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The superfluid-insulator quantum phase transition

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4:00 P.M.

304 Robeson Hall

The superfluid-insulator transition of bosons occurs due to the competition between kinetic energy and repulsive interaction between constituent bosons. In a superfluid phase, bosons move in phase with one another as a part of a single macroscopic wavefunction. In an insulating phase, on the other hand, strong interactions hinder the flow of bosons. As a result, each particle occupies its own quantum well, unaffected by its neighbors, and, thus, the system has no global phase coherence.

The coupling of bosons to additional degrees of freedom can modify the superfluid-insulator transition in a non-trivial way. In my talk, I will discuss what happens to the original superfluid-insulator phase diagram in the presence of fermions. This question is of fundamental importance and is relevant to many physical situations where the bosonic and fermionic degrees of freedom are coupled. The two examples I will consider are the superconductor-graphene systems and cold atom Bose-Fermi mixtures. In the former, the coupling of the Josephson junction array to the reservoir of fermionic excitations in graphene favors the superconducting phase. By changing the fermionic density of states in graphene, one can tune the transition from insulating to superconducting state of the array. In the case of Bose-Fermi mixtures, the experiments exhibit the opposite trend - the presence of fermions leads to the suppression of the superfluid state. I will show that this experimental fact can be explained by considering multi-band model for Bose-Fermi mixtures, where there is a competition between the fermionic screening effect and the renormalization of the boson-boson interaction due to the virtual boson transitions involving higher Bloch bands.