Crossover from Fulde-Ferrell State to Larkin-Ovchinnikov State in Cold Fermion Gases

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A two component fermi gases with population imbalance attracts much attention from both theoretical and experimental point of view. In this system, one expect that the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state which has a spatially modulated order parameter is stable. Roughly speaking, FFLO state is classified into the two phases. One has the order parameter $\Delta(\mathbf{x}) = \Delta_0 \cos(\mathbf{q}\cdot\mathbf{x})$ (LO state) and others has $\Delta(\mathbf{x}) = \Delta_0 e^{i\mathbf{q}\cdot\mathbf{x}}$ (FF state). In the condensed-matter physics, it is understood that the LO state is stable.

In contrast to the condensed-matter physics, various FFLO states may manifest itself in cold atomic gas, for example, angular FFLO (A-FFLO) state in which the order parameter changes its sign along the angular direction. [1] In this research, we investigate a novel FFLO state realized in toroidal trap with rotation. When the system is at rest, the A-FFLO is stable. When a gas is rotated, the Cooper pairs flowing to the right and that flowing to the left are not equivalent. Then, the LO state changes to the "intermediate state" between FF and LO state. We also find the FFLO state with half-quantum vortex. We will report our studies on the physical properties of these FFLO states.

[1] Y. Yanase, Phys. Rev. B **80**, 220510 (2009).