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Outline

Searching for interfacial phenomena of ^4He crystals which are masked by the gravity is the purpose of our investigation. ^4He crystals in the superfluid grow very quickly at sufficiently low temperatures and then they are able to relax immediately to an equilibrium state in accordance with the surrounding condition. The rapid relaxation is attributed to the swift flow of mass transport, the negligibly small release of latent heat and the very pure system which includes no impurities but a small amount of ^3He . Studies of ^4He crystals have provided us with deep understanding of fundamental physics, such as roughening transition, step-step interaction, and facet growth mechanism. On the other hand, ^4He crystals are also sensitive to the gravity. As long as the length scale of an interfacial phenomenon of a ^4He crystal is much larger than the capillary length of about 1 mm, the phenomenon is affected predominantly not by the interfacial free energy but by the gravity. For example, a macroscopic ^4He crystal is deformed horizontally by the gravity to minimize the gravitational energy while the deformation increases the sum of the interfacial free energy of the system. Then, the gravity often masks some interfacial phenomena dependent on the interfacial free energy and it is difficult to study them on the ground.

We are especially interested in equilibrium shapes of ^4He crystals at low temperatures determined by the interfacial free energy. Therefore, we have got started to carry out experiments under microgravity. The microgravity experimental environment was produced by a jet plane's parabolic flight. As the first challenge, we had to develop a refrigerator for microgravity experiments on the jet plane because the jet plane was so small that the cryostat had to clear some restrictions such as experimental space, available electric power and total weight of the experimental system including refrigerators, vacuum pumps, measuring instruments and so on. As a result, we developed two types of refrigerators. One was a ^3He evaporation refrigerator and the other was a dilution refrigerator. Both refrigerators generally require the gravity for the operation in principle, but to our surprise, we found our refrigerators were not affected by the zero gravity for 20 seconds during the parabolic flight even at the lowest temperatures of 0.6 K and 0.15 K.

Using these refrigerators, we succeeded in observing macroscopic ^4He crystals at around 0.6 K and 0.15 K under microgravity. As soon as the gravity was reduced to almost zero by the parabolic flight, the crystals changed their

shapes immediately towards the equilibrium shapes. The crystals did not spontaneously detach from the sample cell wall at any time under microgravity, probably because the adhesive force manifested as partial wetting to the wall was sufficiently strong. The adhesive force also kept the crystallite orientation with respect to the cell constant during the microgravity. The relaxation process to the equilibrium under microgravity varied depending on the crystal orientation since the degree of deformation under gravity was differed. Moreover, the equilibrium shapes we obtained under microgravity depended on the initial shapes just before the relaxation, so we were able to produce different relaxation processes of a ^4He crystal also by applying an acoustic wave pulse to the crystal to deform it. While we could not observe an equilibrium shape completely surrounded by the superfluid, we found *s*-facets to appear on some parts of the crystal at around 200 mK under microgravity which were concealed by the gravity. This is the very first observation of *s*-facet on a ^4He crystal in the equilibrium condition.

In addition, we observed a clean Ostwald ripening of ^4He crystals in the superfluid. Under gravity on the ground, Ostwald ripening is not apparent because it stops growing at the crystal size comparable with the capillary length. However, under microgravity, Ostwald ripening was observed up to the scale of the order of 10 mm due to the extended capillary length, exhibiting a novel evolution of crystal shape driven solely by the interfacial free energy.

In summary, this work opened a new field of physics, crystal shape of quantum solid under microgravity, which had not been studied so far.