# Numerical Simulation for Laminar Two-phase Flow Velocity Fluctuation

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## Purpose

We computed the laminar two-phase flow including more than fifty thousands bubbles, and cleared liquid and each bubbles velocities, fluctuations and void fraction distribution.

## Basic equation

$$\frac{\partial}{\partial t}\left[(1-\alpha)\rho_L\right]+\frac{\partial}{\partial x}\left[(1-\alpha)\rho_L u_L\right]=0 \quad \cdots ①$$

$$\frac{\partial}{\partial t}\left[(1-\alpha)\rho_L u_L\right]+\frac{\partial}{\partial x}\left[(1-\alpha)\rho_L u_L^2\right]=-\frac{\partial p}{\partial x}+\frac{4}{3}\frac{\partial}{\partial x}\left(\mu\frac{\partial u_L}{\partial x}\right) \quad \cdots ②$$

$$\frac{d}{dt}\left[\beta\rho_L\frac{4}{3}\pi r_n^3 u_{Gn}\right]-\frac{D_L}{Dt}\left[\beta\rho_L\frac{4}{3}\pi r_n^3 u_L\right]+\frac{4}{3}\pi r_n^3\frac{\partial p}{\partial x}+C_D\rho_L\pi r_n^2\frac{u_{sn}\left|u_{sn}\right|}{2}=0 \quad \cdots ③$$

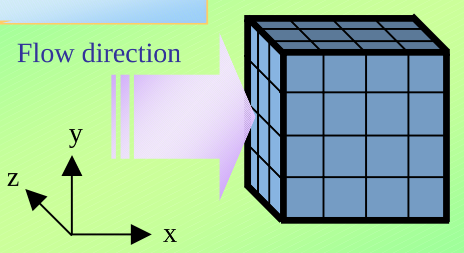
$$r_n\frac{d^2 r_n}{dt^2}+\frac{3}{2}\left(\frac{dr_n}{dt}\right)^2=\frac{1}{\rho_L}\left(p_v+\frac{Q_n}{r_n^3}-\frac{2\sigma}{r_n}-\frac{4\mu_L}{r_n}\frac{dr_n}{dt}-p_n\right) \quad \cdots ④$$

①···Mass conservation equation
②···Momentum conservation equation
③···Equation of bubble motion
④···Equation of bubble compressibility

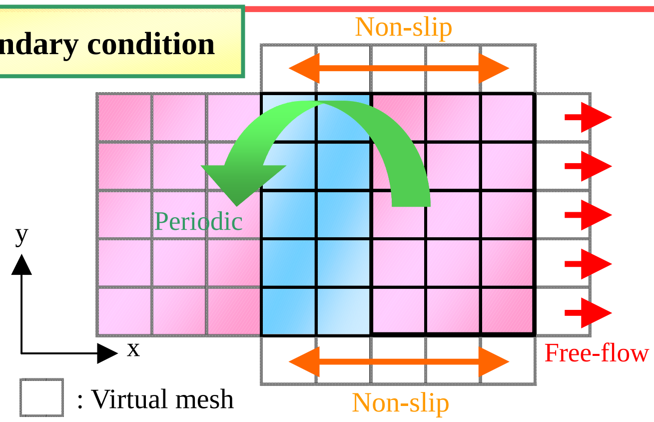
## Initial condition

| | |
|---|---|
| Liquid phase | Water |
| Gas phase | Air |
| Temperature | 293K |
| Number of mesh | 30×30×30 |
| Width of mesh | $3.019\times10^{-4}$m |
| Liquid phase Reynolds number | $3.0\times10^{3}$ |
| Liquid phase velocity(x-direction) | Laminer flow |
| Liquid phase velocity(y and z -direction) | 0m/s |
| Generation bubble velocity | The same liquid phase |
| Generation bubble radius | $2.5\times10^{-5}$m |
| External pressure | $1.01325\times10^{5}$Pa |
| Time step | $2.5\times10^{-6}$s |

## Calculation domain

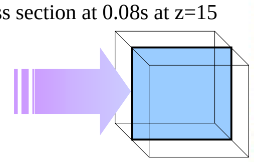



## Boundary condition

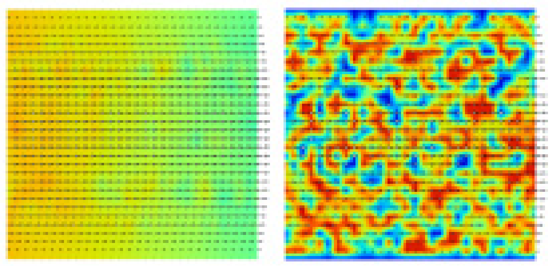



## Result

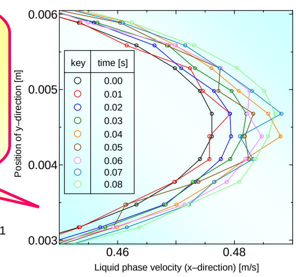
Distribution of liquid velocity and pressure, gas phase velocity and void fraction in the x-y cross section at 0.08s at z=15



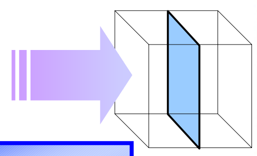
→ : Reference velocity 0.43m/s



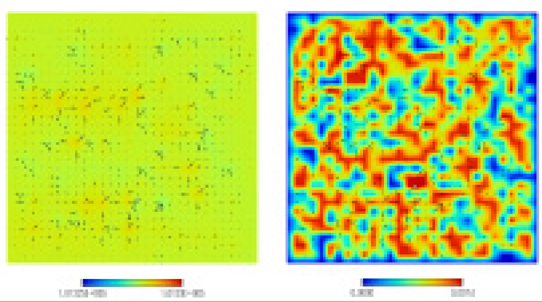
x-direction liquid velocity distribution in the middle of y-z cross section at enlargement near the center

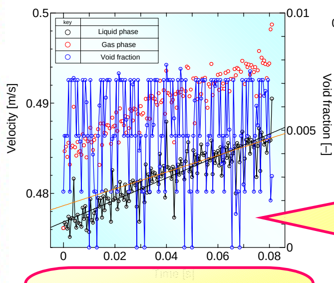



Distribution of liquid velocity and pressure, gas phase velocity and void fraction in the y-z cross section at 0.08s at x=15



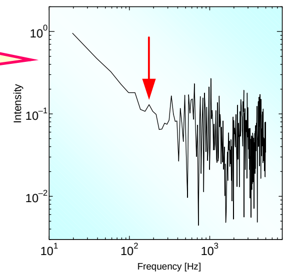
→ : Reference velocity 0.004m/s






Fluctuation of both phase x-direction velocities and void fraction at the center (15,15,15)

Power spectrum of liquid velocity at (15,15,15)




## Conclusion

Our results are follows. After the calculation started, the both phase velocities were immediately fluctuated. During 0.03 second from the calculation started, the periodic fluctuation appeared but this will be the error of initial calculation. After 0.03 second, the flow keeps random velocity fluctuation. The large fluctuation of the velocity was concentrated on the edge of bubble clusters. The maximum fluctuation rate of the velocities was 0.0125. The gas-phase velocity was larger than that of the liquid and the difference between them was 0.008m/s. The averaged velocity of the center flow increased with increasing of the time. From the visualization of flow, the fundamental frequency of the velocity fluctuation should be the order of unity. Our results limited in short time and we cannot perform the frequency analysis directly. Thus we show the 170 Hz as a harmonic component of the fundamental frequency.