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Effects of fermions on the superfluid-insulator phase diagram of the Bose-Hubbard model[1] ROMAN LUTCHYN, University of Maryland, SUMANTA TEWARI, Clemson University, SANKAR DAS SARMA, University of Maryland — Building on the work of Fisher et al. [PRB 40, 546 (1989)], we develop a framework for perturbation theory in the Bose-Hubbard model and apply it to calculate the effects of spin-polarized fermions interacting by contact interactions with the constituent bosons. For the single-band Bose-Hubbard model, the only non-trivial effect of the fermions is to induce an effective space- and time-dependent interaction among the bosons. Using a path integral formulation, we develop the appropriate theory describing the perturbative effects of this fermion-mediated interaction on the superfluid-insulator phase diagram. For the single-band Bose-Hubbard model, we find that the net effect of the fermions is to inherently suppress the Mott-insulating lobes and enhance the area occupied by the superfluid phase in the phase diagram. For the more general multi-band Bose-Hubbard model, we find that, in addition to the fermion screening of the boson interactions, the virtual excitations of the bosons to the higher Bloch bands result in an effective increase of the boson on-site repulsion. If this renormalization of the boson on-site potential is dominant over the fermion screening, the area of the Mott insulating lobes of the Bose-Hubbard phase diagram will be enhanced for either sign of the boson-fermion interactions, as seen in recent experiments.

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