

A Diagrammatic Approach on Mediated Interactions in Quantum Gases: Ensemble Constraint

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Mediated interactions are ubiquitous in quantum many-body systems. From conventional superconductivity to emergent quantum materials, they enable quasiparticles to interact via the exchange of collective excitations of the medium in which they are embedded. In this work, we study, from a diagrammatic perspective, interactions induced by both a Bose–Einstein condensate and a degenerate Fermi gas. We show that ensemble constraints (canonical versus grand canonical) play a crucial role in determining the sign and character of the mediated interactions, consistent with recent theoretical developments [1, 2]. We further extend the formalism to the strongly interacting regime and investigate the interplay between the underlying mechanisms of induced interactions—namely, the exchange of sound modes—and the statistical ensemble of the medium. Our results establish a systematic framework to study mediated interactions in the strong-coupling regime, relevant for the next generation of experiments in ultracold gases and condensed matter platforms.

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