Journal of Zhejiang University-SCIENCE A

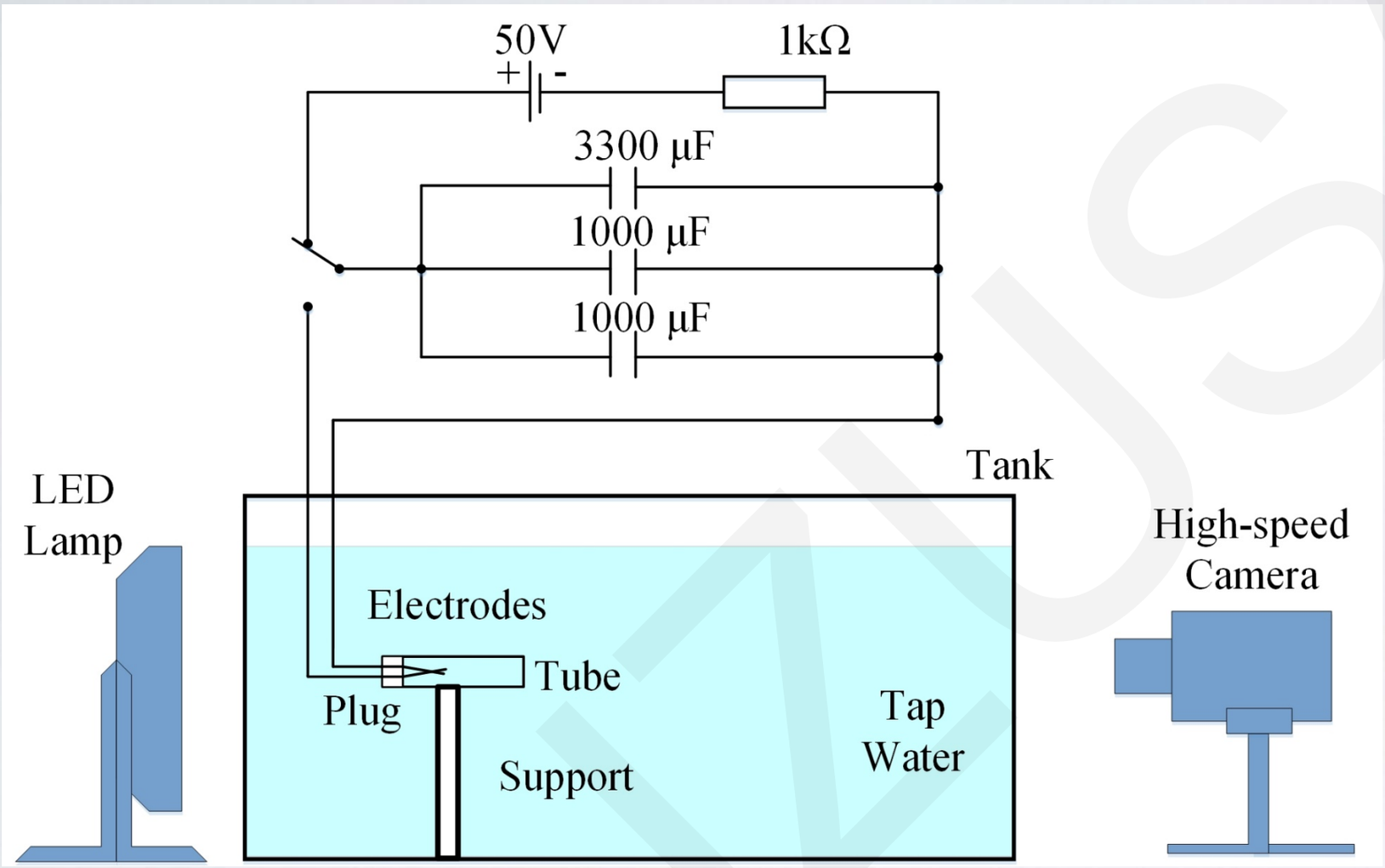
Experimental investigation of vortex-ring cavitation

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Key words: Cavitation, Toroidal cavity, Oscillation period, Impinging on wall

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Experimental setup

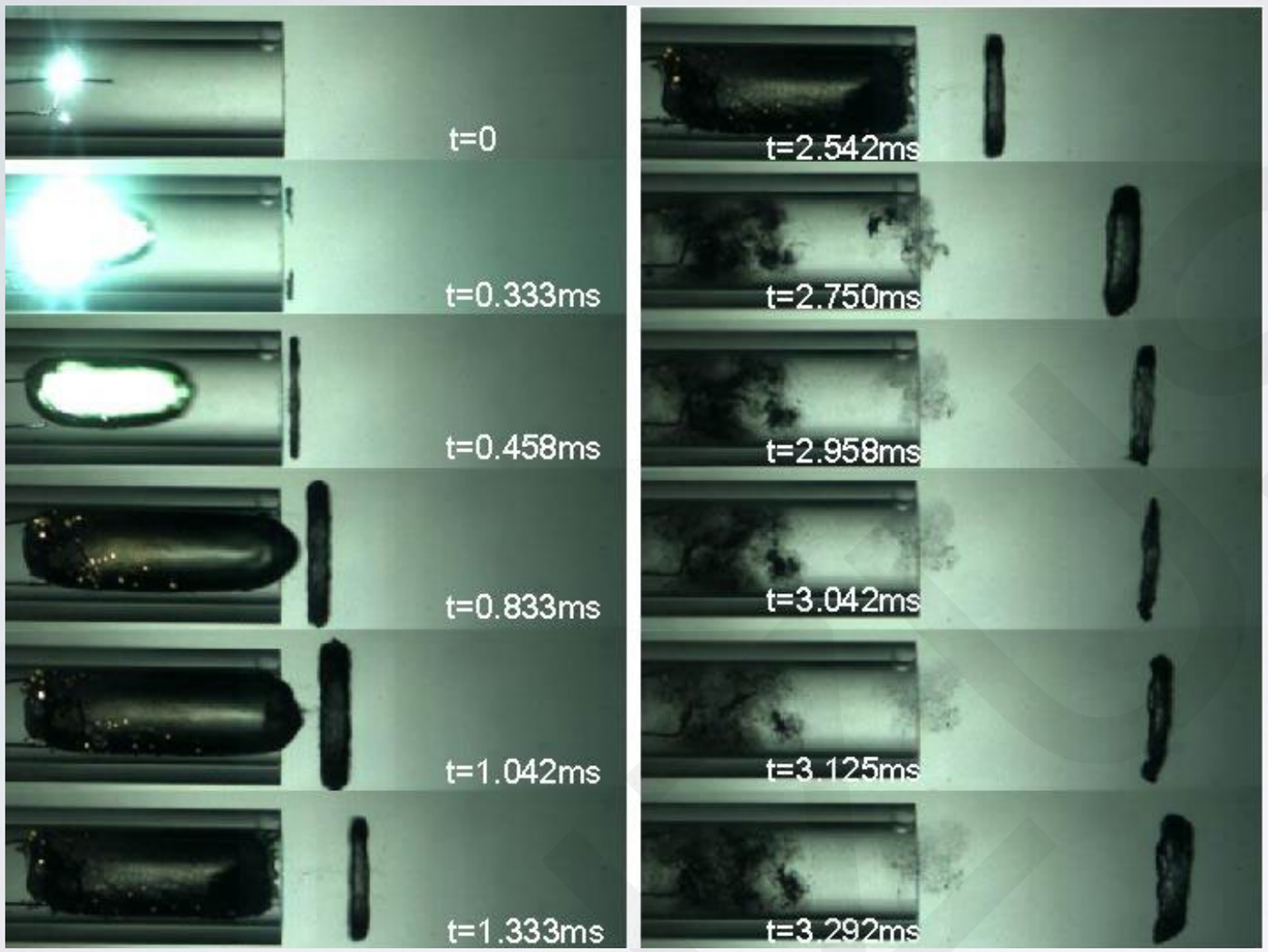


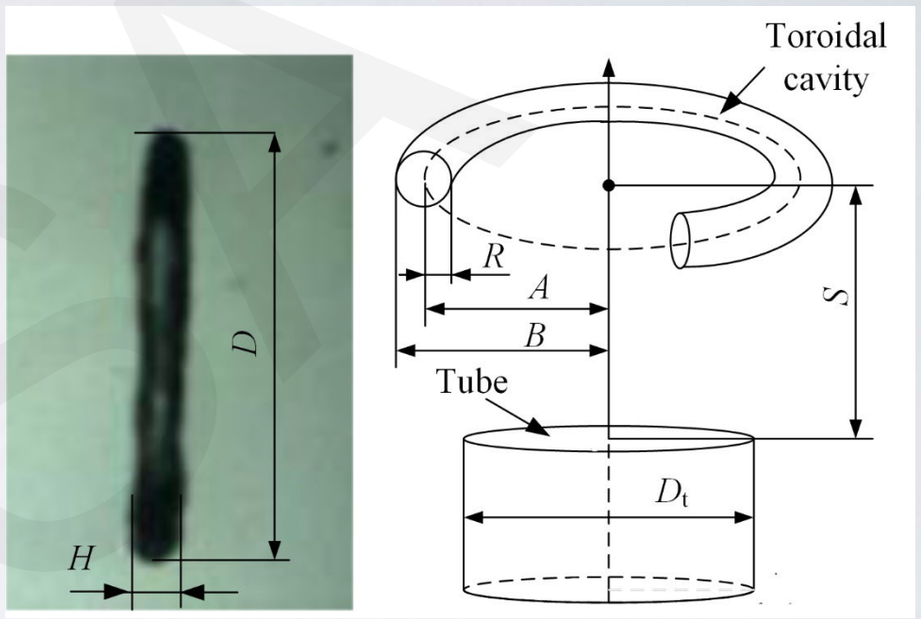
A circuit is used to induce a low-voltage electric spark in a transparent cylindrical tube immersed in tap water, to generate a cavitation bubble in the tube.

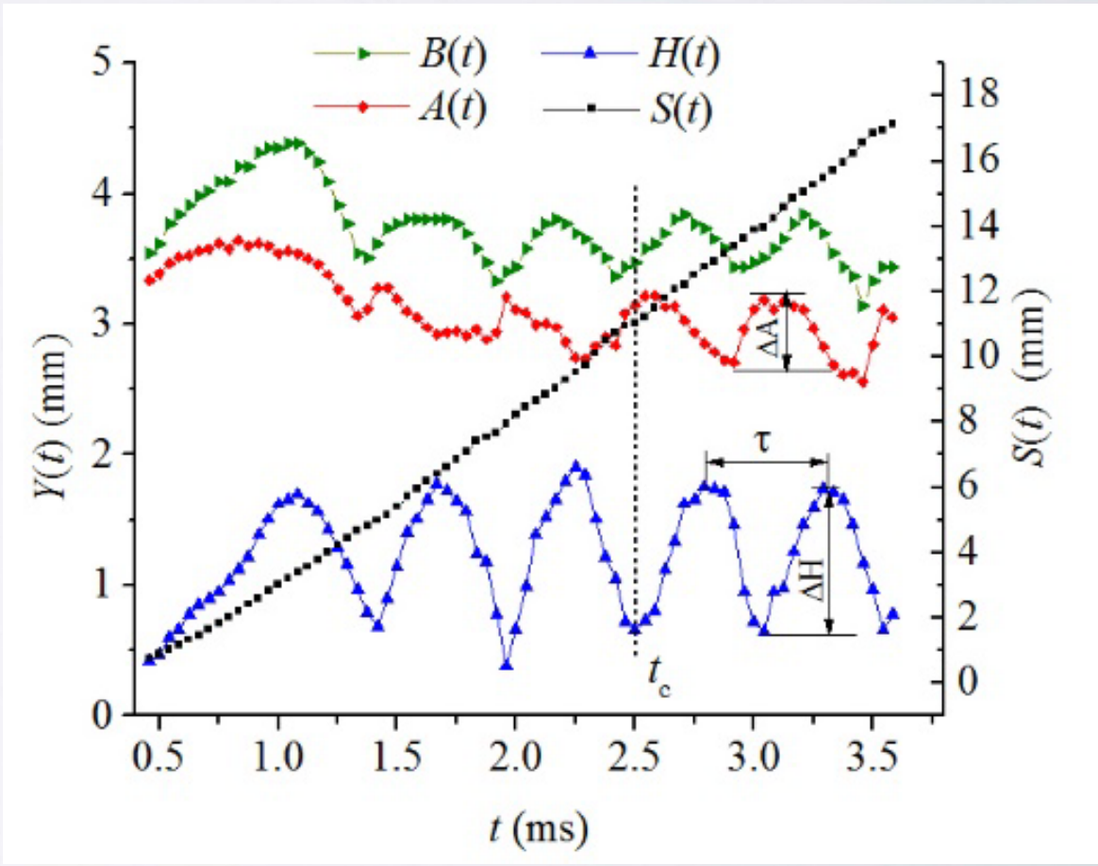
One open end of the tube is blocked by a silica gel plug pierced by electrodes, which encourages the formation of a toroidal cavity around the other open end.

Schematic diagram of the experimental setup

The oscillation of the toroidal cavity

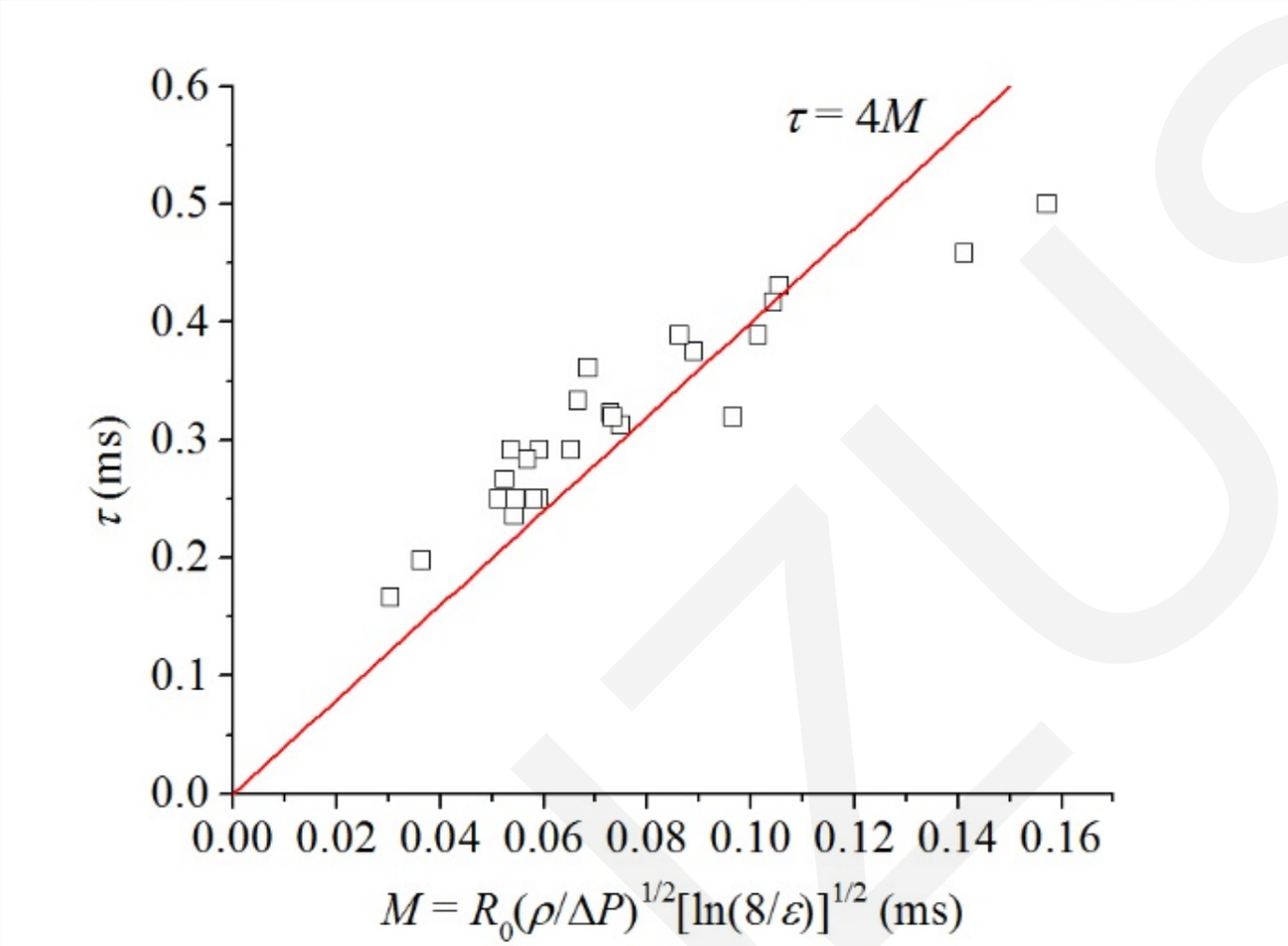






The toroidal cavity oscillated periodically and moved with a constant velocity after the collapse of inner bubble

The oscillation period of toroidal cavities



The oscillation period of toroidal cavities follow the scaling law:

$$\tau \sim R_0(\rho/\Delta p)^{0.5}[\ln(8/\varepsilon)]^{0.5}$$

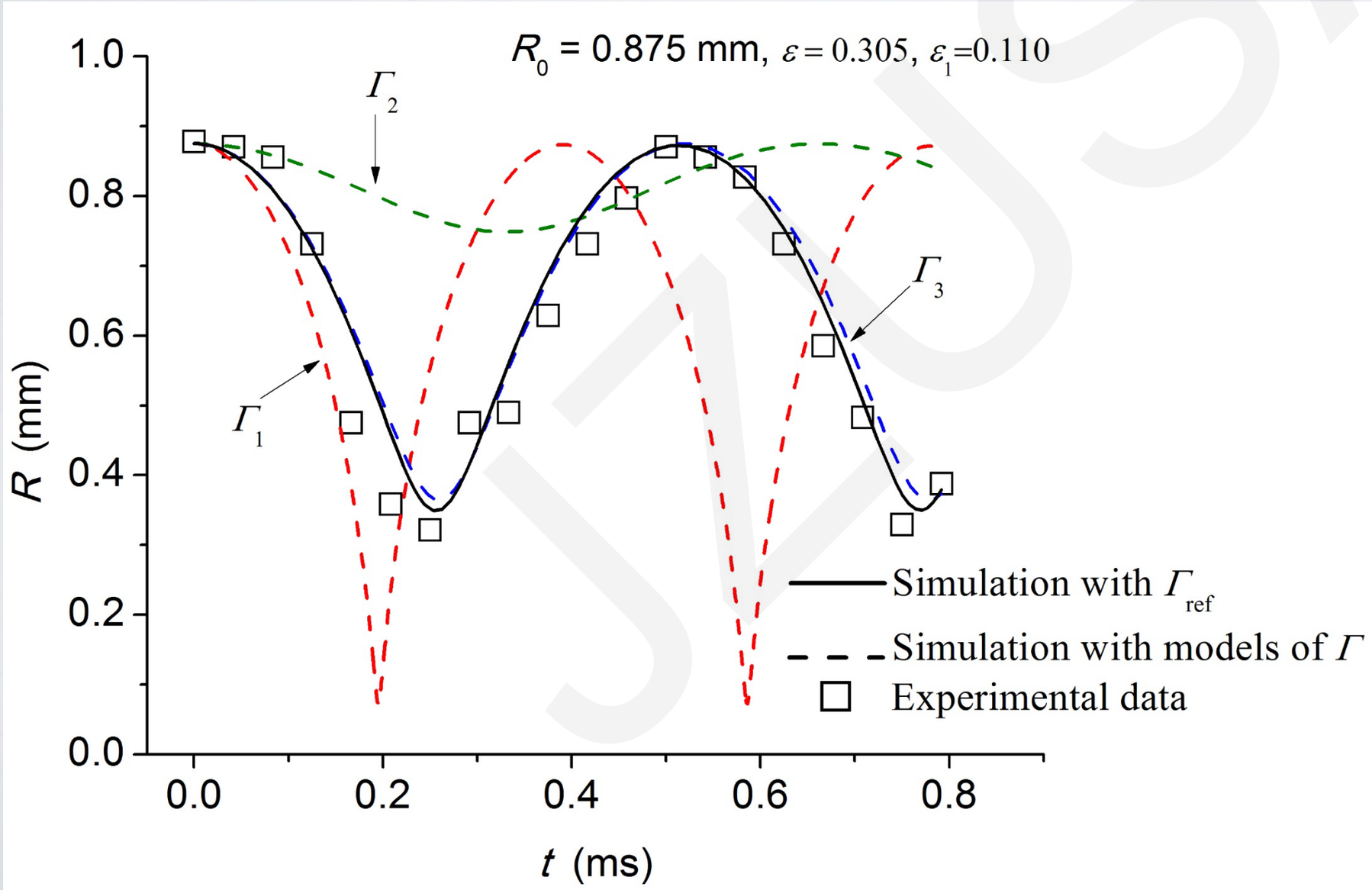
Oscillating model for a toroidal cavity

$$(R\ddot{R}+\dot{R}^2)\ln\frac{R}{8A_0}+\frac{1}{2}\dot{R}^2=\frac{1}{\rho}[P_0-\frac{\rho}{2}\left(\frac{\Gamma}{2\pi R}\right)^2-P_v-P_{g0}\left(\frac{R_0}{R}\right)^{2k}+\frac{\sigma}{R}]$$

The circulation Γ is hard to measure ⇨ How to evaluating Γ?

⇩

Circulation calculation



Line vortex model

$$\Gamma_1=2R_0V_z$$

Hollow core model with maximal core radius

$$\Gamma_2=\frac{4\pi R_0V_z}{\left(\varepsilon\log\frac{8}{\varepsilon}-\frac{1}{2}\varepsilon\right)}$$

Hollow core model with minimal core radius

$$\Gamma_3=\frac{4\pi R_1V_z}{\left(\varepsilon_1\log\frac{8}{\varepsilon_1}-\frac{1}{2}\varepsilon_1\right)}$$

Summary

- The oscillation of toroidal cavities induced by vortex rings is investigated experimentally.
- The experimental data agree well with the theoretical analysis: $\tau \sim R_0(\rho/\Delta p)^{0.5}[\ln(8/\varepsilon)]^{0.5}$
- An estimation model of circulation is proposed

$$\Gamma = 4\pi R_1 V_z \Big/ \left(\varepsilon_1 \log\frac{8}{\varepsilon_1} - \frac{1}{2}\varepsilon_1 \right)$$