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# Two components in sonoluminescence spectra of Na emission

## Na ソノルミネセンススペクトル中の二つの成分

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### 1. Introduction

In the study of sonoluminescence from alkali-metal atoms induced by ultrasonic cavitation, we observed a broadening and peak shift of the line spectrum which were caused by a high temperature and high pressure within bubbles[1]. Sonoluminescence from NaCl solution exhibited Na emission composed of peaks at 589.6nm and 589.0nm, and a continuum extending from ultraviolet to infrared region. Hayashi and Choi suggested that the Na lines consists of two components, one of which is broadened component which are shifted from original D lines, and the other is unshifted narrow component[2]. We refer these components as Broad and Narrow component.

In order to investigate the origine of these two components, we spatially separated Broad and Narrow components by capturing sonoluminescence images using different optical filters. We also temporally separated these components by measuring light pulses which transmitted through the filters and detected with two photomultipliers and a fast sampling oscilloscope.

### 2. Experimental

NaCl aqueous solution with the concentration of 4M was degassed and saturated with Ar, Kr or Xe gas. NaCl solution, a volume of 350 mL, was contained in a cylindrical glass cell and irradiated by ultrasound at the frequency of 145 kHz. The temperature of the cell was kept at 10℃ by circulating temperature-controlled water. We used a blue-pass filter (Transmission band wavelength of 400~470nm) and a Na filter (Center wavelength of 589.3nm, FMHM 9.92nm) to separate the continuum and Na emission, respectively. We also used a filter N(Center wavelength of 589.3nm, FMHM 1.18nm) and a filter B(Center wavelength of 592.5nm, FMHM 1.57nm) to separate the two components of Na emission. Figure 1 shows the spectra of the Na components which were measured with different filter. The filter N extracts only Narrow component, and filter B extracts only Broad component. For the space separation of these components, we put a filter before a camera (Canon EOS 6D) and photographed with a sensitivity of ISO 12800. The exposure time were 0.5 and 5 s for the continuum and Na emission, respectively.

An experimental setup of the temporal separation is shown in Fig.2. The light emission was divided by a half mirror, transmitted through the filters and detected with two photomultipliers. Single shots of SL light pulse were observed with a 4 G Sa/s oscilloscope. (Agilent DSO5052A ).

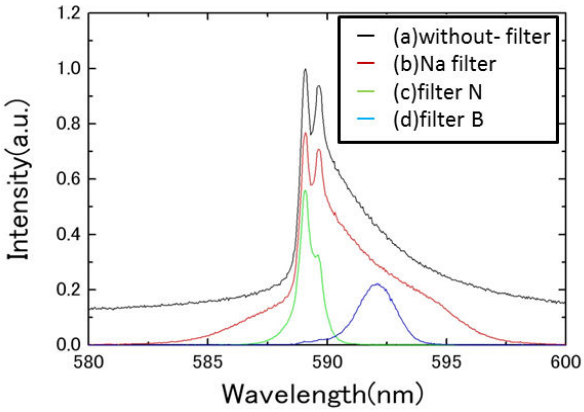


Fig.1. Na spectra separated by different filter.

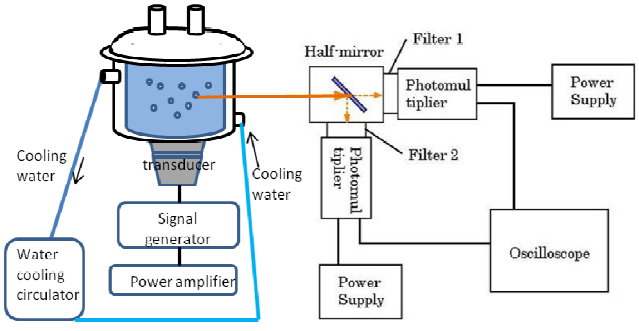


Fig.2.Experimental setup for temporal separation of sonoluminescence pulses.

## 3. Results and discussion

Figure 3 shows the oscilloscope tracings of the detected light pulses. We observed Broad component in Ch.1(the upper trace in Fig.3(a)) and Narrow component in Ch.2 (the lower trace in Fig.3(a)). The trigger of the oscilloscope was set by Ch.1. Figure 3 (a) indicates that the timing of the light pulses of Narrow component does not coincide with that of Broad component. This suggests that the emissions of both components occur at different timing. Similarly, light pulses of Broad component were not detected when we set the trigger by Narrow component. Figure 3(b) shows a similar comparison between the continuum emission and Na emission. Similar to the results of the Fig.3 (a) , the two emissions showed different timing. We found that there are differences in the timing of the light pulses of Broad component, Narrow component and the continuum.

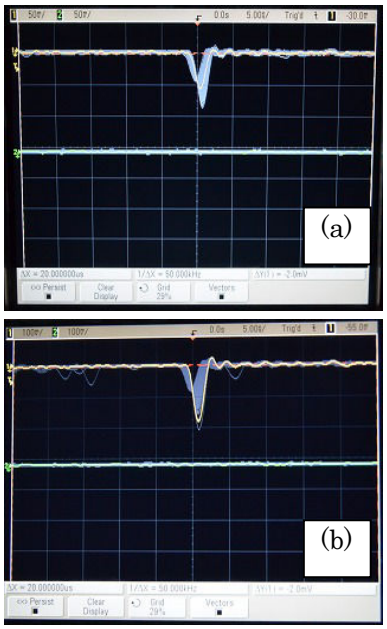


Fig.3.Sonoluminescence pluse from NaCl saturated with Xe gas (a)upper:Broad component, lower:Narrow component, (b)upper:Cotinuum, lower: Na emission. Traces of single pulse are accumulated.

In Fig.4, shown are SL photographs for the continuum, Broad component and Narrow component from top to bottom. Left half of Fig.4 are photographs taken from the front of the cell, the right half of Fig.4 are those taken from the top of the cell. Emission of the continuum is relatively strong in the region near the bottom of the cylindrical cell where sound pressure is probably larger. Emission of Narrow component is relatively strong in the region at the center of the cell. Emission of Broad component is mostly distributed near the side wall of the cell so as to surround the center of the cylindrical cell. Sound pressure is high at the center axis of the transducer. It is concluded that the distribution of light emission is different for the three kinds of emission, and depends on sound pressure at the emission region. The sound pressure in the region of the continuum emission may be higher than that of Na emission. And the sound pressure in the region of Narrow component may be higher than that of Broad component.

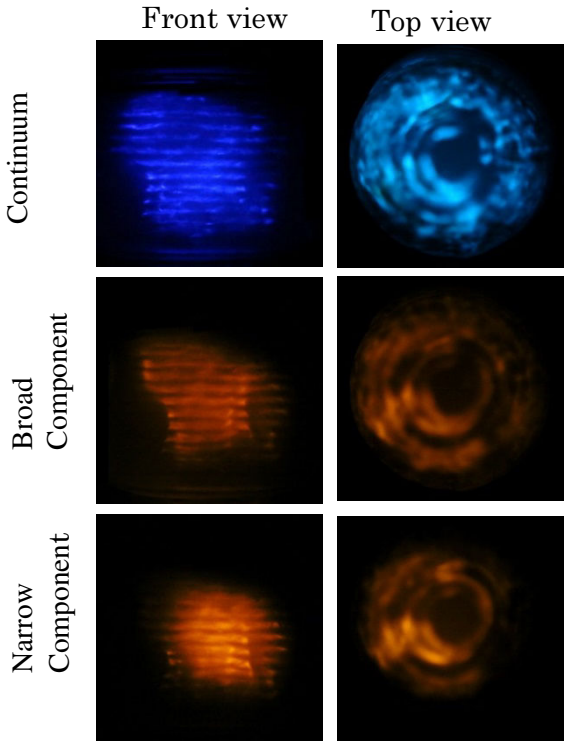


Fig.4 .Sonoluminescence from 4M NaCl saturated with Kr gas

## 4. Conclusion

The timing of light pulses and light emitting distribution were different between the Broad and Narrow components and also between continuum and Na component. These results conclusively show that the continuum, the Broad component and Narrow component of Na emission are originated from different bubble populations.

## References

1. Yuichi Hayashi and Pak-Kon Choi, J. Phys. Chem. B, **116**, 7891-7897(2012)
2. Yuichi Hayashi and Pak-Kon Choi, AIP Conf. Proc., **1474**, 159-162(2012)