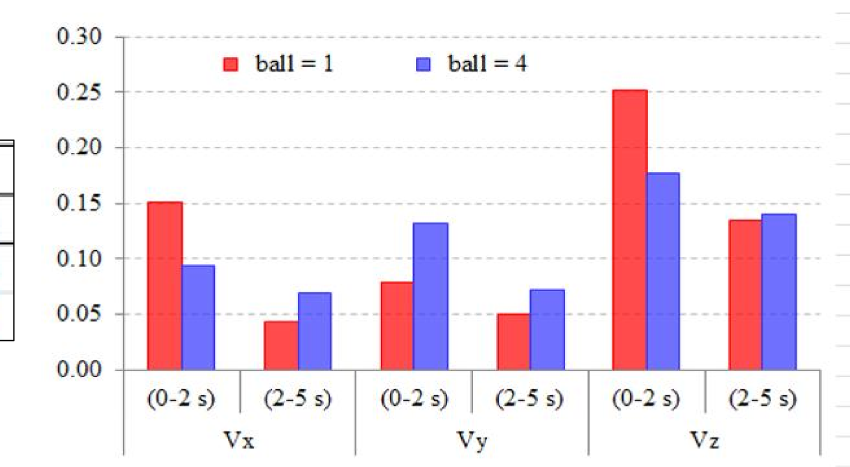


Fig.3. This shows the summary values for translational velocity of a single ball vs multiple balls. Here, we can see that the single ball starts with greater vertical translation (v_z) compared to the multiple ball system but after some time (2-5s), both systems have close vertical translational velocity.

The difference between the rotational velocity of a single ball vs multiple balls

	Rx		Ry		Rz	
	(0-2 s)	(2-5 s)	(0-2 s)	(2-5 s)	(0-2 s)	(2-5 s)
ball = 1	4.078	2.788	3.348	3.941	2.537	2.978
ball = 4	7.224	4.798	7.270	4.551	4.512	2.464

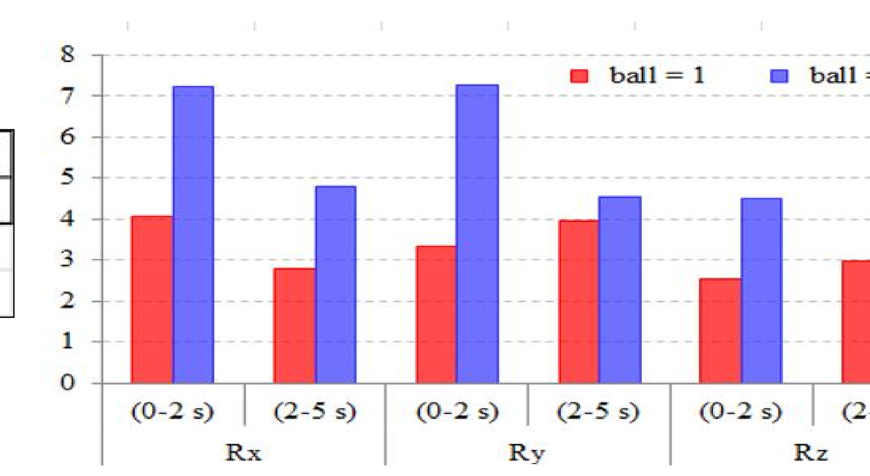


Fig 4. This shows the summary values for rotational velocity of a single ball vs multiple balls. Here, we can see that the multiple ball system has greater rotations compared to a single ball.

SUMMARY AND CONCLUSION

- ☐ There are characteristic differences in the time evolution of the translational (v_x, v_y, v_z) and rotational (ω_x, ω_y, ω_z) velocity magnitudes of the bouncing ball/s in the two scenarios examined
- ☐ The translation of a single centrally located ball (Case 1) is seemingly confined along the vertical direction only while that of the four balls (Case 2) have sizable components along the horizontal xy-plane
- ☐ It takes 0.303 seconds for the single ball to covera 1-mm distance along the xy-plane but during such time, the four balls (Case 2) have already covered a corresponding average distance of 89 ± 8 mm
- ☐ In terms of rotational velocity magnitudes, Case 2 yields consistently larger ω (rad/s) values, especially in the time window from 0 to 2 seconds where the average ω_x, ω_y, and ω_z values are 77.2%, 117%, and 77.9% greater, respectively, compared to that in Case 1.

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