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Bubbles in a ferromagnetic superfluid

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Overview

- **Introduction**: What is a ferromagnetic superfluid?
- **Theoretical background**: Coherently coupled BEC spin-mixtures
- **Data analysis**: False Vacuum Decay bubbles
- **Conclusions**

Introduction

What is a **ferromagnetic superfluid**?

Theoretical background: Ideal Bose gas

The ideal Bose gas is a quantum system of N non-interacting bosons, described by statistical mechanics.

$$\langle n_i \rangle = \frac{1}{e^{\beta(\epsilon_i - \mu)} - 1}$$

The occupation number of the ground state $N_0 = \langle n_0 \rangle$ corresponds to the condensation. There is a phase transition at $T = T_c$.

$$\frac{N_0}{N} = 1 - \left(\frac{T}{T_c}\right)^{\alpha} \quad \text{for } T < T_c$$

In a finite box $\alpha = 3/2$, in harmonic confinement $\alpha = 3$.

Theoretical background: Gross-Pitaevskii equation

A system of weakly-interacting bosons can be described by a single wavefunction by a mean-field approximation, yielding the GPE

$$i\hbar\frac{\partial\psi(x,t)}{\partial t} = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(x,t) + g|\psi(x,t)|^2\right]\psi(x,t)$$

In the stationary case

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(x) + g|\psi(x)|^2\right]\psi(x) = \mu\psi(x)$$

When the interaction dominates

$$n(x) = \frac{\mu - V(x)}{g}$$

Theoretical background: Two-component mixtures

The GPEs are coupled because of the interspecies interaction constant

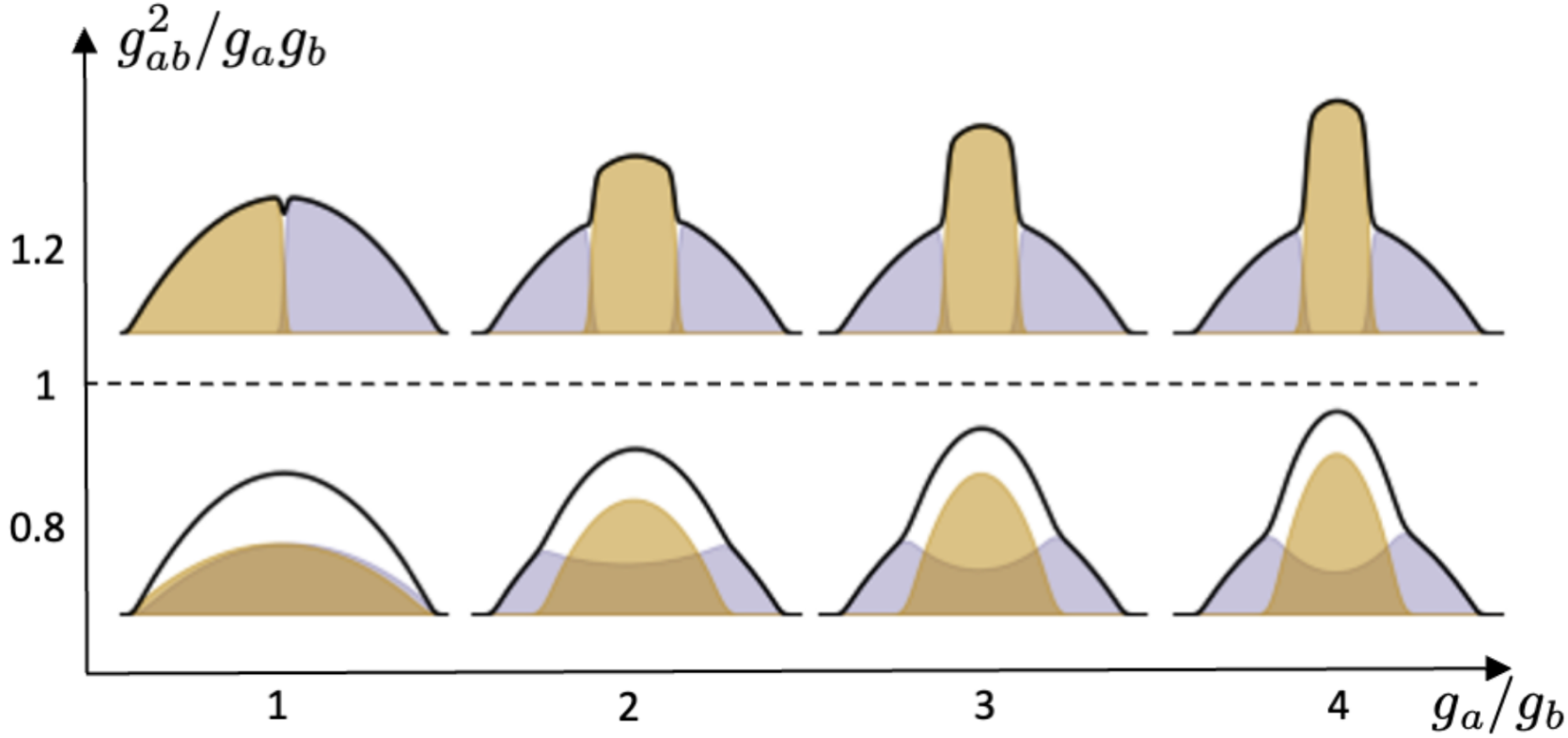
$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(x) + g_{aa}|\psi_a(x)|^2 + g_{ab}|\psi_b(x)|^2\right]\psi_a(x) = \mu_a\psi_a(x)$$

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(x) + g_{ab}|\psi_a(x)|^2 + g_{bb}|\psi_b(x)|^2\right]\psi_b(x) = \mu_b\psi_b(x)$$

Depending on the values of g_{aa}, g_{bb} and g_{ab}, the system GS can behave in different manners

Theoretical background: Two-component mixtures

The mixture can be miscible or immiscible: buoyancy effect



Theoretical background: Coherent coupling

Theoretical background: False Vacuum Decay

Data analysis: Experimental platform

Data analysis: Bubble fit

Data analysis: Shot sorting

Data analysis: Parameters clustering

Data analysis: FFT and ACF

Conclusions

Thank you for the attention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