

Neutral Fermion Superfluids with Population Imbalance

K. Machida, T. Mizushima and M. Ichioka

Department of Physics, Okayama University, Okayama 700-8530, Japan.

In this talk we will discuss the present status of the problem associated with neutral Fermionic atom gases with ${}^6\text{Li}$. Recently two experimental groups, MIT [1] and Rice Univ. [2] have succeeded in producing Fermionic superfluids where the two atomic species; up and down spin populations are different, the so-called imbalance Fermionic superfluid. They found several interesting features (1) Superfluid state breaks down at the critical relative imbalance $P=0.7$ at the zero temperature on the Feshbach resonance point $H=834\text{G}$. This is a quantum critical phenomenon, which is a topic widely discussed with various strongly correlated condensed matter systems. (2) The spatial structure of minor component shows a prominent bimodal feature. (3) The polarization profile also exhibits a double peak structure associated with superfluidity.

We consider this problem by examining a possibility of Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state, namely the superfluid state is described by non-uniform Cooper pair wave function. Indeed we have demonstrated that the FFLO-like state is stable all the way up to the critical imbalance $P=0.7$ at $T=0$. We will also explain a possible phase diagram in temperature vs P [3].

[1] M.W. Zwierlein, et al, Science 311, 492 (2006), cond-mat/0605258.

[2] G.B. Partridge, et al, Science 311, 503 (2006).

[3] K. Machida, T. Mizushima and M. Ichioka, cond-mat/0604339.

T. Mizushima, K. Machida and M. Ichioka, Phys. Rev. Lett. 94, 060404 (2005).