π-phase and Spontaneous Supercurrent induced by Pseudo-ferromagnetic Junction in a Spin-polarized Superfluid Fermi Gas

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We theoretically propose a novel superfluid state with spontaneous current in a superfluid Fermi gas. When a weak non-magnetic potential barrier is embedded in a superfluid Fermi gas with population imbalance ($N_\uparrow > N_\downarrow$, where N_σ is the number of atoms with pseudospin $\sigma =\uparrow, \downarrow$), the barrier is known to be "magnetized" in the sense that some excess $\uparrow$-spin atoms are localized around it[1,2]. This "ferromagnetic" junction naturally leads to the so-called π-phase, where the superfluid order parameter changes its sign across the junction. Using this phenomenon, we show that, when a non-magnetic potential barrier is set in a ring-shaped torus trap, the induced ferromagnetic junction twists the phase of the superfluid order parameter by π along the ring, leading to finite circulating Jpsephson current. In contrast to the ordinary *metastable* supercurrent state, this phase-twisted state with spontaneous current is shown to appear as the *stable* ground state at $T = 0$.

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