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Cold atom Fermi/Bose quantum liquid mixtures

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One of the intriguing avenues opened up by the advances in cold atom fermion cooling is the prospect of exploring fermion-boson quantum liquid mixtures in atom traps. Past experiments with condensed helium-3/helium-4 fluid mixtures, the only such mixtures accessible so far to table top experimentation, revealed an intricate phase diagram even though helium-3 remained normal (i.e. non-superfluid). However, strong-interaction effects greatly complicate any quantitative microscopic description of such striking phenomena as the phase separation of the helium-3 and helium-4 fluids. The helium-4 mediated interactions that are responsible for the separation were shown to be an order of magnitude weaker than calculated in lowest order perturbation. The Helium-3 mediated interactions, still attractive, can pair the helium-3 fluid into a superfluid, but at much lower temperatures. In comparison, the anticipated cold atom fermion-boson experiments could be amenable to first principle descriptions and their realizations would cover a much wider range of parameters. We will present insights from a theoretical study of the collective excitations of the simplest fermion-boson mixture: a single component fermion gas mixed in a with a cold atom Bose-Einstein condensate. We suggest that we can understand the dynamics of the onset of a phase separation, and we point out that retardation radically alters the nature of the mediated interaction if the Fermi-velocity exceeds the velocity of BEC-sound (not the regime of the helium mixtures). Even for mixtures in which the second fluid consists of only a single quantum particle, we find that the mediated interactions can give rise to non-trivial effects.