

Microscopic Investigation of Vortex-Vortex Interaction in Conventional Superconductors

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We have examined the vortex-vortex interaction microscopically, using the Bogoliubov-de Gennes (BdG) equation. Previously, we have investigated the vortex structures in nano-sized square superconducting plate, using the BdG equation and the finite element method.¹ And we found that quasi-particle bound states around vortices affect the stable vortex structures in such nano-sized superconductors. And this result means the interaction between vortices is affected by the quasi-particle bound states, although phenomenological theory predicts purely repulsive interaction between vortices because of the repulsive force on the magnetic flux of one of vortices from the current surrounding another vortex. In order to confirm this conclusion, we have developed new numerical method for solving the BdG equation around a pair of vortices using elliptic coordinates and Mathieu functions². We examined how interference of between the quasi-particle bound states around two vortices changes when the distance between two vortices changed. Also we investigate the stable distance of two vortices comparing the free energy of self-consistent solution with fixed vortex-vortex distance.

¹H. Suematsu, T. Ishida, T. Koyama, M. Machida and M. Kato, J. Phys. Soc. Jpn. **79**, 12704 (2010).

²Y. Niwa, M. Kato, and K. Maki, Physica C **470**, 1151 (2010).