Quantum Ultracold Gases in Reduced Dimensions wih Tunable Interactions: from Atomtronic to Fundamental-Physics tests

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Why

- **Quantum ultracold gases are realized in labs by combined atomic-physics techs of cooling and trapping**
- **Extreme quantum conditions by tuning: Temperature, Interactions, Dimensions and Geometry, Quantum statistics, External fields including «magnetic», disorder**
- **Controlled with high precision and amenable to modeling with no significant number of fitting parameters**

For What

- **Fundamental physics-Precision measurements**
- **Quantum information-Atomtronics- Atom litography**
- **Strongly correlated ground states**

Collaborations

Guglielmo Tino group, *LENS, Florence (Italy)* **[MAGIA-Adv]**

Vladan Vuletic group, *MIT, Boston (US)* **[MIT-Unipi Prog]**

Murray Holland group, *JILA &Uni. Colorado@Boulder (USA)*

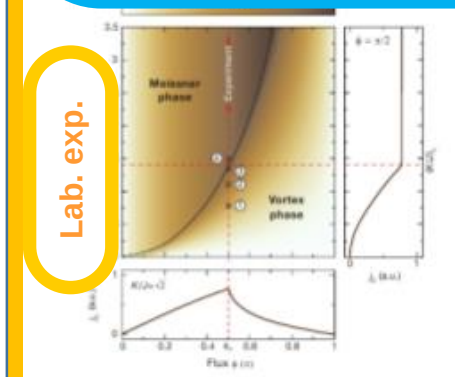
Stefania De Palo, *Democritos, Trieste (Italy)*

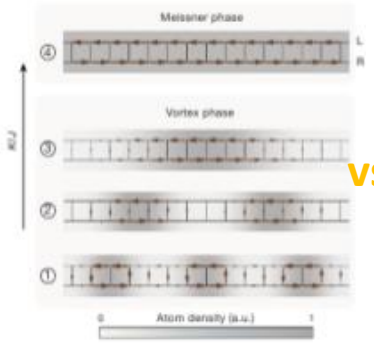
Roberta Citro, *University of Salerno (Italy)*

Edmond Orignac, *ENS-Lyon (France)*

Spin& Density Structure and Transport in 1D coupled chains with artificial magnetic fields: Meissner-to-Vortex phase transitions

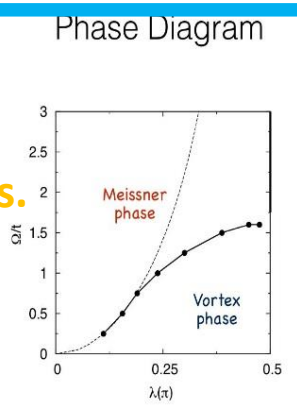
Lab. exp.





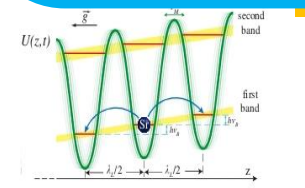
From Atala et al. Nat. Phys. (2014)

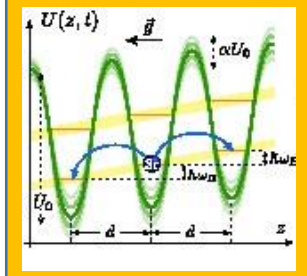
vs.



DMRG num. exp.

Precision measurements & Quantum transport in modulated optical lattices. Theo and Exp [@LENS]





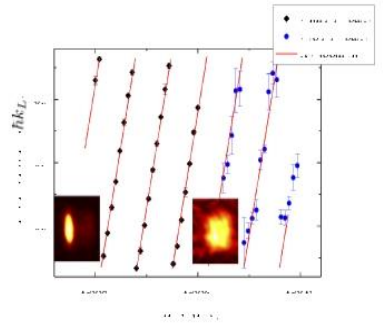
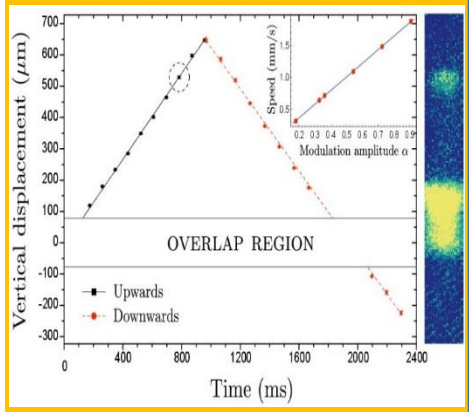
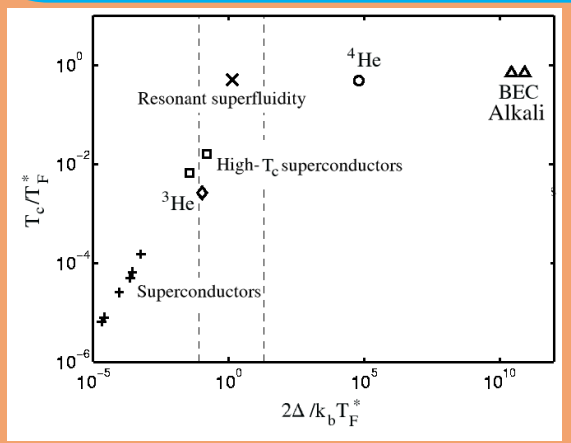


FIG. 6. Comparison between Bloch oscillation phase evolution with initial AM burst (black diamonds) and without it (blue circles). In the insets, 2D TOF atomic distributions in the two cases. The red line is obtained from the best fit with a sawtooth function.

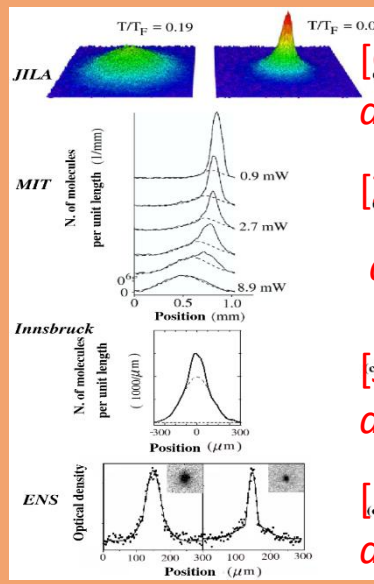


RESONANCE SUPERFLUIDITY IN FERMI GASES



[MC, M. Holland & D. Jin&Co]

BEC of "2-fermion molecules"

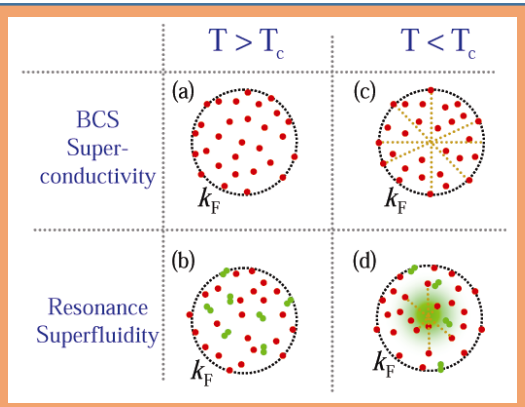


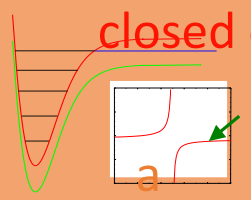
[Greiner *et al.* '03]

[Zwierlein *et al.* '03]

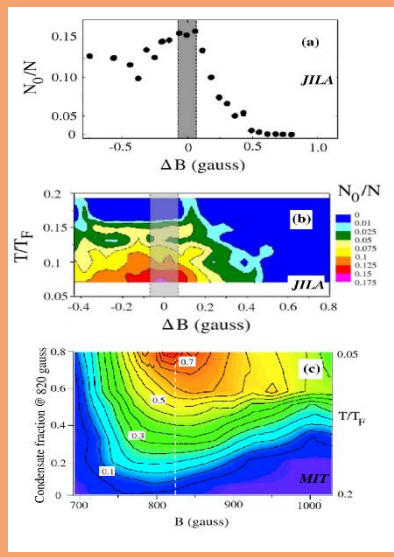
[Jochim *et al.* '03]

[Bourdel *et al.* '03]

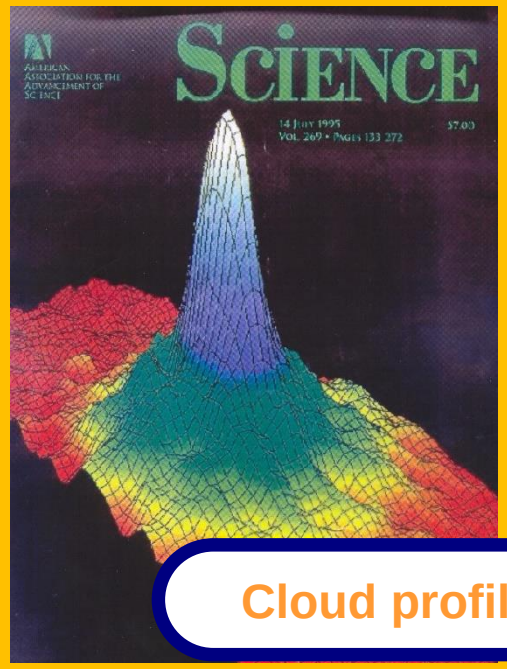




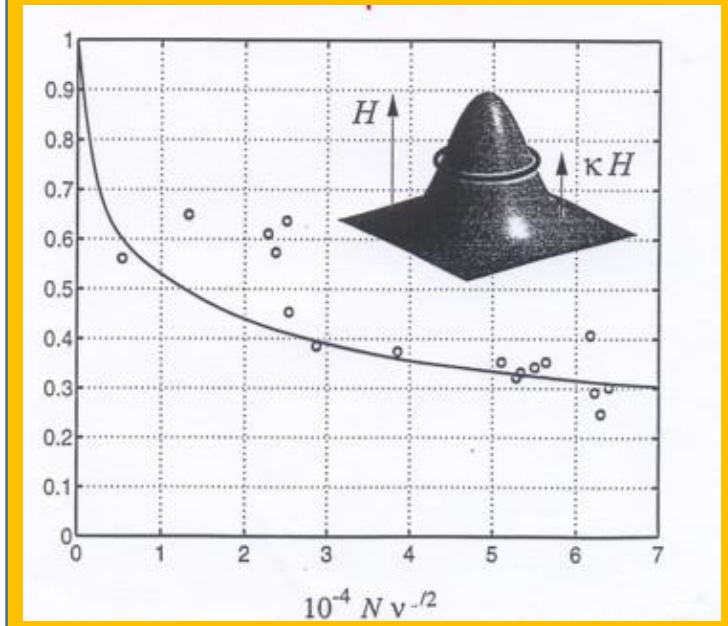
Tuning across resonance

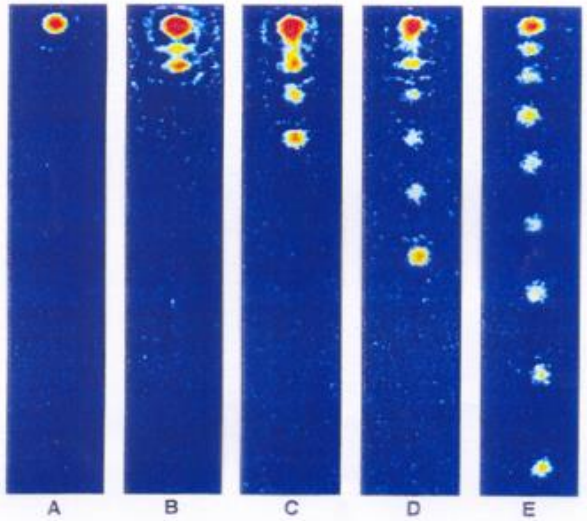


[Regal *et al.* '04] [Zwierlein *et al.* '04]



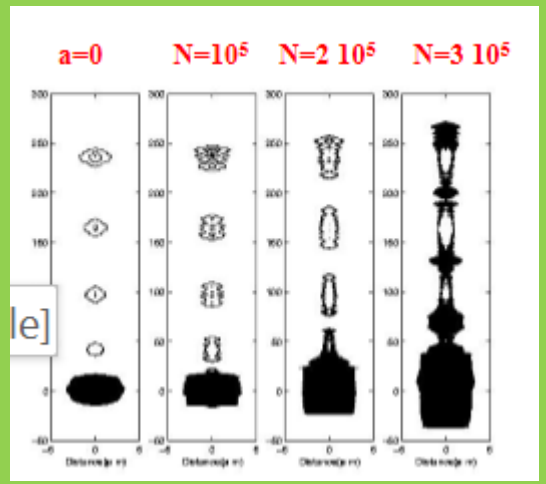
Cloud profiles

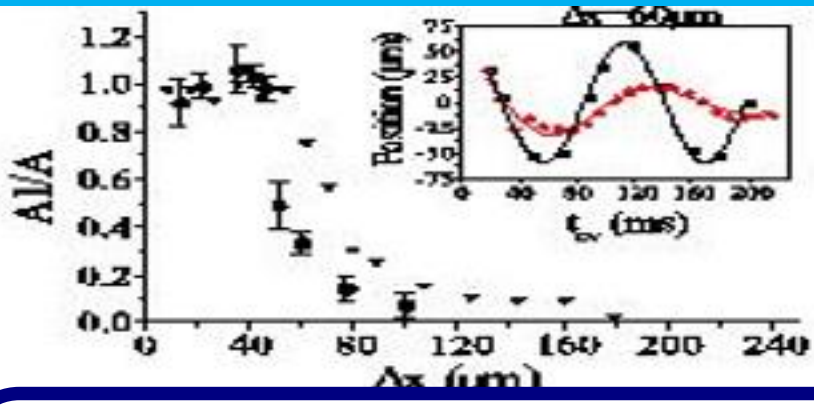




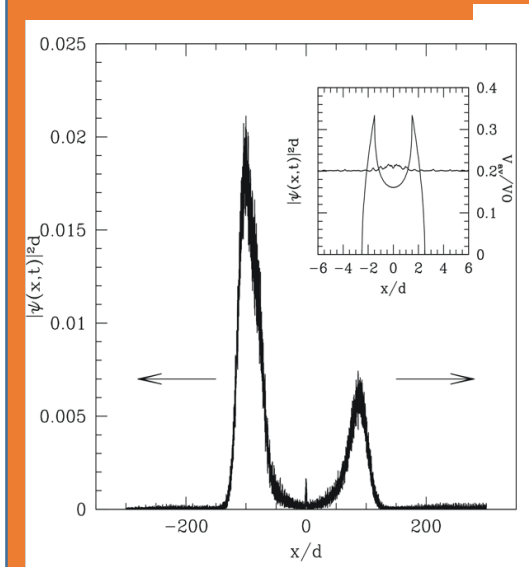
Anderson & Kasevich, Science (1998)

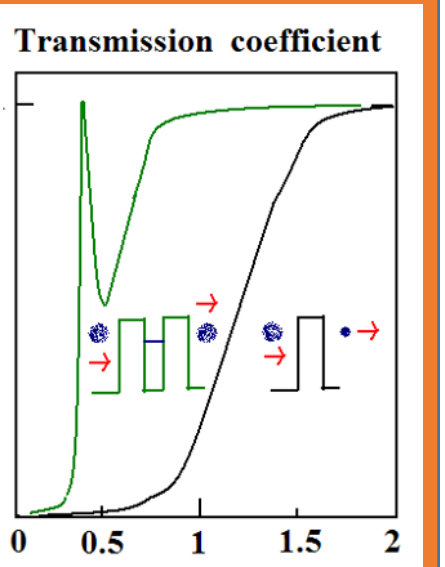
Atom laser





Oscillations in periodic lattices





Resonant tunneling