Application of Ultrasound Acoustic Levitation for X-ray Protein Crystallography Experiments using Rotating Levitated Thin Films

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Background, Motivation and Objective

Ultrasound acoustic levitation is a well-established technique with several applications offering non-contact sample manipulation capability [1-3]. Recently, we have demonstrated its application for protein X-ray diffraction experiments [1]. Using levitated droplets as the sample carrier and combining with the high-brilliance X-ray source and fast-frame-rate X-ray image detectors, as shown in Fig. 1(a), data collections within a few seconds have been achieved. Further, we have shown the observation of slow bio-chemical reaction using the same technique [4]. To extend the method to samples prepared in a highly viscous medium, we propose the X-ray diffraction experiment using levitated thin films as the sample carriers.

Statement of Contribution/Methods

We used a single-axis ultrasound levitator excited by bolt-clamped Langevin-type oscillator. The levitator acoustic cavity was formed by a horn and a concave-mirror reflector (focus of 20 mm), both with the diameter of 20 mm. The ultrasound pressure was monitored by a piezo-sensor attached to the mirror, Fig. 1(a). In the experiments, we studied the rotation of polymer films with the size of ~4 mm and various shapes as function of the ultrasound pressure for passive rotation control. This was supplemented by active rotation control using pulses of pressurized gas. The streaming flow was visualized by incense fume, Fig. 1(b).

Results/Discussion

We have found that the levitated films in the ultrasound wave rotates with the controllable rotation speed, and successfully utilized it for pilot protein crystallography experiments. In this work, we wish to present our investigation on the physical mechanisms of the rotation, a method to control the rotation speed, as well as its correlation with the acoustic streaming flow, Fig. 1(b). Crucially, we were able to control the rotation conditions in the range of 0-100 Hz, that is relevant to the X-ray data collection.

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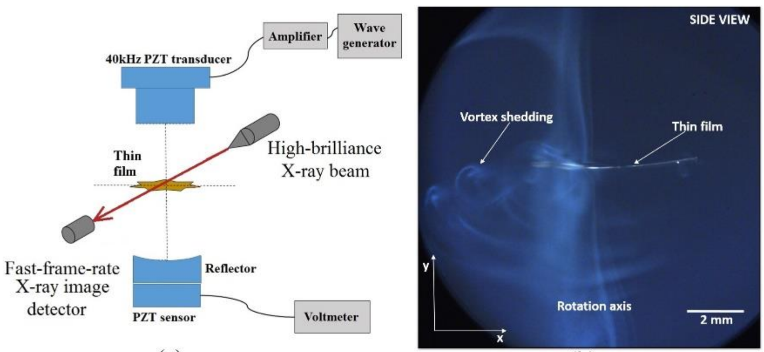
[3] A. Marzo and B. W. Drinkwater, **PNAS** 116, 1, 84-89 (2019).
[4] T. Tomizaki et al., **AIP Conference Proceedings**, 2054, 060072 (2019).



(a) (b)

Figure 1: (a) Experimental setup for X-ray protein crystallography using thin film ultrasound acoustic levitation compatible with the fast-frame-rate detector. (b) Incense smoke used to visualize vortex shedding for different film geometries and levitation parameters.