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Bose-Fermi mixtures with pairing interactions in two dimensions

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Ultracold dilute Bose-Fermi mixtures are systems that offer a large degree of tunability and are highly controllable, allowing for the investigation of substantially different conditions and quantum effects in matter. In such a mixture with a pairing interaction, one can study the competition between the formation of fermionic composite molecules and the tendency of bosons towards condensation. One possible application is a recent proposal to obtain a quantum simulator for p-wave superfluidity ([1]).
I will present the study of a 2D ultracold Bose-Fermi mixture at zero temperature. We describe the system applying to two dimensions an (imaginary time) T-matrix many-body approach in the ladder approximation. This has been previously used successfully for 3D systems ([2], [3]). Using both analytical and numerical techniques to solve the resulting integrals, we obtain quantities like the chemical potentials and the momentum distributions for both species, and the bosonic condensate fraction.
We also study the minimum value of boson-boson repulsion necessary for the mixture to be stable against phase separation or mechanical collapse. To this end, we extend the Bogoliubov approximation to Popov theory, in order to better consider boson-boson interaction.
Finally, we focus on single-particle spectral properties, which could be relevant for future experiments performing radio-frequency spectroscopy (like for 3D systems in [4]) on 2D Bose-Fermi mixtures. To calculate these dynamic quantities, we need to reformulate our theory for real time and frequencies (as done in 3D in [5]). Our results for the fermionic spectral weight function, from weak to strong boson-fermion attraction, show the presence of unexpected single-particle excitations at low-momenta, and a new branch at positive frequencies for sufficiently strong couplings.

References
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