Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

Critical superfluid velocity of spin-1 bosons in an optical lattice[1]
SHION YAMASHIKA, RYOSUKE YOSHII, SHUNJI TSUCHIYA, Department of Physics, Chuo University — We study the superfluid (SF) - Mott insulator (MI) transition of spin-1 bosons with antiferromagnetic interaction in an optical lattice based on the spin-1 Bose-Hubbard model [1]. It has been shown that in contrast to the spineless case the SF-MI phase transition is of first order [2]. We derive the time-dependent Ginzburg-Landau (TDGL) equation expanding up to the 6th order of the SF order parameter in the vicinity of the first-order SF-MI phase transition. We employ the TDGL equation to study the stability of superfluid mass current and spin current. Mass current induces dynamical instability involving the U(1) phase mode [3]. We find that the critical velocity of mass current is finite at the SF-MI phase boundary due to the existence of the metastable SF state and it vanishes at the point where the metastable SF state disappears. Spin current also induces dynamical instability that involves spin wave excitations. We find a parameter region where the superfluid polar state is unstable against infinitesimal spin current. This implies emergence of an unknown magnetic phase in this parameter region that cannot be described by the mean-filed theory.
[1]S. Tsuchiya, *et al.,* PRA **70**, 043628 (2004).
[2]T. Kimura, *et al.,* PRL **84**, 110403 (2005).

[1]This work was supported by KAKENHI Grant No. JP19K14616 and No. JP19K03691.

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Date submitted: 17 Mar 2020 Electronic form version 1.4