§12. On the Measurement Technique of Velocity Fluctuation in Super Fluid He II

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When the liquid helium has its temperature below 2.2K, it becomes a super fluid, and indicates the unique properties. For instance, there exits the mass flow without friction, anomalous heat transport by a mechanism known as second sound, and quantized vortex lines in the turbulent state. These characteristics have been investigated by temperature fluctuation measurement and the second sound attenuation technique. However, they are model dependent and do not give the dynamical information of the fluid flow. For this reason, we have been interested in applying the visualization technique to the super fluid helium in order to obtain the local velocity fluctuation, and study the statistical characteristics.

Particle image velocimetry (PIV) is a potential tool to measure the local velocity and it promises us to give a deep understanding of complex super fluid motions. PIV is a standard technique in classical fluid researches. But its application to super fluid has just started, and there remains several problems[1,2]. The most difficult one is the development of proper imaging particles that can be spread in homogeneous over the liquid and track the flow field. Liquid helium is a very low density fluid with small viscosity, and it exists in low temperature. These conditions prevent the conventional particle spreading techniques developed so far in classical fluid.

On the successful application of tracer particles, there have been two challenges of PIV measurement in super fluid turbulence. One is the use of commercial (d~1μm) polystyrene microspheres and the other is the condensationand dispersion of solid hydrogen particulates from the gas phase. In the present study, we tried the former approach. Figure 1 shows the schematic view of experimental apparatus.

In the grass dewar, rectangular duct (cross section is $A = 1.69[\mathrm{cm}^2]$, length is $L = 20[\mathrm{cm}]$) made of GFRP is set. The liquid He temperature is set at 1.9K. The heater is located at the bottom, which generates the thermal counter flow. We measure the temperature inside the duct by small thermistors at two locations. From the temperature gradient, heat flux carried by the normal fluid is calculated, which is compared to the heater supplied power $q[\mathrm{W/cm}^2]$.

CCD camera (1018×1008[pixels]) is used for visualizing the area $47[\mathrm{mm}] \times 47[\mathrm{mm}]$. Double pulse YAG laser is operated to generate the laser sheet whose thickness is about $1[\mathrm{mm}]$. We used the polystyrene microspheres whose density is $\rho_p = 145[\mathrm{kg/cm}^3]$ and the diameter is $d_p = 50[\mu\mathrm{m}]$. Figure 2 shows the visualized particles. They are carried by the thermal counter flow jet, but small density difference from the density of super fluid, the particles goes down gradually. We are thinking that this point should be improved in the next experiment.

Figure 2 Tracer particles in liquid He at 1.6K.

[1]Nakano, A., Murakami M. and Kunisada, K. (1994) Cryogenics 34: 991-995.
[2]Zhang, T., Celik, D., and Van Sciver, S. W. (2004) , J. Low Temp. Phys. Vol. 134: 985-1000.

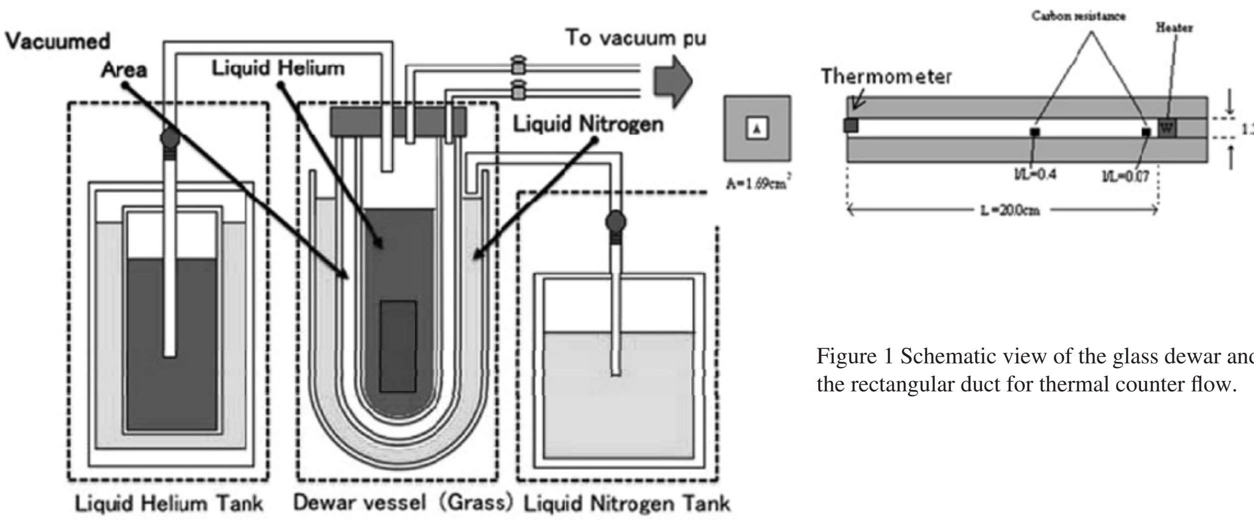

Figure 1 Schematic view of the glass dewar and the rectangular duct for thermal counter flow.