Beyond-Mean Field Effects in Rabi-Coupled Two-Component Bose-Einstein Condensate

A Hammond[1], L Lavoine[1], A Recati[2], D Petrov[3], and T Bourdel[1]

[1]*Laboratoire Charles Fabry, Institut d'Optique, Avenue Augustin Fresnel, Palaiseau, France*
[2]*INO-CNR BEC Center, University of Trento, Via Sommarive 14, Trento, Italy*
[3]*LPTMS, CNRS, Univ. Paris Sud, Université Paris-Saclay, Orsay, France*
Contact Email: alfred.hammond@institutoptique.fr

Recently, it was discovered that quantum mixtures of two Bose-Einstein condensates with repulsive intraspecies interaction and attractive interspecies interactions permit cancellation of the global mean-field interaction without a reduction of the magnitude of the beyond mean-field effects [1, 2]. They can then play a dominant role in the dynamics of the system and compete with the reduced mean-field energy. In this context, quantum droplets, i.e. self-bound Bose-Einstein condensates due to beyond-mean field effects, have been predicted and experimentally observed [3, 4]. We consider a Bose gas formed by atoms with two internal levels which are coherently coupled.

We analytically calculate the beyond mean-field (BMF) energy density in the experimentally relevant case of an asymmetric Rabi-coupled Bose mixture and show that it can be tuned from a 2.5-body interaction as in an uncoupled BEC mixture to a 2- and 3-body interaction. Experimentally, we quantitatively measure the BMF as a function of the Rabi-coupling strength in a ^{39}K spin-mixture. This is done in a direct way by observing the expansion of the condensate in a waveguide in a regime where the system is driven by the BMF energy [5].

References

[1] D S Petrov, Phys. Rev. Lett. **115**, 155302 (2015)

[2] T G Skov, M G Skou, N B Jørgensen and J J Arlt, arXiv:2011.02745 (2020)

[3] R Cabrera, L Tanzi, J Sanz, B Naylor, P Thomas, P Cheiney and L Tarruell, Science **359**, 301 (2018.

[4] G Semeghini, G Ferioli, L Masi, C Mazzinghi, L Wolswijk, F Minardi, M Modugno, G Modugno, M Inguscio and M Fattori, Phys. Rev. Lett. **120**, 235301 (2018)

[5] G Berthet, L Lavoine, M K Parit, A Brolis, A Boissé and T Bourdel, Phys. Rev. Res **2**, 013386 (2020)