Crossing Over from Attractive to Repulsive Interactions in a Tunneling Bosonic Josephson Junction

Giovanni Ferioli*[1], G. Spagnolli[2] G. Semeghini[2] L. Masi[1] A. Trenkwalder[2] S. Coop[2] M. Landini[2] L. Pezzé[1,2] G. Modugno[1] M. Inguscio[2] A. Smerzi[1,2] M. Fattori[1,2]

1. LENS and Universitá di Firenze, 50019 Sesto Fiorentino, Italy

2. CNR Istituto Nazionale Ottica, 50019 Sesto Fiorentino, Italy

We study the dynamics of a spatial bosonic Josephson junction realized by an atomic BEC loaded in a double well optical potential [1]. We can tune both the tunneling energy, by controlling the height of the barrier between the two wells, and the interaction energy U using a magnetic Feshbach resonance. By preparing the system with a finite population imbalance $z \neq 0$, we observe the transition from Rabi to Josephson oscillations between the two wells when the interaction goes from zero to finite values. In particular we observe that the oscillation frequency increases for $U > 0$ and decreases on the negative side, until it vanishes in correspondence of a quantum phase transition that we studied in a previous work [2]. The exquisite control of tunneling and interactions in the system paves the way to the realization of a Mach-Zehnder interferometer (built with the two spatial modes of the double-well potential) with trapped atoms: with non interacting clouds we can perform the linear beam splitter operation, while interactions could be used to create many-body quantum-entangled states, improving the phase resolution of the device beyond the shot noise limit.

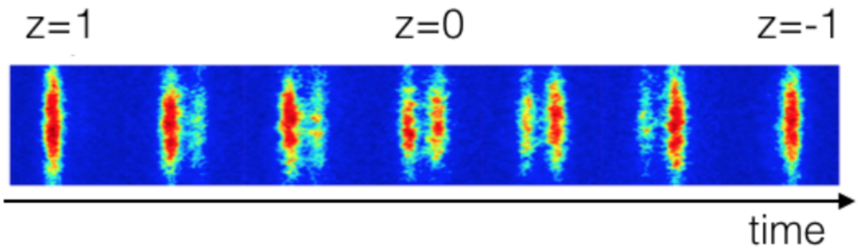

Fig. 1: Oscillation of population imbalance between the two spatial mode

References

[1] G. Spagnolli *et al.*. PRL accepted

[2] A. Trenkwalder *et al.*, Nature Physics (2016)

*Corresponding author: ferioli@lens.unifi.it