Stability of object in Acoustic Field

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I. Introduction

Acoustic levitation has become more and more important nowadays, it's a technique of suspending objects by sound waves. Many applications take advantage of it, whether in chemical industry or biomedical applications.

Our research aims to study the performance of the sound field, observe the behavior of the ball with different shapes in the standing waves, and try to control the dynamic of it.

II. Apparatus for Experiment

Experimental setup including two Arduino and ultrasonic arrays. We program the Arduino for generating the signal with 40K in frequency and automatic control. With changing the voltage applied to each ultrasonicator, we could change the superposition of acoustic field and control the object to move between the nodes in horizontal.

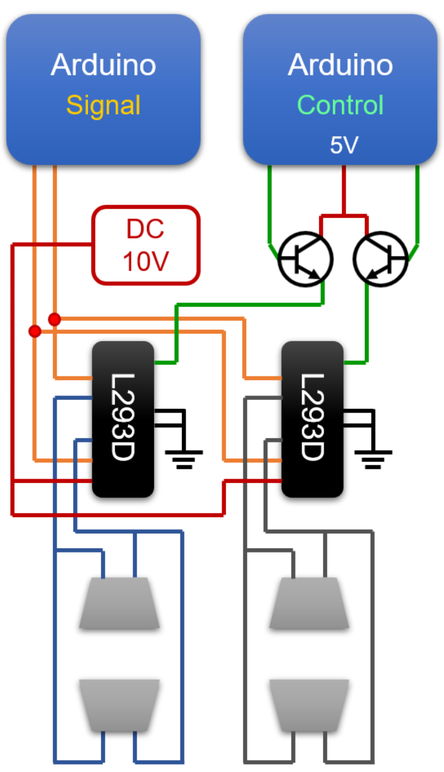

Fig. 1 Circuit

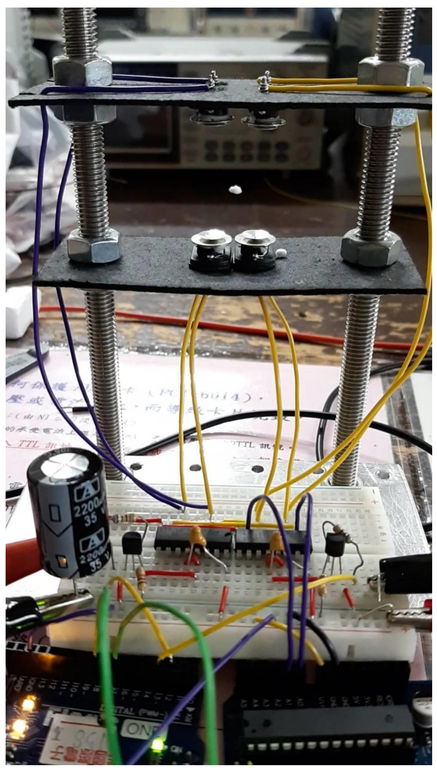

Fig. 2 Diagram of apparatus

III. Experimental Results

In our experiment, we control movement of the object by moving it left and right repeatedly, and then increase the oscillation frequency gradually. During this process, the behavior of the object would become more unstable when it move fast, and in the end it will fall.

We use tracker to track the motion, observing how object act in this motion state. Numerical data like position or acceleration are displayed in chart, we also do some simulation with Python.

	Sphere			Flat Disk		Ellipsoid
	A	B	C	D	E	F
$2r_c$	0.25	0.3	0.35	0.35	0.25	0.4
$2r_b$	0.25	0.25	0.3	0.3	0.25	0.25
$2r_a$	0.15	0.2	0.25	0.15	0.1	0.2

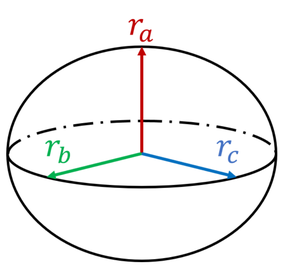

Fig. 3 The size of different objects in centimeters

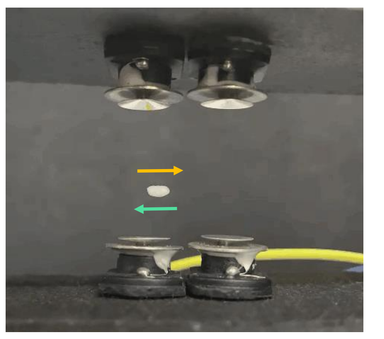

Fig. 4 The x – t diagram of Object D

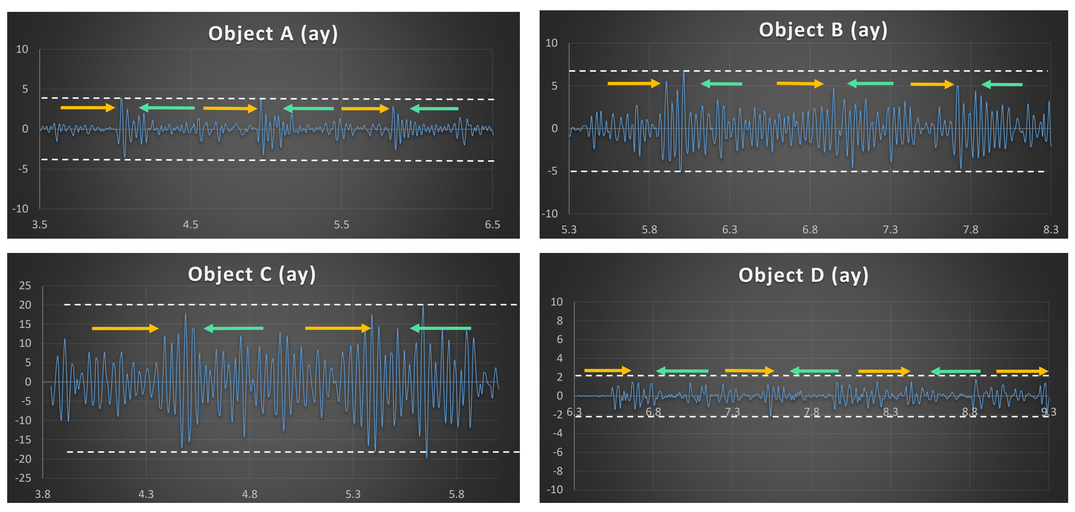

Fig. 5 The comparison of different shapes in ay – t diagram

The largest object C has the highest vertical acceleration up to 20 (m/s^2). Obviously, the larger radius, the more unstable state it will be. We also found that object in flat disc shape is more stable than the one in sphere shape.

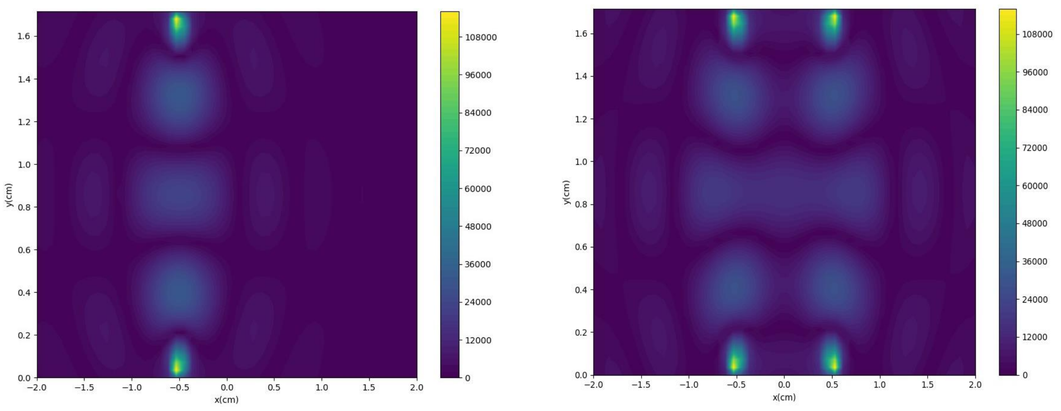

Fig. 6 Simulation of acoustic field. The left one represents the standing wave field switching to the left, while the right one is the opposite.

IV. Discussion

From (Fig. 6 - Left) we can see that the shape of the standing wave node is horizontal strip, so with larger r_a > 1/4 wavelength, the greater the pressure difference in contact, making the acoustic field can't hold it stable. Also note that the node in (Fig. 6 - Right) is slightly rough. We believe that is why the flat disk shape of the ball moves more stable.

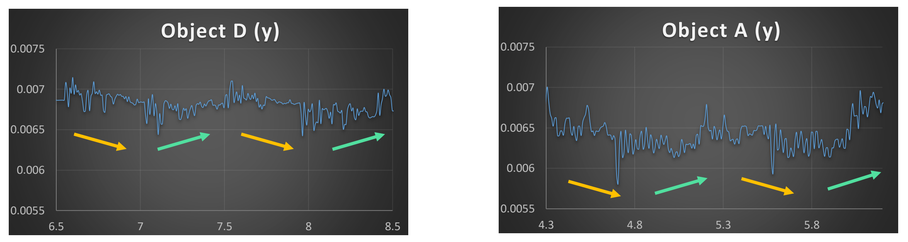

Fig. 7 Compare between flat disk and sphere y – t diagram

V. Conclusion

1. For the object $r_a$exceeds (Fig. 3) a 1/4 wavelength, it will become unstable in the acoustic field.
2. Also the object would be more stable when it fit the shape of the sound well perfectly.

Reference:

[1] Asier Marzo, Sue Ann Seah, Bruce W. Drinkwater, Deepak Ranjan Sahoo, Benjamin Long & Sriram Subramanian, *Holographic acoustic elements for manipulation of levitated objects*, Published: 27 October 2015

[2] Z. Y. Hong, J. F. Yin, W. Zhai, N. Yan, W. L. Wang, J. Zhang & Bruce W. Drinkwater, Dynamics of levitated objects in acoustic vortex fields, Published: 2 August 2017