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# Phase Profiles and Dynamical Coupling of Binary Ultracold Atomic Mixtures

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We discuss the phase mixing and separation of binary mixtures of ultracold atomic gases. Experimentally, this is typically examined after time-of-flight expansion using a homogeneous mean-field criterion based on the relation between inter- and intra-component interaction strengths.

For a trapped condensate mixture with overlapping trap centres, we show that the in situ miscible-immiscible transition depends critically on the condensate numbers, deviating from this simple homogeneous prediction; we demonstrate that this transition can be mapped out experimentally by measuring the damping rate and the frequency of the dipole oscillations [1].

By performing the first full numerical analysis of time-of-flight expansion dynamics for T > 0, we observe the dynamical emergence of striking density features, numerically reproducing observations in 87Rb-41K experiments. We demonstrate that the homogeneous phase-separation criterion actually emerges dynamically in mixtures during expansion as a result of mechanical equilibrium across the condensate interface region, without however a clear transition point between the miscible and immiscible phases, with a non-negligible shift in the trap minima (due to gravity) advantageous for identifying this transition region [2].

Our simulations are conducted at non-zero temperatures and are based on coupled condensate-Boltzmann cloud (“ZNG”) description of the mixture [3], which also facilitate the study of thermalisation in such mixtures [4].

We also discuss how a thermal quench across the Bose-Einstein condensation phase transition, leads to the dynamical emergence of spontaneous defects. [5]
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[1] Lee et al., PRA, 94, 013602 (2016);
[2] Lee et al., arXiv:1712.07481 (NJP accepted, 2018);
[3] Edmonds et al., PRA, 91, 011602(R) (2015);
[4] Lee et al., JPB, 49, 214003 (2016);
[5] Liu et al., PRA 93, 023628 (2016).