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Observation of vortices driven by dc current using scanning tunneling spectroscopy

*Shin-ichi Kaneko[1], Takashi Ogawa[1], Kazuki Tsuchiya[1], Koshiro Kato[1], Koichiro Ienaga[1], Hideaki Sakata[2], Satoshi Okuma[1]

Department of Physics, Tokyo Institute of Technology[1]
Department of Physics, Tokyo University of Science[2]

We have constructed a scanning-tunneling-microscopy/spectroscopy (STM/S) system which allows us to conduct transport and STM measurements at low temperatures and high fields for the same sample. We study configurations of vortices in weak pinning amorphous Mo_xGe_{1-x} films under dc currents I both in plastic-flow and flux-flow regimes. The applied field is well below the peak-effect field. First, we drive the vortices by I for a long time until the steady state is reached. After freezing the vortex configuration by switching off I, we perform STS measurements. We observe a triangular vortex lattice within a scanning area of 240 × 240 nm^2 for all I studied, not only in the flux-flow region at high I where the vortex configuration is considered to be an ordered lattice, but also in the plastic-flow region at low I where the configuration is expected to be disordered [1]. We find, however, that at low I, the orientation of the lattice with respect to the flow direction differs when we change the scanning area. Furthermore, real-time measurements of the tunneling spectrum at a fixed tip position show an intermittent vortex motion. These results indicate that the vortex flow at low I corresponds to that of vortex polycrystals with domain sizes larger than 240 × 240 nm^2. This is different from simulations predicting the formation of flow channels at the domain boundaries. At high I, on the other hand, we obtain images of a vortex lattice with the same orientation over a wide area, consistent with the results of a mode-locking resonance [2]. We will also show the significance of the present STS system for the study of nonequilibrium phenomena in the vortex system [3,4].

[1] C. J. Olson, C. Reichhardt, and F. Nori, Phys. Rev. Lett. **81**, 3757 (1998).
[2] S. Okuma, D. Shimamoto, and N. Kokubo, Phys. Rev. B **85,** 064508 (2012).
[3] S. Okuma, Y. Tsugawa, and A. Motohashi, Phys. Rev. B **83,** 012503 (2011).
[4] M. Dobroka *et al.,* New J. Phys. **90,** 053023 (2017): **21,** 043007 (2019).

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