

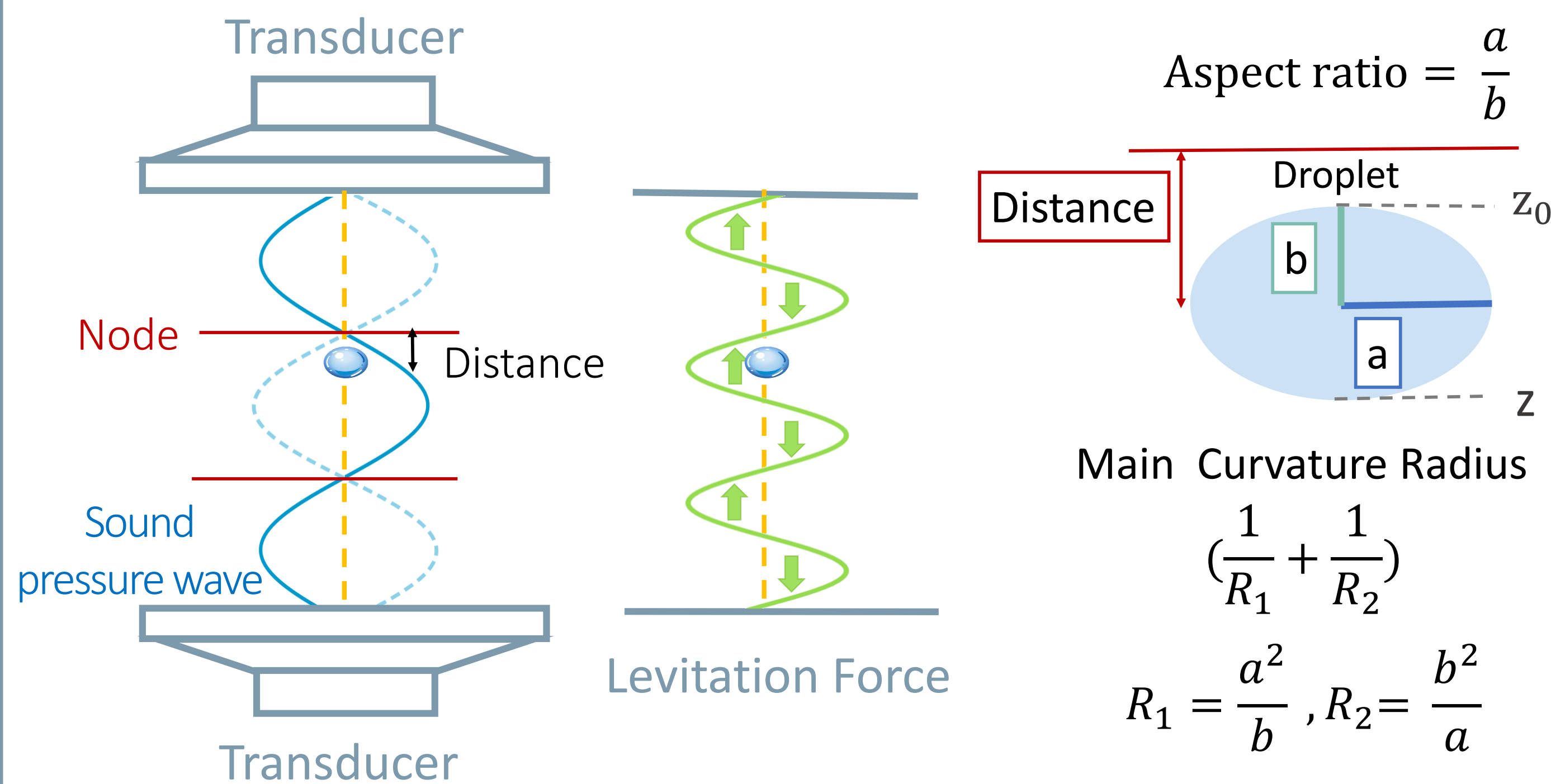
Droplets Pinched by Acoustic Hand

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Acoustic levitation is a special method for measuring the surface tension. When the droplet is acoustically levitated, the shape of the droplet is determined by the sound pressure and its surface tension. Because the sound pressure is difficult to measure, the value of the sound pressure is derived by suspending the liquid with a known surface tension. Then, the surface tension of other liquids surface can be measured.

Introduction

Surface tension can be measured by many different techniques [1]. In the common methods, the liquid has to contact with a solid material [2]. Acoustic levitation provides a non-contact method to measure the surface tension [3]. The surface tension is measured by observing the shape of the droplet controlled by the ultrasound. Because acoustic levitation is a non-contact method and requires a small amount of the liquid, we adopted this novel method to measure the surface tension. Besides, because of the thermal agitation, we also study the surface tension as a function of temperature.



Theory

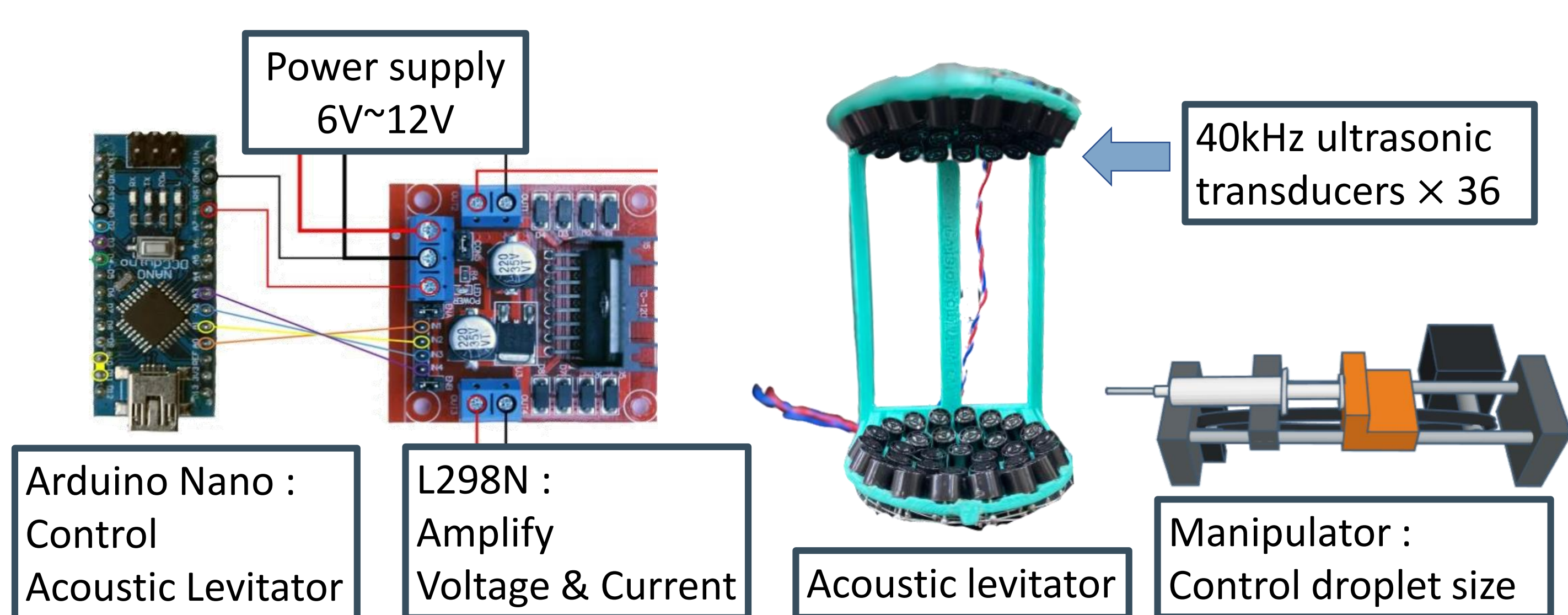
$$\gamma \cdot \left(\frac{1}{R_1} + \frac{1}{R_2} \right) = \Delta P_{st} + \Delta P_{rad} + \Delta P_g$$

$$= \frac{2\gamma}{R} + \Delta P_{rad} + \rho_L(1 - \lambda)g(z_0 - z)$$

(ρ_L : liquid density, g : gravity, λ : $\frac{\text{air density}}{\text{liquid density}}$, z/z_0 : shown above)

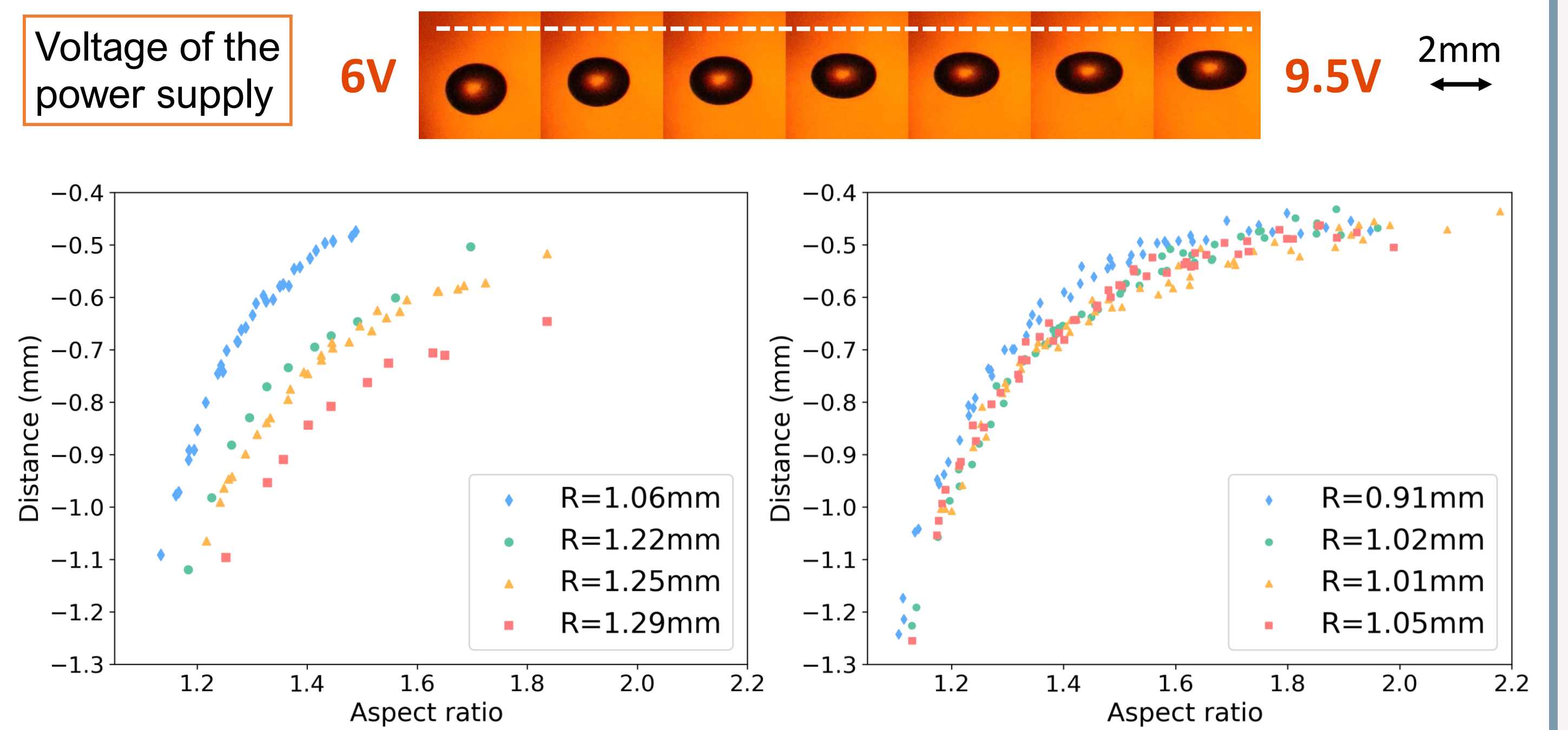
Acoustically levitated droplet's surface tension (γ) is controlled by the droplet's shape, surface pressure difference (ΔP_{st}), acoustic pressure difference (ΔP_{rad}) and gravity difference (ΔP_g). The ΔP_{rad} can only be measured indirectly in this experiment. With the control liquid (water) surface tension, the ΔP_{rad} can be derived and the surface tension of the other liquid is measured. The R_1 , R_2 and ($z_0 - z$) are measured by the shape of droplet. Because it is a circle from the top view, the volume can be calculated by the $\frac{4}{3}\pi a^2 b$. R is the radius of sphere with the same volume as droplet.

Experimental Setup

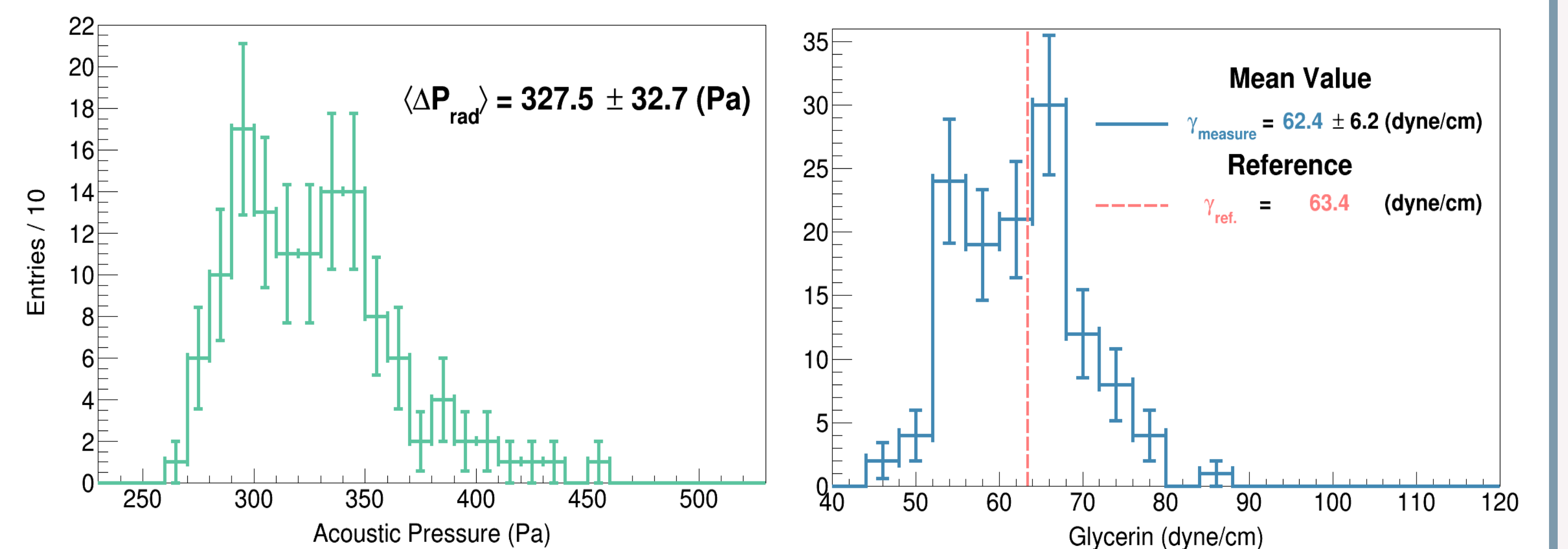


Results

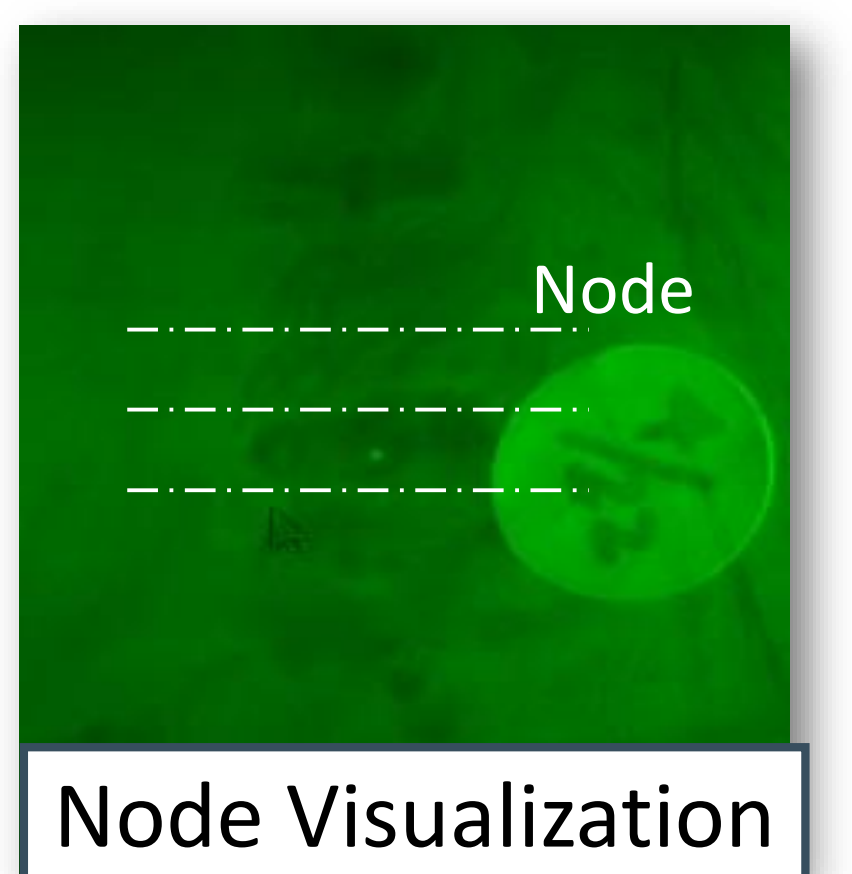
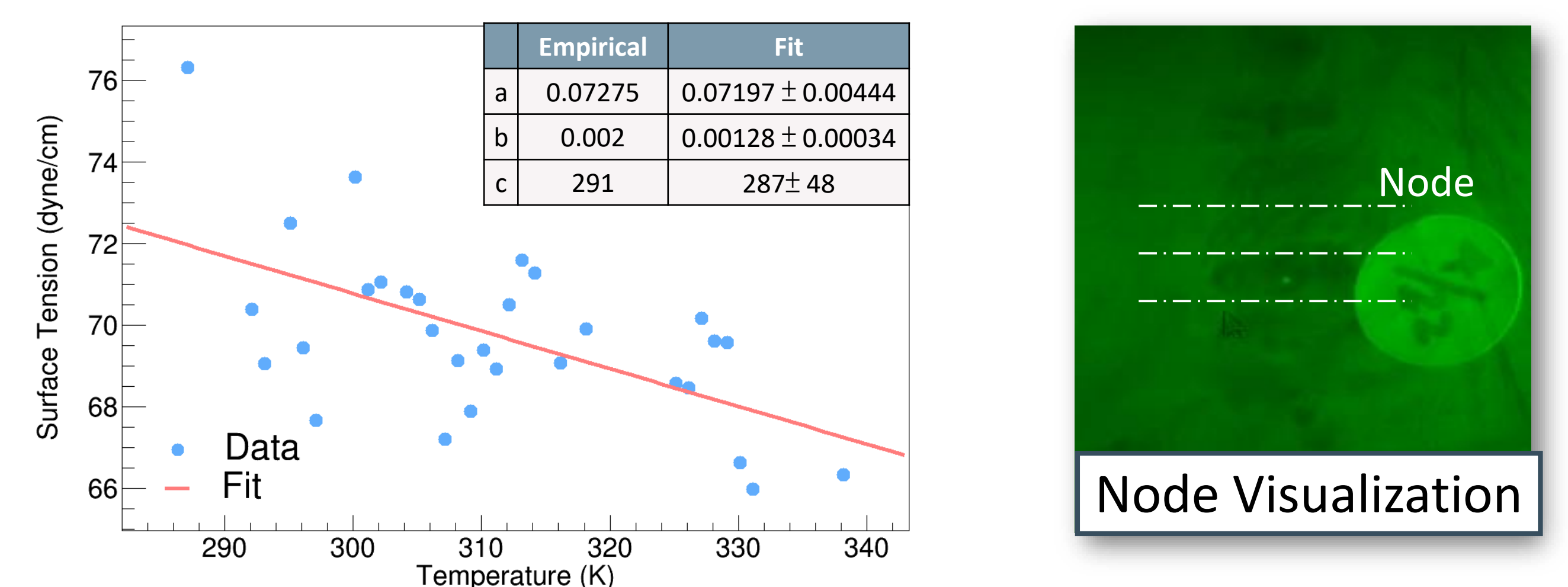
When changing the amplitude of acoustic (the voltage of the power supply), the static position of the droplet would be far from the node, and the shape tends to be a circle.



The average derived sound pressure is 327.5 ± 32.7 (Pa). Besides, the measured surface tension of glycerin is 62.4 ± 6.2 (dyne/cm), 1.6% relatively difference to the reference value (63.40) [5].



As the thermal agitation increasing, the surface tension of the water is decreasing. The relation is summarized by fitting an empirical formula $\gamma = a(1 - b(T - c)) \times 10^3$ [6].



Conclusion

1. The surface tension of droplets can be derived by surface pressure difference (ΔP_{st}), acoustic pressure difference (ΔP_{rad}) and gravity pressure difference (ΔP_g).
2. As the droplet is far from the node, its shape is round.
3. The derived acoustic pressure is 327.5 ± 32.7 (Pa).
4. The measured surface tension of glycerin is 62.4 ± 6.2 (dyne/cm), 1.6% difference from the reference [5].
5. As the thermal agitation increasing, the surface tension is decreasing as a function of $\gamma = a(1 - b(T - c)) \times 10^3$ [6].

[1]: Physical Chemistry of Surfaces, 6th ed. (1990). [2]: Phys. Chem, 56, 284(1952).
[3]: Rev. Sci. Instrum. 66, 3349 (1995). [4]: Physics of Fluids 7, 2601 (1995).
[5]: Computational Techniques for Multiphase Flows, 7th ed. (2007).
[6]: https://en.wikipedia.org/wiki/Surface_tension