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Title(English)	Non-equilibrium Phenomena and Phase Transitions in Superconducting Vortex Systems
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In this thesis, first, I report experimental studies on fast driven vortex lattices in Corbino disk (CD) subject to shear forces, focusing on a change in the coherence of lattices by changing a drive velocity or effective pinning. Then, I present critical dynamics of individual vortices associated with dynamic ordering near the non-equilibrium phase transitions observed in the low velocity region. Samples used in this work are uniform amorphous Mo_xGe_{1-x} films with weak pinning. Through this thesis, I demonstrate that the superconducting vortices are a very suitable system to study the physics of plastic flow and novel non-equilibrium phenomena.

In earlier work, our group found the formation of rotating vortex rings composed of triangular arrays in CD by means of a mode-locking (ML) resonance. However, information on the transverse dynamic correlations, namely, the width of the lattice rings remains unresolved. This information is indispensable to understanding the physics of plastic flow. In this thesis, I perform precise measurements of dc current-voltage ($I-V$) relation for the lattice rings rotated by dc I superimposed with ac current I_{rf} in CD. With increasing I_{rf}, the ML resonance becomes more pronounced and $I-V$ curves at large I show a trend to decrease. This is opposite to the generally accepted behavior of vortex flow, where I_{rf}-induced depinning results in an increase in a flux-flow voltage. The observed peculiar behavior is explained by the I_{rf}-induced growth in the width of the rotating lattice rings.

Using the periodically sheared vortex system in CD, our group offered evidence of a reversible-irreversible transition (RIT), as originally reported in a driven colloidal system. By increasing a displacement d of vortices per cycle, a threshold displacement $d(\equiv d_{c1})$ for RIT was determined as an onset of flow noise S_V. The amplitude of time-dependent voltage $|V(t)|$ exhibited a gradual increase toward a steady-state value, indicative of dynamic ordering, and a relaxation time τ shows a power-law divergence at d_{c1}. Here, to obtain information about the vortex configuration near the RIT, I perform comparative measurements of $V(t)$ generated by ac drive, focusing on how the initial vortex configuration in CD affects the transient vortex dynamics. It is found that when the initial vortex configuration is disordered or prepared by freezing the irreversible flow, the increase in $|V(t)|$ toward the steady state indicative of random organization is visible. In contrast, when the initial configuration is ordered or prepared by freezing reversible flow, only a fast decay in $V(t)$ coming from dynamic disordering is observed. The obtained results seem qualitatively consistent with the general theoretical view that the irreversible vortex motion occurs in correspondence with the flow of topological defects in the vortex lattice.

I extend the measurements of S_V to a much larger d regime and find the second characteristic displacement d_{c2} in addition to d_{c1}. This d_{c2} is a new length scale characterizing the phenomenon associated with RIT and is interpreted as a displacement separating the completely irreversible regime, where all flow channels are irreversible ($d > d_{c2}$), from the coexistence regime composed of irreversible and reversible flow channels ($d_{c1} < d < d_{c2}$).

I note that experimental evidence of RIT has been obtained only in colloidal and vortex systems where a global shear inversely proportional to a radius is present. Here, I conduct an experiment of RIT in strip samples where only a local shear due to random pinning centers is present. We again obtain evidence of RIT with a critical behavior similar to that for CD, consistent with the theoretical prediction. I also find the critical behavior similar to that of RIT for the same vortex system in the strip samples driven by superimposed ac and dc forces. Seen in the moving frame driven with a dc velocity, the "reversible" phase is enlarged and a relaxation time to the steady state is significantly suppressed. They are explained by the weakened effective pinning strength due to the dc velocity. I find an unexpected suppression of critical exponents from ν =1.4 in the rest frame to 0.7 in the moving frame. I propose two possible interpretations based on RIT with different pinning properties and on a novel dynamic transition characterized by ν =0.7.

Finally, I study a general phenomenon of plastic depinning using the same vortex system, focusing on whether the critical behavior near the dc depinning transition found in our group is also observed for the ac drive. The results show that the critical behavior of the depinning transition is commonly observed for the ac drive. The critical exponents for the dc and ac depinning transitions are around ν =1.4, which are close to the ones obtained in RIT. These results are consistent with the theoretical prediction that the RIT and the plastic depinning transition may fall into the same universality class as the absorbing transition.