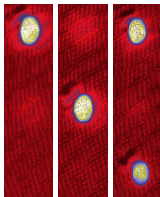


Spin-Dipole Oscillation and Polarizability of a Binary BEC

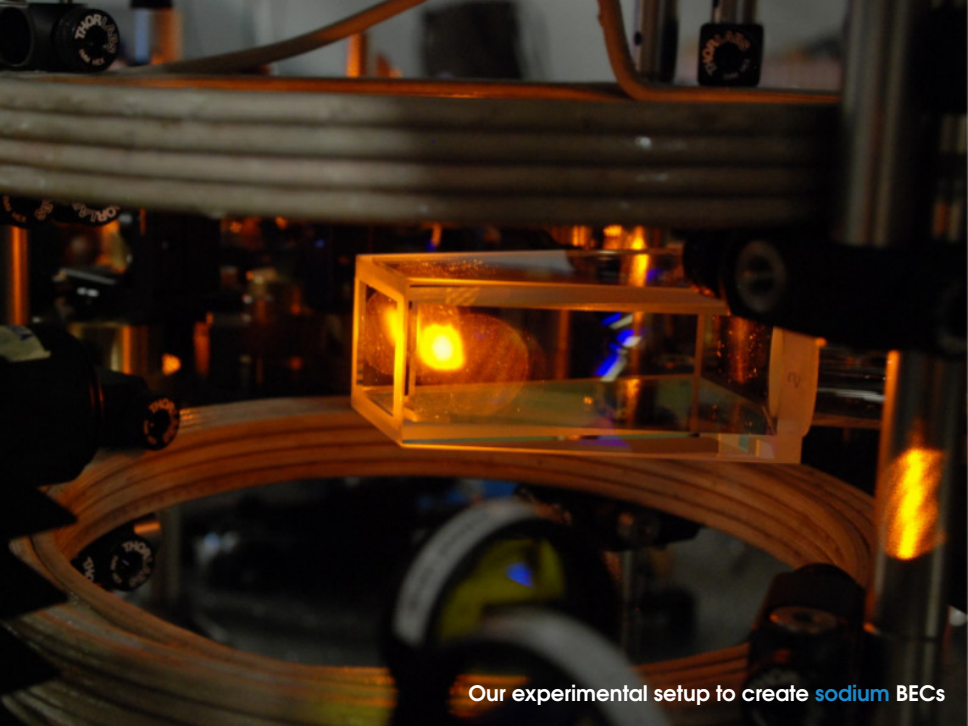
T. Bienaimé, E. Fava, G. Colzi, C. Mordini, S. Serafini,
C. Qu, S. Stringari, G. Lamporesi and G. Ferrari

BEC group, INO-CNR & University of Trento, Italy



MACRO conference

Newcastle, September 14th, 2016

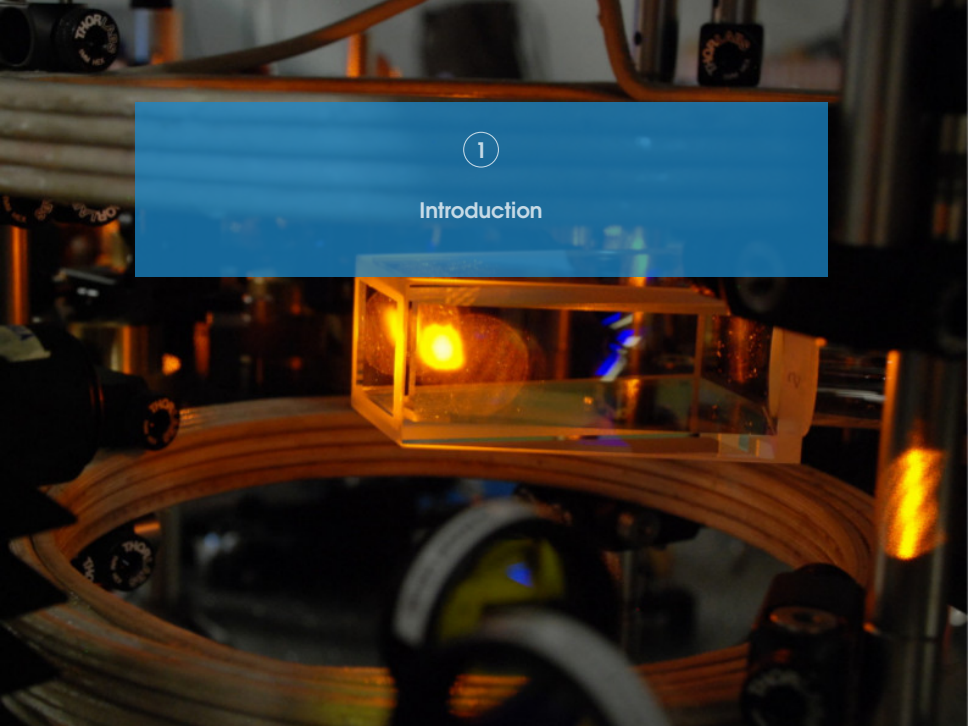


Our experimental setup to create **sodium** BECs



1

Introduction





1

Introduction

2

Spin-Dipole polarizability



1

Introduction

2

Spin-Dipole polarizability



1

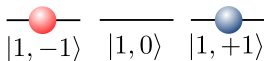
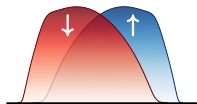
Introduction

2

Spin-Dipole polarizability

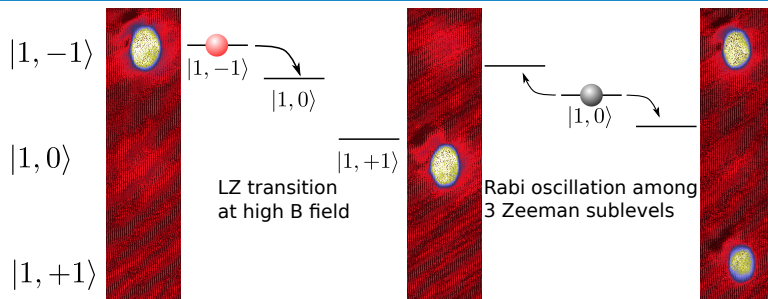
Introduction: Bose-Bose miscible mixture without buoyancy

- 2-component BEC: 2 Zeeman levels $|\uparrow\rangle, |\downarrow\rangle$
- Characterized by scattering lengths:
 - Intracomponent: $a_{\uparrow\uparrow}, a_{\downarrow\downarrow}$
 - Intercomponent: $a_{\uparrow\downarrow}$
- Important property: miscibility if $a_{\uparrow\downarrow} < \sqrt{a_{\uparrow\uparrow}a_{\downarrow\downarrow}}$
- Even when miscible: buoyancy problem in harmonic trap when $a_{\uparrow\uparrow} \neq a_{\downarrow\downarrow}$
- It prevents the study of the static and dynamic response in harmonic trap
- Our system: $|3^2S_{1/2}, F=1, m_F=\pm 1\rangle$ states of sodium



- Advantages
 - Miscible
 - Without buoyancy $a_{\uparrow\uparrow} = a_{\downarrow\downarrow} \equiv a$
 - Close to the miscible/immiscible phase transition $(a - a_{\uparrow\downarrow})/a = 0.07 \ll 1$
- Goals
 - Study the linear and dynamic response
 - Observe that these properties are drastically modified close to the phase transition despite the weakly interacting nature of the gas

Spinor preparation



Goal: static and dynamic response of the system close to miscible/immiscible transition

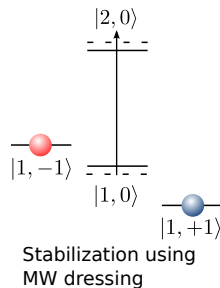
Parameters:

$$N_{\uparrow} = N_{\downarrow} \simeq 10^6$$

$$[\omega_x, \omega_y, \omega_z] / 2\pi = [47.7, 207.2, 156.8] \text{ Hz}$$

$$a_{\uparrow\uparrow} = a_{\downarrow\downarrow} = 54.54(20)a_0$$

$$a_{\uparrow\downarrow} = 50.78(40)a_0$$





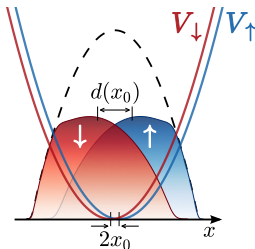
1

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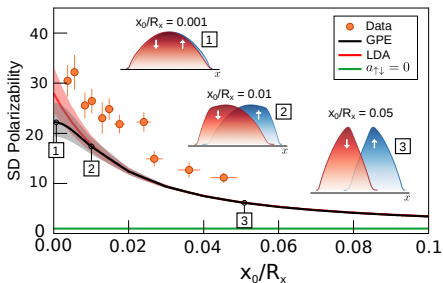
2

Spin-Dipole polarizability

Spin-Dipole Polarizability: static measurement



Define SD polarizability: $\mathcal{P}(x_0) \equiv \frac{d(x_0)}{2x_0}$



LDA calculation: $\mathcal{P}(x_0 \rightarrow 0) = \frac{a+a_{\uparrow\downarrow}}{a-a_{\uparrow\downarrow}}$



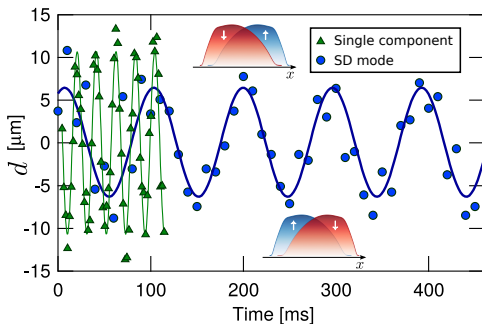
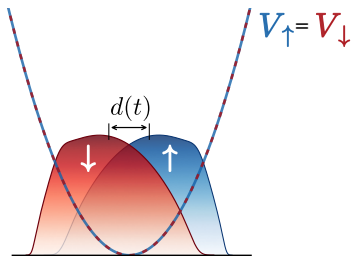
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2

Spin-Dipole polarizability

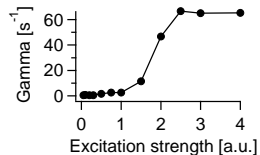
Spin-Dipole Oscillation: dynamic measurement



- We measure $\omega_{\text{SD}}/\omega_x = 0.218(2)$
 - LDA $\omega_{\text{SD}} = 0.189(15)\omega_x$
 - GPE $\omega_{\text{SD}} = 0.213(17)\omega_x$
- Sum rule approach links polarizability \mathcal{P} and SD mode frequency ω_{SD} :

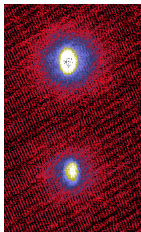
$$\omega_{\text{SD}} = \frac{1}{\sqrt{\mathcal{P}}} \omega_x$$

Dynamical instability



M. Abad et al., EPJD (2015)

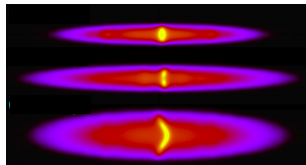
Finite temperature (four fluid model)



J. Armqitis et al., PRA (2015)

K. L. Lee et al., PRA (2016)

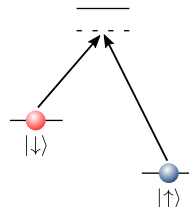
Magnetic soliton



C. Qu et al., PRL (2016)

Coherent coupling between spin components

Many references and ideas...



The background image shows a complex laboratory setup. A central feature is a rectangular glass chamber containing a bright, glowing orange light source. This chamber is mounted on a metal frame. Below the chamber, there is a large, curved, metallic structure that resembles a ring or a large lens. The entire setup is illuminated with warm, orange light, and there are various mechanical components and cables visible in the background.

1

New Bose-Bose mixture

Miscible, without buoyancy, vicinity to the miscible/immiscible transition



1

New Bose-Bose mixture

Miscible, without buoyancy, vicinity to the miscible/immiscible transition

2

SD polarizability and oscillation

Close to the transition: large polarizability, softening of the SD mode.

1

New Bose-Bose mixture

Miscible, without buoyancy, vicinity to the miscible/immiscible transition

2

SD polarizability and oscillation

Close to the transition: large polarizability, softening of the SD mode.

More info: Arxiv:1607.04574 (2016)

mail: tom.bienaima@unitn.it – **web:** <http://bec.science.unitn.it/>

Acknowledgments

- BEC [experiment](#) @ Trento

T. Bienaimé

E. Fava

G. Colzi

C. Mordini

S. Serafini

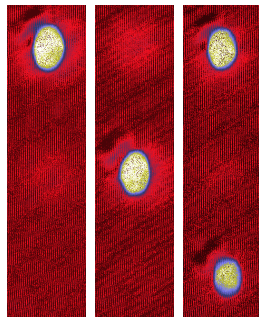
G. Lamporesi

G. Ferrari

- [Theoretical](#) study @ Trento

C. Qu

S. Stringari



- [Funding](#) & [Support](#)



Thank you for your attention !