# 3P4-3

# Electrification of a bubble under SBSL
SBSL 気泡の帯電

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## 1. Introduction

During multibubble sonoluminescence (MB SL) measurements in Kr-saturated water at 1 MHz, we have observed an orange emission [1]. The orange emission occurred near the peelded part of ground electrode of the piezoceramic transducer, which part was partly peeled by cavitation-induced erosion and exposed to water. The spectra of the orange emission exhibited a broad component whose intensity increased towards the near-infrared region peaking at 713 nm and 813 nm which are corresponding to the vibrational transitions of water molecules. The orange emission occurred at the timing of bubble collapse. Those results suggested that the cavitation bubbles ware affected by the electric fields which leaked from peeled ground electrode. A possible emission mechanism was proposed based on charge induction by electric fields and the charged droplet model.

This sonoluminescence study suggested that the cavitation bubbles can be charged. Therefore, we investigated a possibility of electrification of a bubble under single-bubble sonoluminescence (SBSL). We measured the sonoluminescing bubble positions under externally controlled electric fields and determined that the bubble under SBSL is positively charged.

## 2. Experiments

**Figure 1** shows an experimental system. The ultrasound frequency used was 28.5 kHz. The sample liquid was deionized water, which was degassed until the dissolved oxygen (DO) was less than 1 mg/L, and contained a cylindrical cell (a depth is 64 mm and height is 66 mm) made of quartz glass. The electric conductivity of sample liquid was 1 μS/cm. The temperature of the cell was kept at 15℃ by circulating temperature controlled water through a silicone tube that surrounded the cell.

Platinum needles with diameter of 0.5 mm were used as electrodes. The electrode tips were faced with each other. The distance between of electrodes is 12 mm and the bubble was located in the middle of the electrodes.

SL was detected with a photomultiplier

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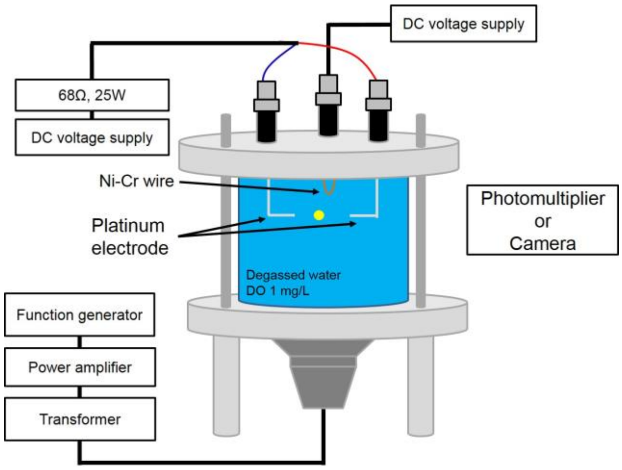


Fig.1 Experimental system

(Hamamatsu Photonics H7422-01). The position of the bubble was captured with a digital camera (Canon EOS6D) incorporated with a large magnification lens. We obtained the bubble positions under electric fields from the photographs. We applied direct-current (DC) voltage (±150 V) to electrode and measured the leaking voltage at the bubble location using a platinum probe with 1mm diameter.

## 3. Results and discussion

**Figure 2** shows SBSL intensities from water under no electric fields as a function of driving voltage of function generator. At the low acoustic pressure, i.e. at the voltage of 290 m $V_{pp}$ in Fig.2, The bubble exhibited dancing. When the driving voltage increased to 330 $mV_{pp}$, the bubble became spatially stable and emitted bluish white light. Furthermore, the intensity of SBSL increased with increasing driving voltage. At the highest acoustic pressure, i.e. the voltage of 385 $mV_{pp}$, the bubble completely disappeared. We performed electrification measurement at the driving voltage of 350 $mV_{pp}$, which exhibited spatiotemporally stable SL.

**Figure 3** shows the SL bubble positions when various DC voltages were applied to electrode. Initial bubble position with applying no electric field was at the origin. The hot electrode and ground position was denoted as (5.8, -0.5), (-6.2,

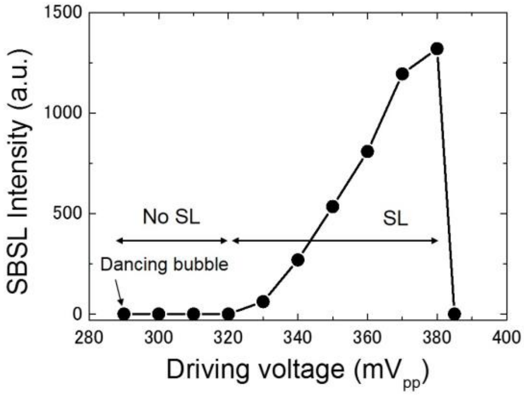


Fig.2 Intensity of SBSL from deionized water as a function of driving voltage.

-0.5) in coordinates, respectively. When +70 V was applied to the hot electrode, +10 V was measured at the initial bubble position using a platinum probe. The bubble positions shifted to minus direction receiving repulsion force from electrode when DC positive voltage was applied. Conversely, the bubble shifted to plus direction receiving attractive force from hot electrode when DC negative voltage was applied. The displacements of bubble increased as the applied voltage to hot electrode increases both for positive and negative cases. Those results indicated that the sonoluminescing bubble is positively charged.

**Figure 4** shows the dependence of bubble positions under electric fields on sonoluminescing time. The positon of bubble was obtained at the timing of 1 s and 300 s after SL light emitted. The result showed that the displacement for 300 s was larger than that for 1 s. The displacements in the cases of longer than 300 s showed similar values as that for 300 s. This dependence suggested that the duration of cavitation time affected the electrification of SL bubble.

Most of studies on the electrification of bubble showed that a bubble has negative charge. The production process of an acoustic cavitation bubble is quite different from a non-cavitation bubble in water. The temperature of inside cavitation bubble at the violent collapse increases to approximately 10,000 K. Under the condition, oxidants such as OH radicals, hydrogen peroxide are formed and diffuse out from a bubble into the surrounding liquid [2]. It is suggested that the extreme conditions of cavitation bubble will be determining factor of the electrification of SL bubble.

## 4. Conclusion

Displacement of a stable bubble under SBSL

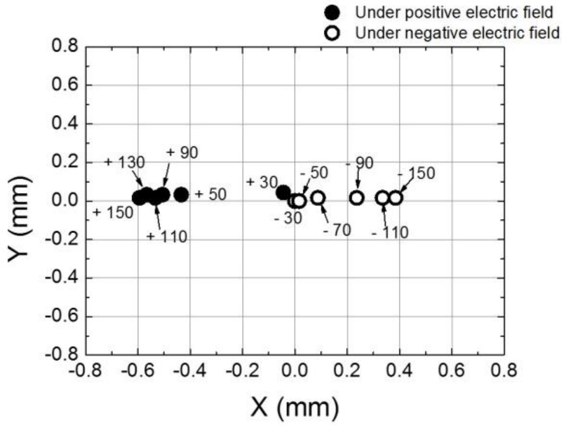


Fig.3 The bubble positions under various electric fields. Initial bubble position was at the origin. The electrode and ground position was (5.8, -0.5), (-6.2, -0.5) in coordinates, respectively. The closed circles are bubble positions under positive electric fields and the number indicated applied voltage value to electrode. The open circles are in the case of negative electric fields.

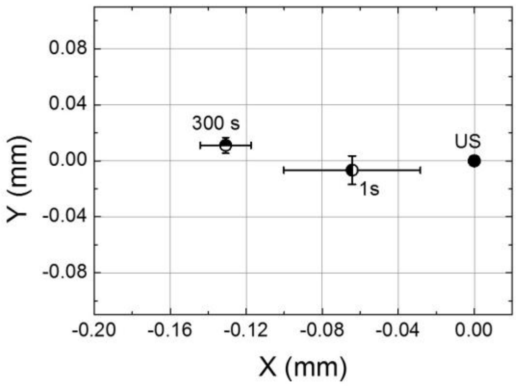


Fig.4 Dependence of bubble positions on sonoluminescing time under electric fields. The closed circle indicates the bubble position under ultrasound only. The left half and upper half closed circles indicate the bubble positions when + 70 V was applied at the timing 1 s and 300 s after the bubble emitted light, respectively.

was studied when DC voltage was applied to the bubble. The bubble position shifted by receiving repulsive or attractive force from an electrode when DC voltage was applied. The displacement of bubble positions depended on sonoluminescing time. The results suggested that the bubble under SBSL is positively charged and the quantity of the charge depends on the duration of cavitation.

## References

1. H.B. Lee and P.K Choi: Ultrason. Sonochem. **42** (2018) 551.
2. K. Yasui, T. Tuziuti, Y. Iida and H. Mitome: J. Chem. Phys. **119** (2003) 346.