DYNAMICS of VORTEX RING

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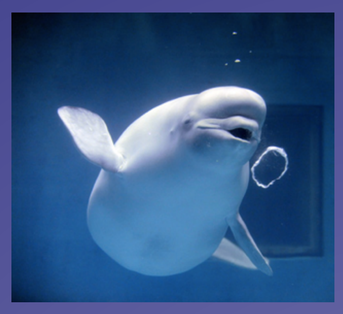
We are interested in the dynamics of vortex ring, so we setup a tank to study it. We are interested in the vortex ring will appear in what kinds of situation. Besides, we would like to study how the vortex ring can be generated, how it evolves and its flow field. Thus, we produce the bubble in three pressures with three diameters of hole in the tank to study.

MOTIVATION

Some dolphins, whales and porpoises would produce vortex rings for fun and also for communication.[1]. This phenomenon is interesting to us but only few articles talk about the bubble ring, so we want to examine the properties of the ring by ourselves.

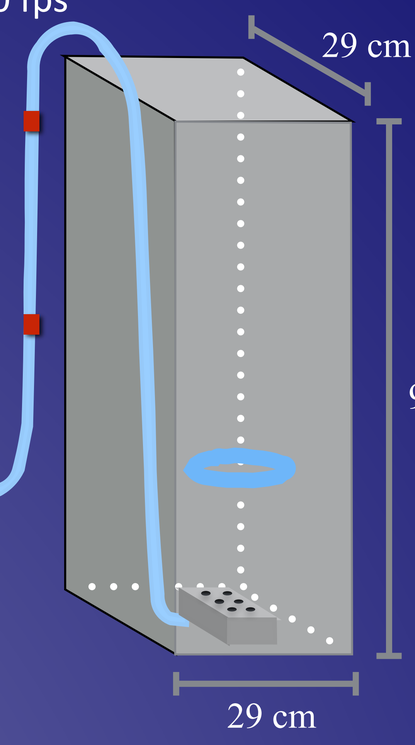
We want to know what kind of pressure is the most suitable for the rings to form and whether the orifice affects the formation of the ring. Then, we study the motion of vortex ring such as its velocity and the evolution of the bubble as a function of depth. In addition we use the PIV method to analyze the flow field around the bubble ring.



EXPERIMENTAL SETUP

- Porous Aluminum block (5.5x3.2x12.1)cm^3
- High speed camera with 240 fps
- The hose and two valves
- Acrylic tank (29×29x90)cm^3
- A barometer
- A inflator

1. How the vortex ring is generated ?
2. How it evolves ?
3. What is its flow field ?



INTRODUCTION

- Figure1 shows the flow field of the vortex ring.
- The vortex ring is in steady state(the shape remains the same) after it is generated.

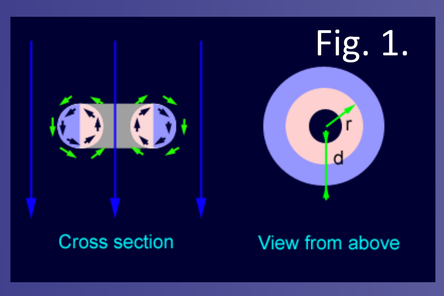
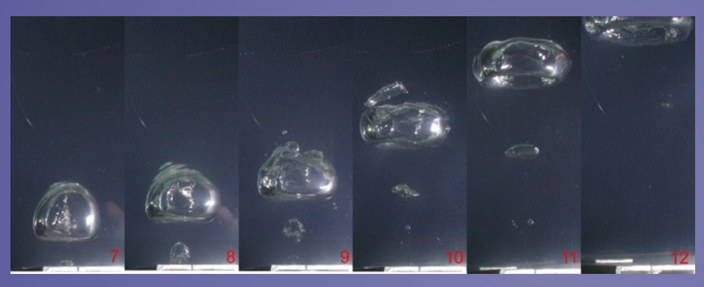
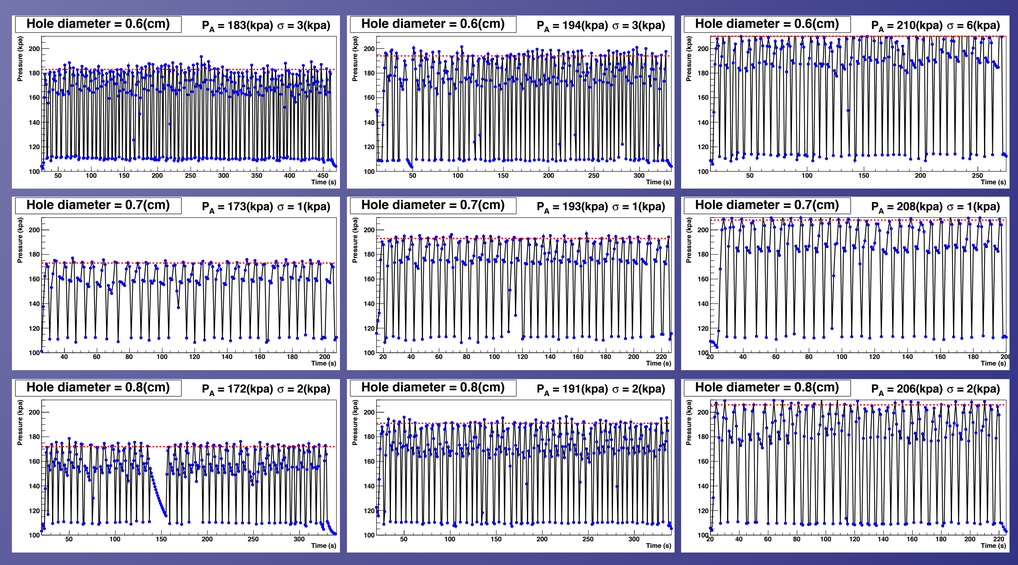


Fig. 1.



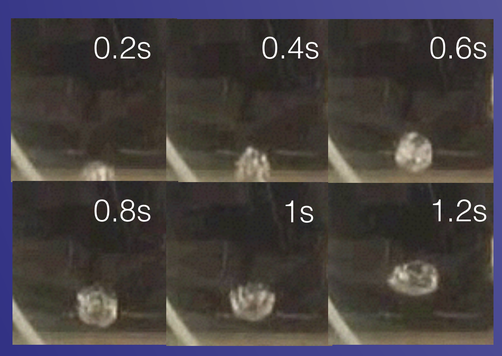
EXPERIMENTAL PROCEDURES

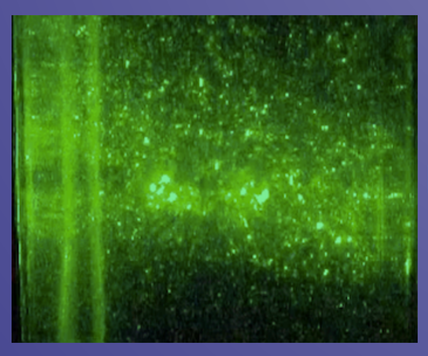
- Pump the air into the hose and lock the air by valves, and barometer to measure the pressure.
- Produce the 20 nice vortex bubbles per pressures and per hole. We control the pressure to around 170kpa, 190kpa, and 200kpa with the accuracy within 6kpa.
- Record the evolution of the bubble and vortex ring by high speed camera.

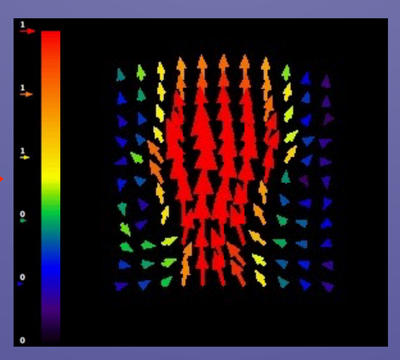


RESULTS

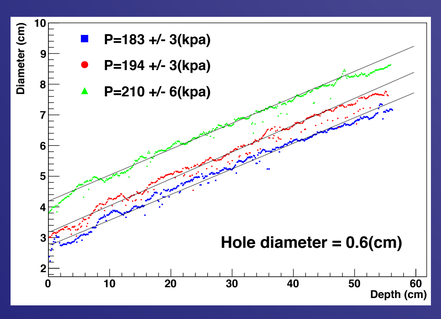
FORMATION PROCESS AND FLOW FIELD

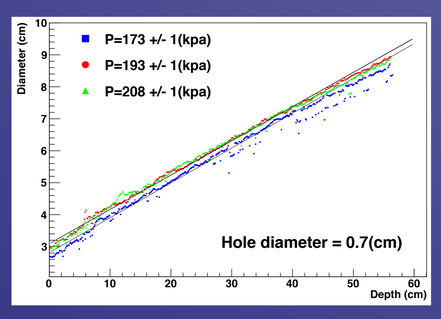


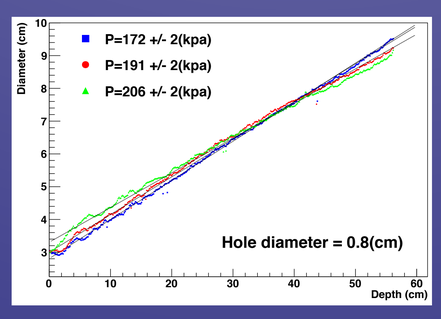




DIAMETER VS. WATER DEPTH

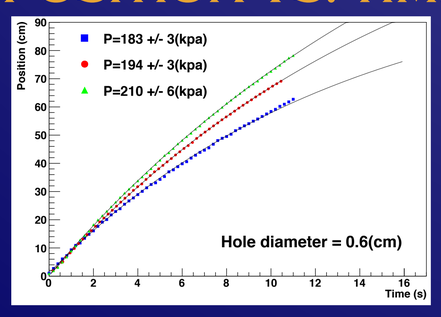


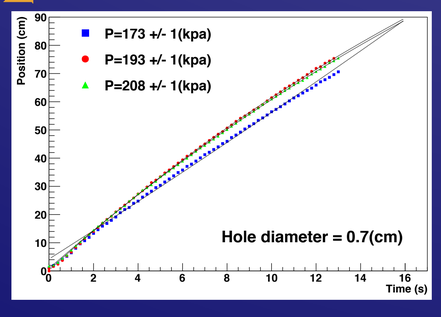


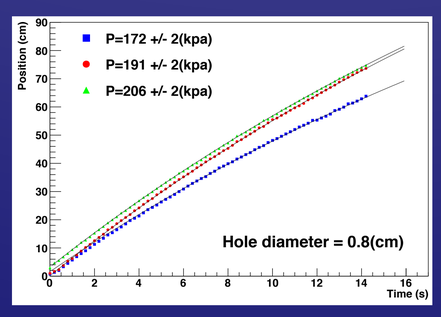


- The data are fit to f(x)=ax+b[2].
- The results show the evolution of the vortex ring linearly depends on the water depth.
- The statistical uncertainty is not shown to make the plots neat, but it is included in the fit.

POSITION VS. TIME







- The data are fit to $f(x)=a-be^{-cx}$,which can describe the data well.
- The statistical uncertainty is not shown to make the plots neat, but it is included in the fit.

CONCLUSION

1. We learn the mechanism of the vortex ring generation.
2. Vortex ring has a flow field which is continuously revolving from center bottom of bubble to the top, and then toward outside of bubble.
3. The smaller hole needs more pressure to form a vortex ring.
4. The results show the evolution of the vortex ring linearly depends on the water depth.
5. The data of position vs. time are fit to $f(x)=a-be^{-cx}$,which can describe the data well.

REFERENCE

[1] Journal of Comparative Psychology 2000, Vol. 114, No. 1, 98-106

[2] Proceedings of the royal society a mathematical, physical and engineering science, J.S. Turner, 1597, Vol. 239, Issue 1216

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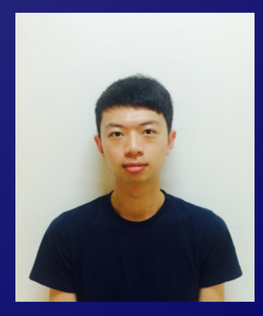

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