Anomalous Tunneling of Spin Wave in Polar State of Spin-1 BEC

S. Watabe[a,b], Y. Kato[c], and Y. Ohashi[a,b]

[a]Department of Physics, Keio University, Yokohama, Japan
[b]CREST(JST), Saitama, Japan
[c]Department of Basic Science, The University of Tokyo, Tokyo, Japan

We theoretically investigate barrier tunneling and reflection of a collective spin wave in the polar phase of a spin-1 spinor Bose–Einstein condensate (BEC). Within the mean-field theory at $T = 0$, we show that this spin wave exhibits the perfect transmission in the long wavelength limit through a potential barrier which couples to the local density. This property still holds in the current-flowing superfluid state, except when the system is in the critical current state and strengths of spin-dependent and spin-independent interactions are equal; this is quite different from the Bogoliubov mode of the scalar BEC[1], in which it results in finite reflection. In this spin wave tunneling, we find a scaling law in the energy-dependence of the transmission coefficient, scaled by the difference of the two interaction parameters. When this spin wave is scattered from the local magnetic field, on the other hand, this anomalous tunneling disappears. Similar results are seen in Bogoliubov mode and transverse spin wave in the ferromagnetic phase of a spin-1 BEC[2] and Heisenberg spin chain[3]; our result supports that anomalous tunneling through a symmetry-preserving potential is common among NG modes in various broken-symmetry states.

[1]I. Danshita, N. Yokoshi, and S. Kurihara, New J. Phys. **8**, 44 (2006), [2]SW, YK and YO, Phys. Rev. A, 83, 033627(2011). [3] YK, SW and YO, (presentation in LT26).