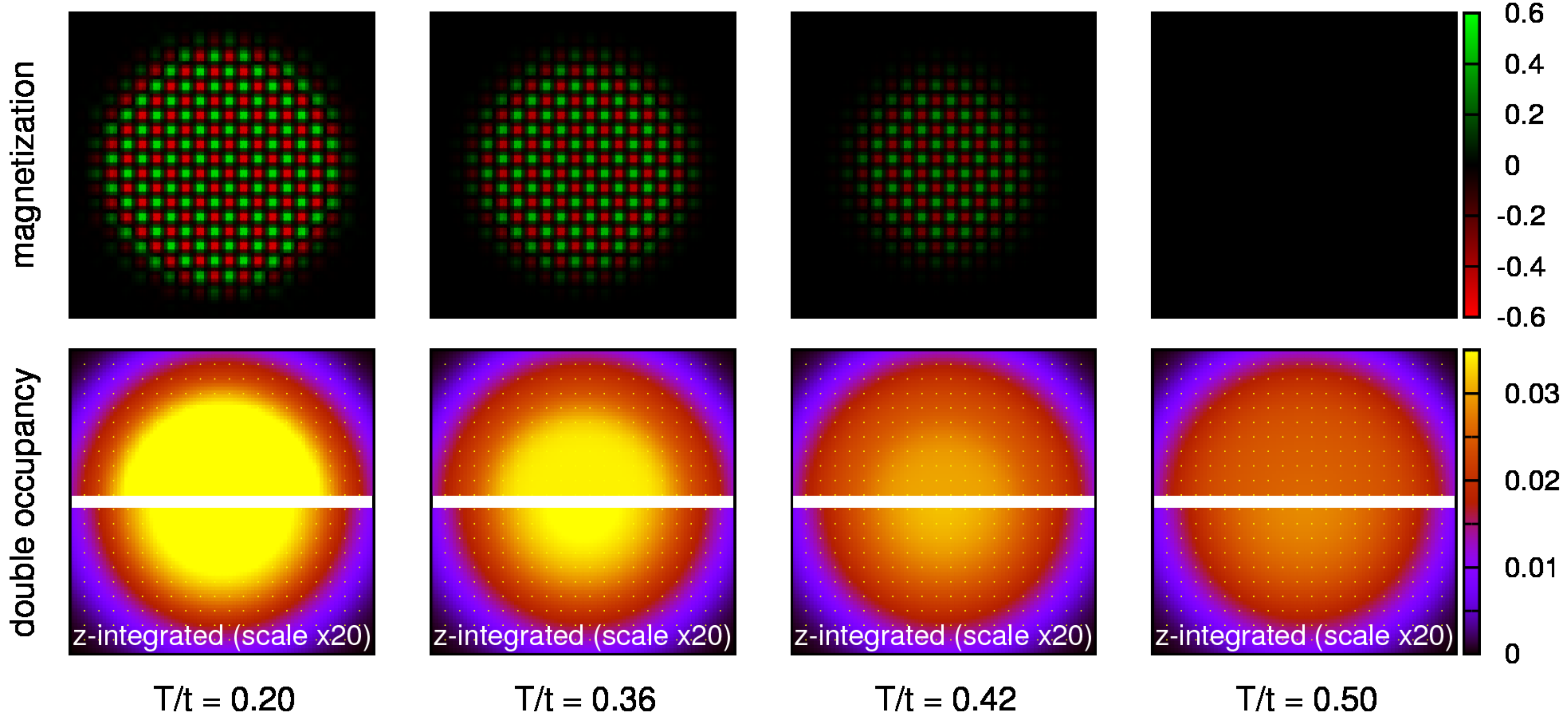
Néel Transition of Lattice Fermions in a Harmonic Trap: a Real-Space Dynamic Mean-Field Study

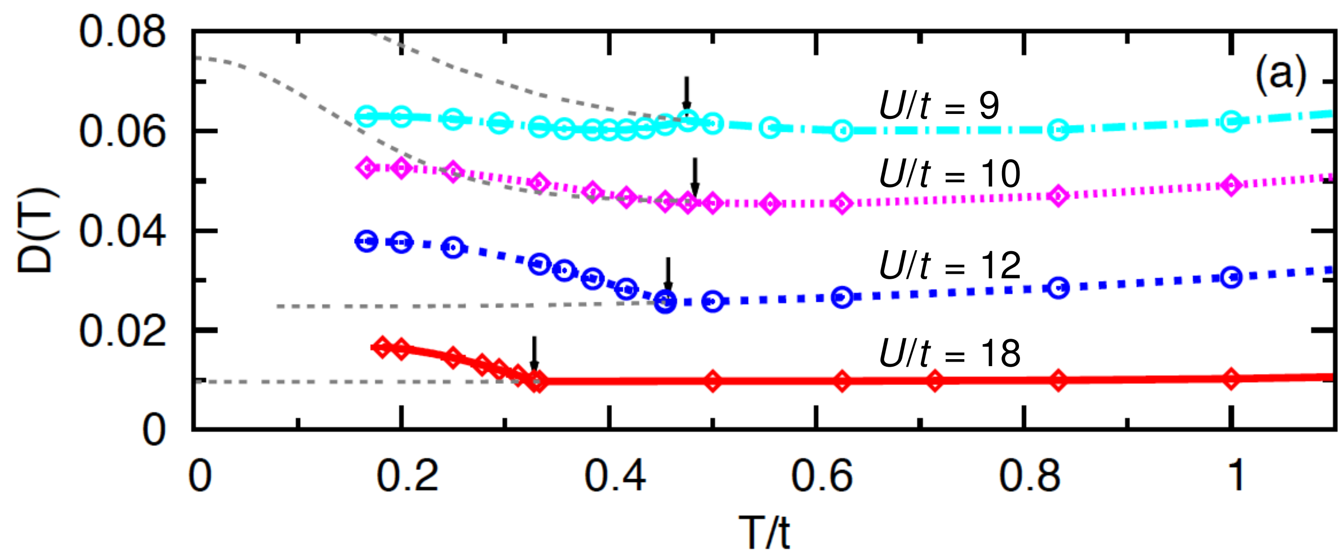
Elena Gorelik, Irakli Titvinidze, Walter Hofstetter, Michiel Snoek, and Nils Blümer

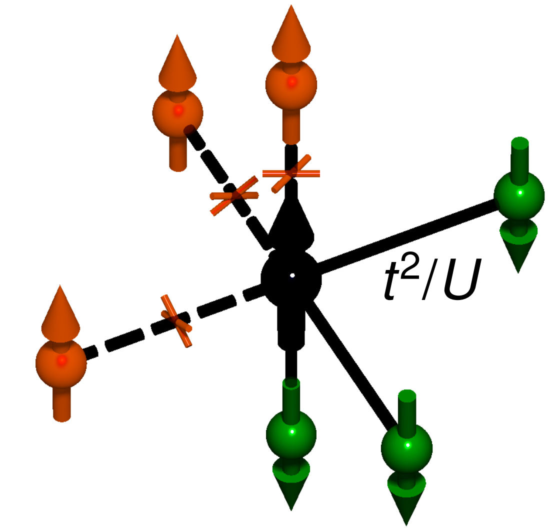
Nils Blümer, Univ. Mainz, Germany



AF correlations signaled by enhanced double occupancy (cubic lattice, $U/t = 12$)

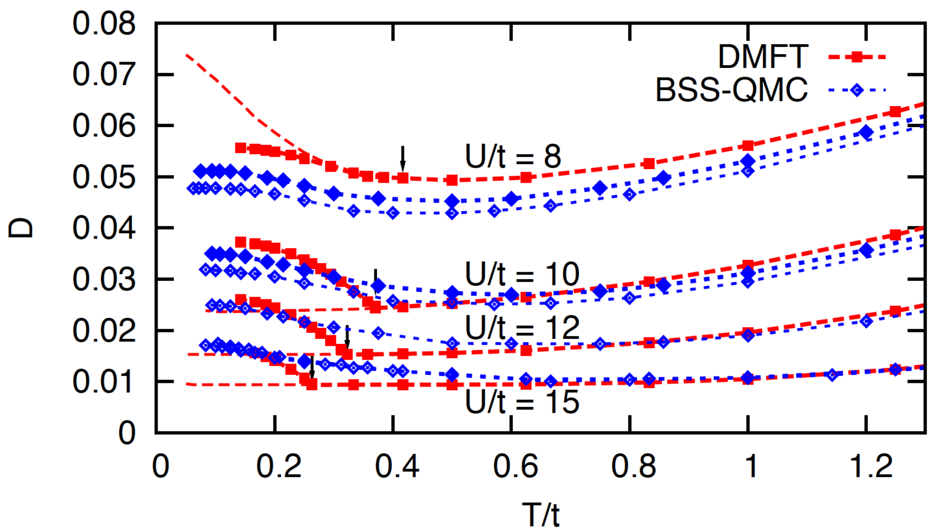
Enhancement of *D*: genuine strong-coupling effect (cubic lattice, n = 1)

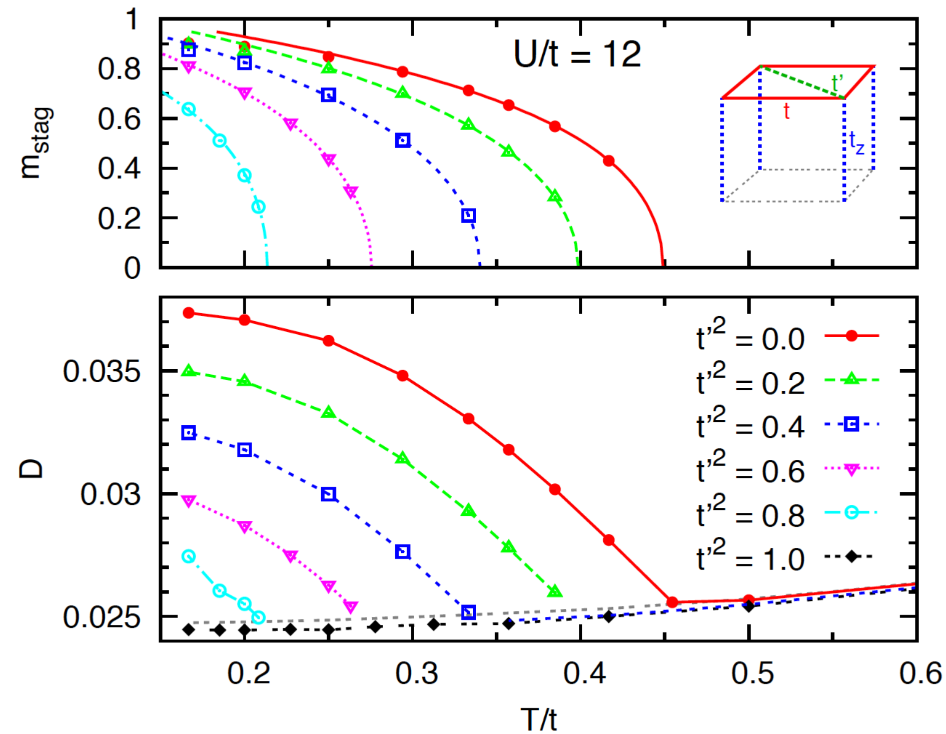




DMFT scenario confirmed for □ lattice

Effect suppressed by frustration (⇝ Δ)



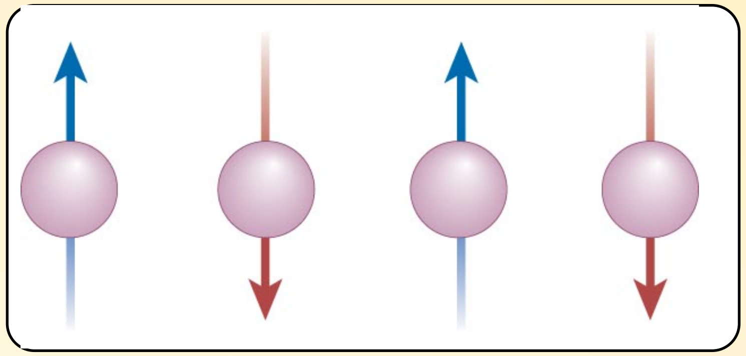


Cavity-aided MRI of ultracold atoms

Nathan Brahms, T. Purdy, D.W.C. Brooks, T. Botter, D.M. Stamper-Kurn

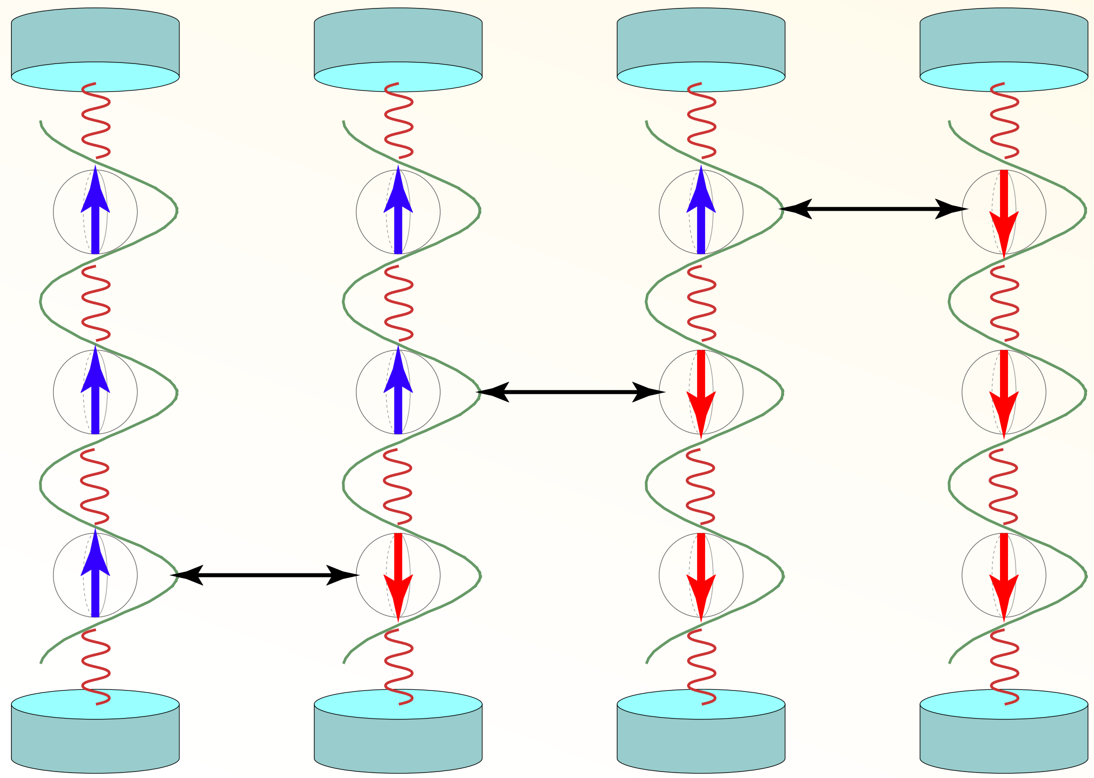
University of California, Berkeley

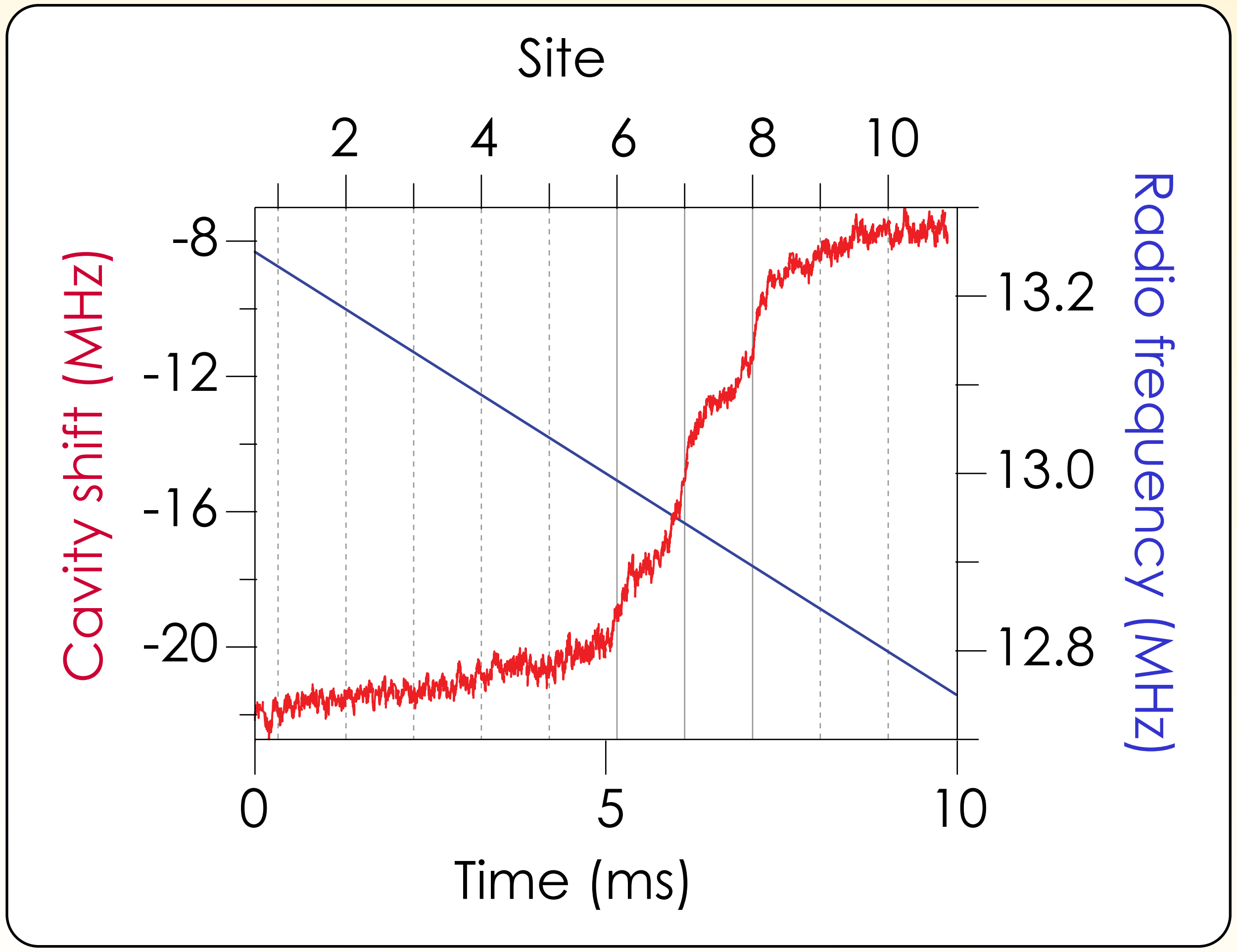
Microscopic imaging techniques for quantum magnetism, QIP, spatially varying properties



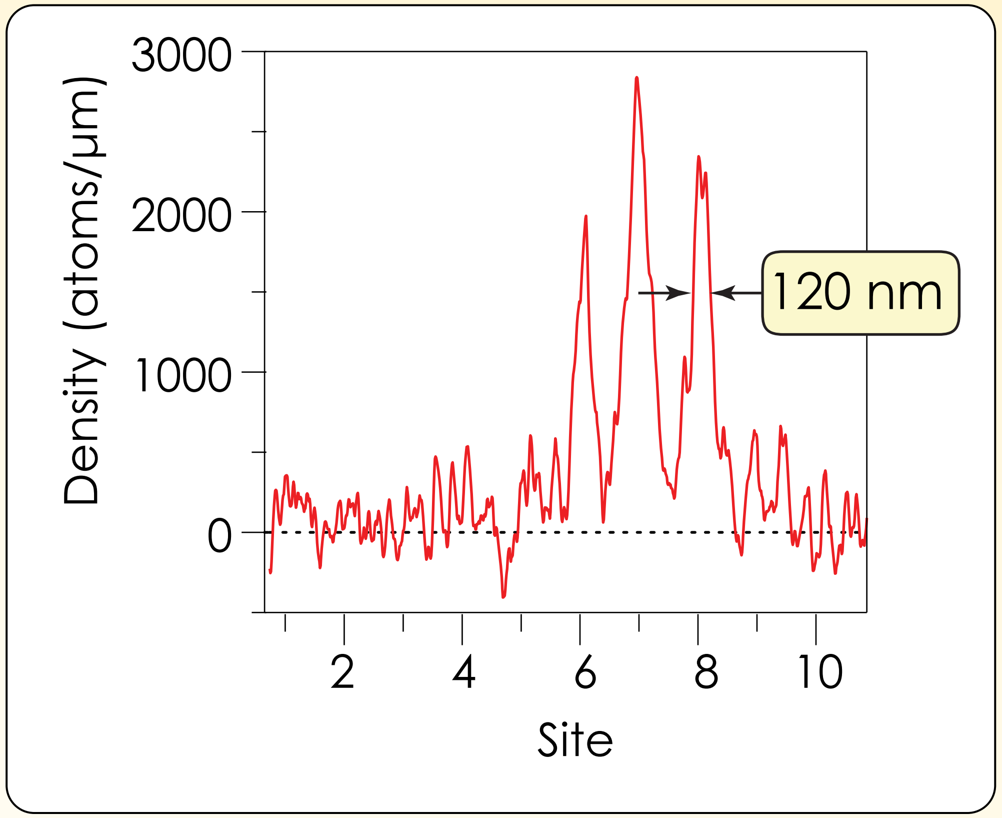
Coleman and Schofield, *Nature* **433**, 226 (2005)

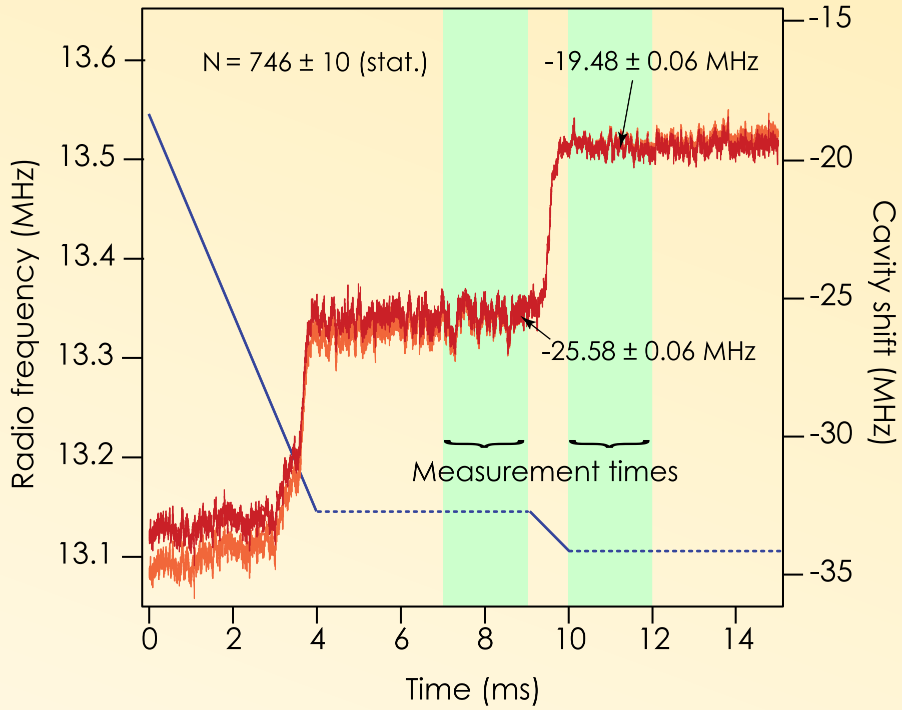
Use dispersive cavity QED + MRI for
state-sensitive, minimally destructive,
high-resolution, high-precision imaging





Sub-wavelength spatial resolution



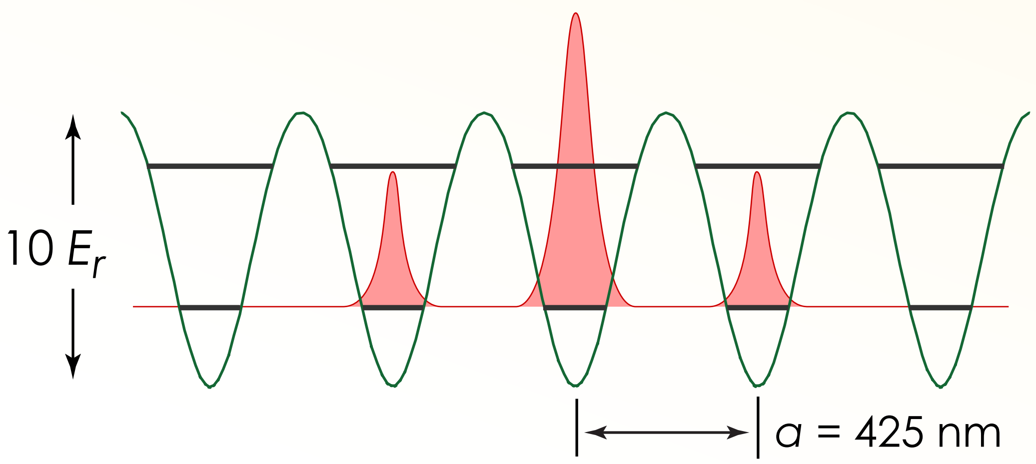


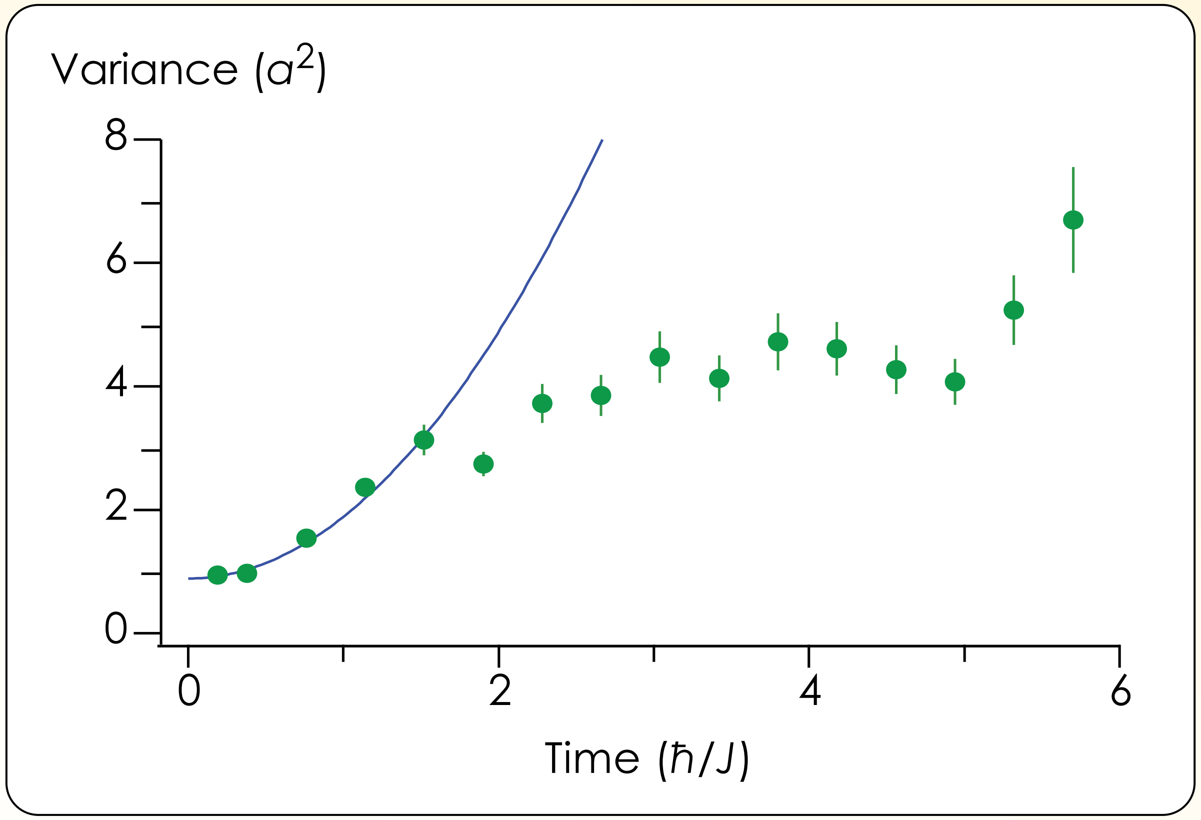
Sub-Poissonian measurement precision

$\delta S_Z \sim 5\,\hbar$ $\delta N \sim 2.4$

Physical application:

Quantum transport in an optical lattice

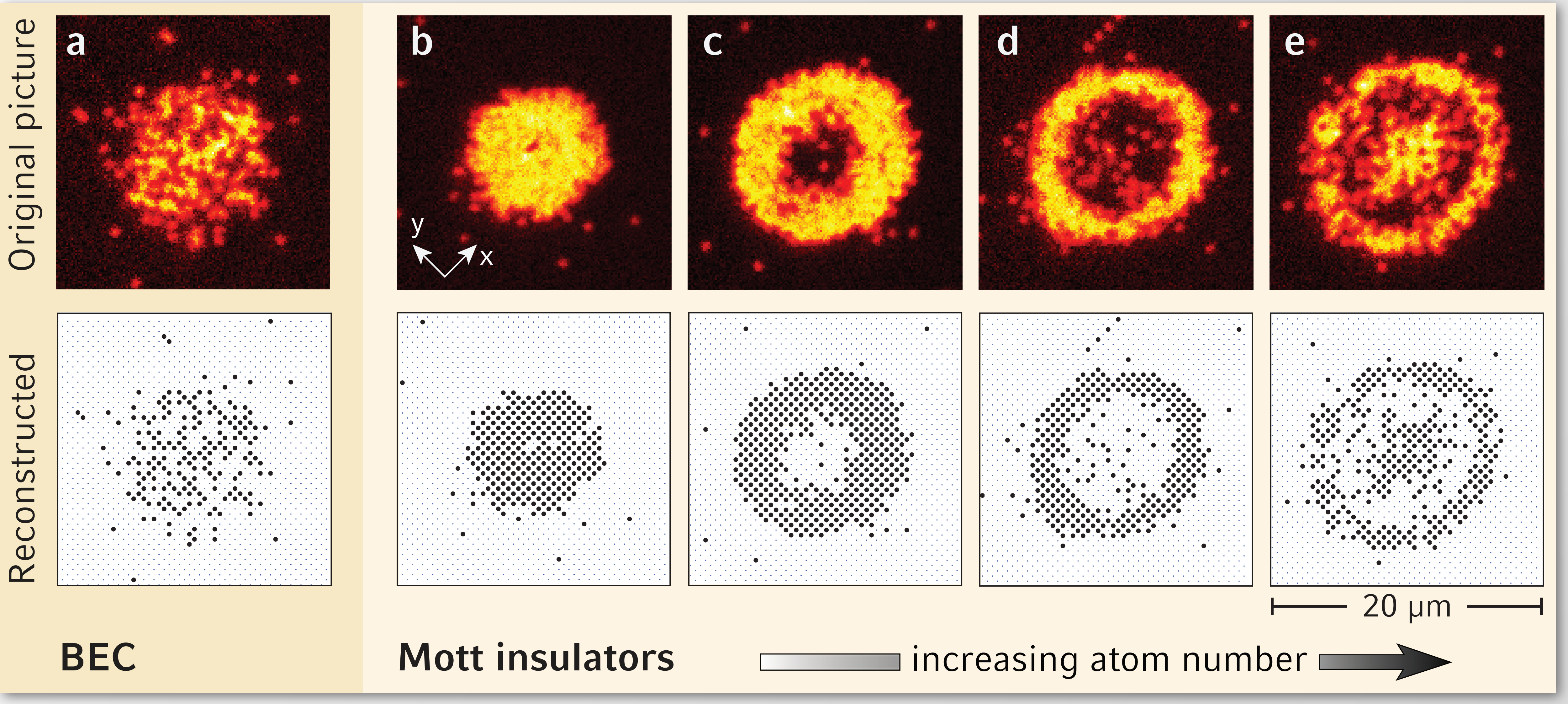




Single-site and single-atom resolved addressing of correlated quantum states in optical lattices

Talk by Stefan Kuhr this morning

Observation of Mott insulators

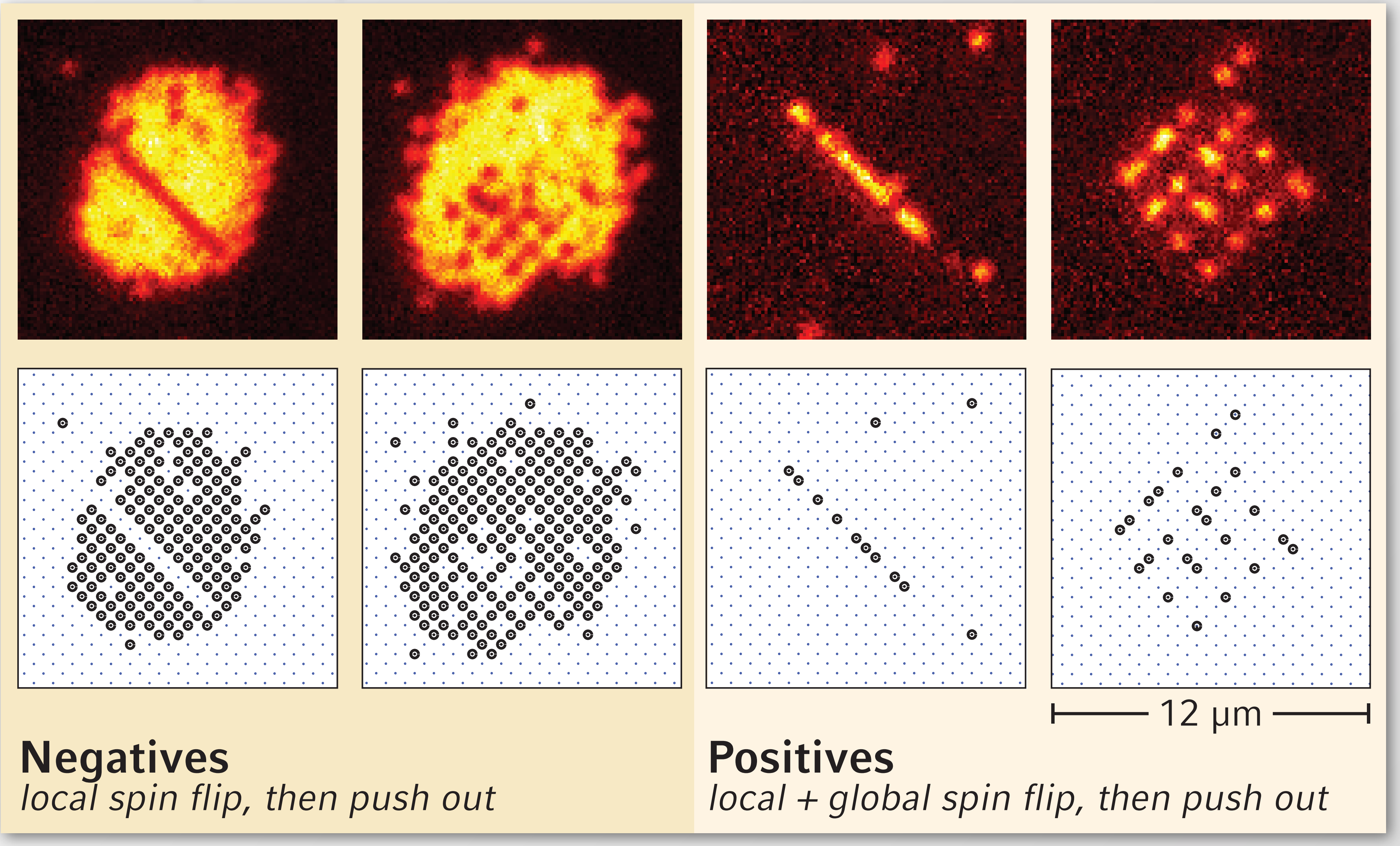


Marc CHENEAU

Max-Planck-Institut für Quantenoptik – Garching, Germany

Single-site and single-atom resolved addressing of correlated quantum states in optical lattices

Local spin flips



Marc CHENEAU

Max-Planck-Institut für Quantenoptik – Garching, Germany

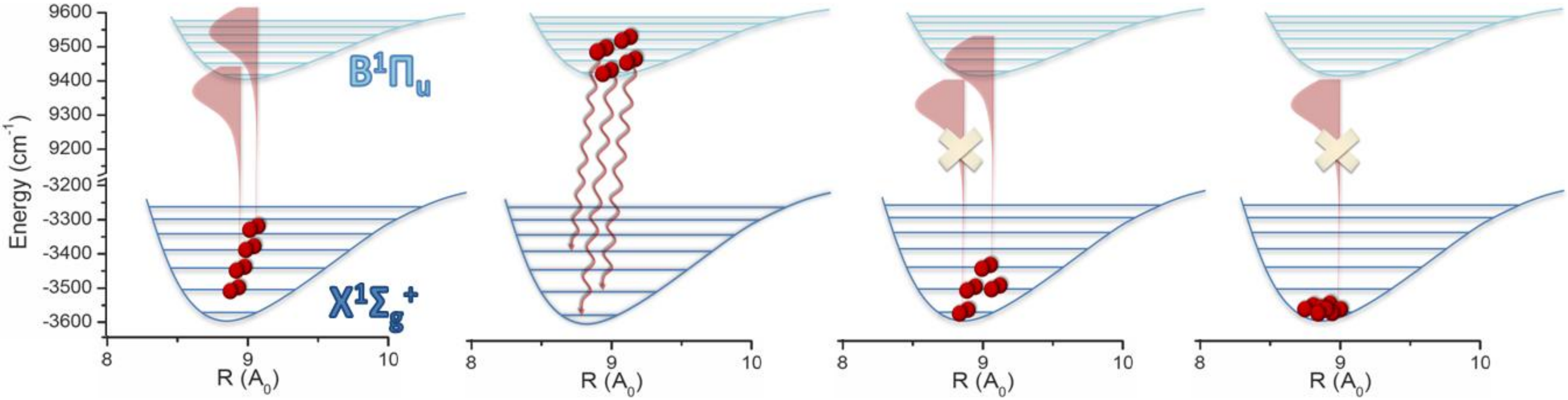
Molecular (vibrational cooling) Optical Pumping with shaped light

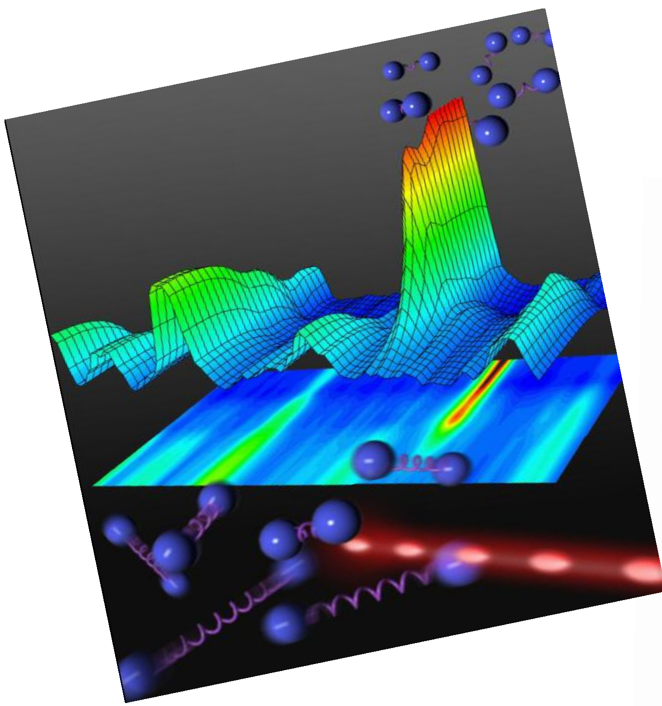
D. Comparat, Laboratoire Aimé Cotton, CNRS, Orsay, France

Coherent (pump-probe) control: femtosecond laser : A. Zewail Nobel 1999

1969	Optical pumping (sub-Zeeman)	Drullinger Zare
1972	Electric beam deflection (bi-alkali)	Dagdigian Wharton
1979	Light pressure force: beam deflection Na_2	Herrmann, Leutwyler, Wöste, Schumacher
1981	Laser cooling (anti-stokes) of CO_2 by laser. (proposed in 1950 Kastler)	Djeu, Whitney
1997	Dipole Force	Corkum
1998-2008	Beam slowing, cryogenic cooling, molecular ions, …	Meijer, Doyle, Drewsen, …
2008	Internal state (Vibrational) cooling with incoherent shaped laser	Comparat, Pillet
2010	Laser cooling (momentum transfer) of SrF	DeMille

Molecular (vibrational cooling) Optical Pumping with shaped light

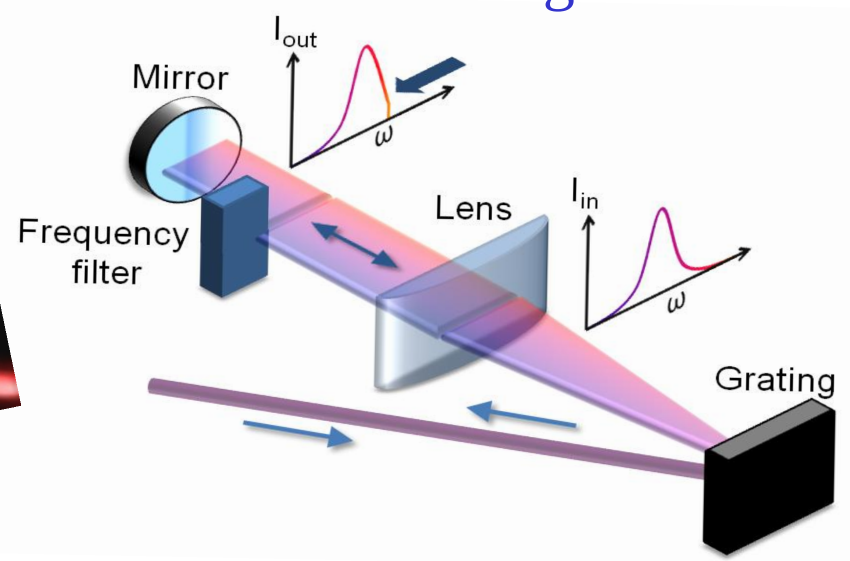




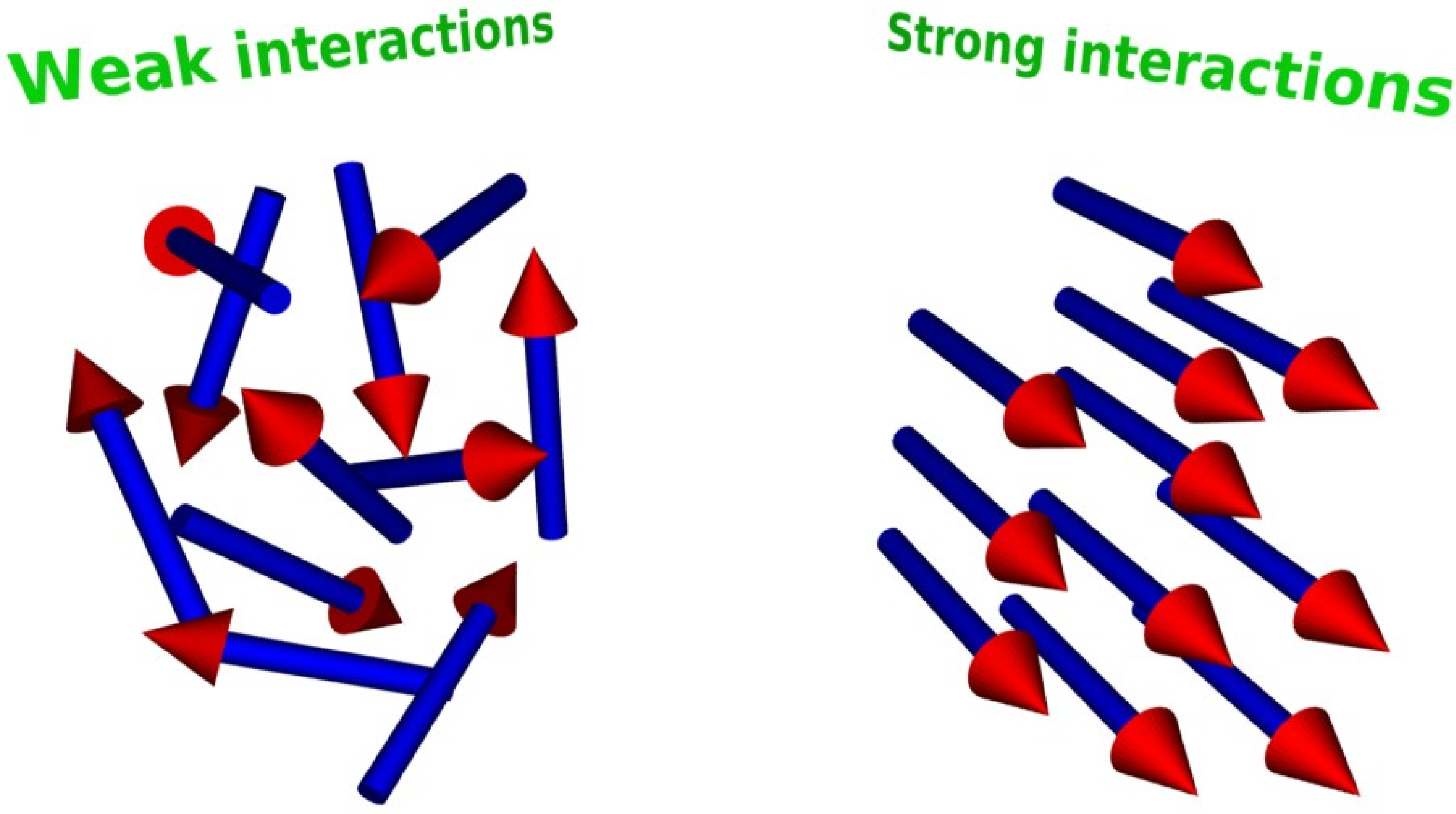
Triplet-singlet conversion

Rotational cooling

Toward general laser cooling



Perspectives on itinerant ferromagnetism in an atomic Fermi gas



Gareth Conduit[1, 2], Ben Simons[3] & Ehud Altman[1]

1. Weizmann Institute of Science, 2. Ben Gurion University, 3. University of Cambridge

T-matrix approach for few-body physics in ultracold atoms

Xiaoling Cui

Institute for Advanced Study, Tsinghua University, Beijing

$$T = U + UG_0(E)T$$

$$Det[1 - UG_0(E_b)] = 0$$

Well-known method but bran-new application in cold atoms!

X.L. Cui, Y.P. Wang and F. Zhou, Phys. Rev. Lett. 104, 153201(2010)
X.L. Cui, to appear on arxiv

Main results:

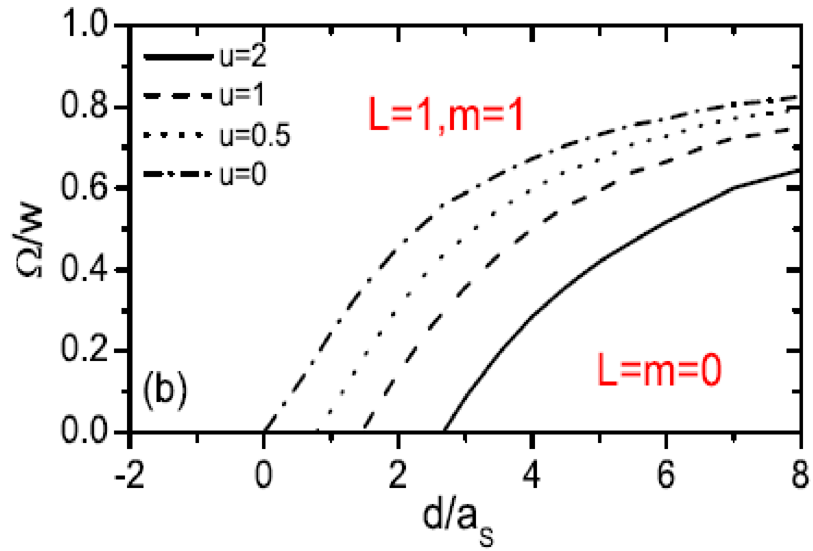
In most general cases, the problem is reduced to a matrix equation expanded by various orthogonal molecular states describing external center-of-mass motions of a pair of interacting particles; while each matrix element is guaranteed to be finite by properly renormalizing the short-range contributions for internal relative motions.

Advantage:

I. systematic, bridge from two-body to many-body problem

II. Physically insightful, by employing concept of renormalization

III.Transparent to analyze scattering properties and energy spectrum



Application: quantum Hall transitions of atom-dimer fermionic system in a rotating harmonic trap

Probing quantum systems through adiabatic dynamics

Claudia De Grandi

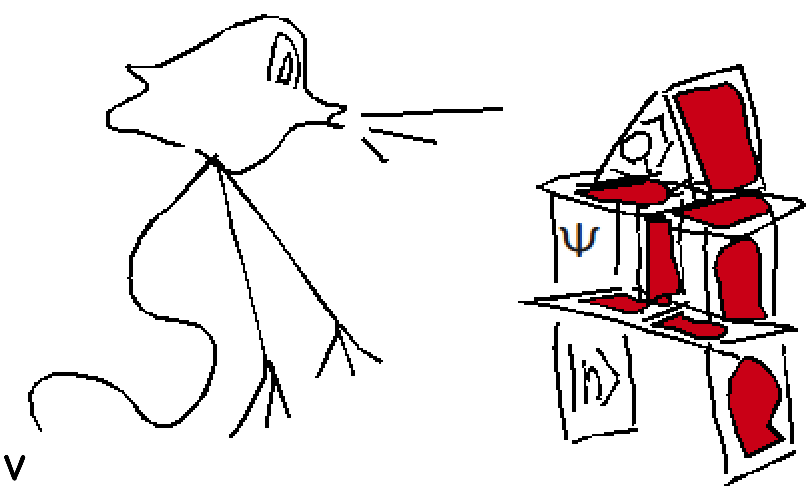
Quantum system
at the quantum critical point
t=0

+

t>0
small external perturbation

→

?
Response of the system



In collaboration with:
R. Barankov, A. Polkovnikov
V. Gritsev (U. of Fribourg)

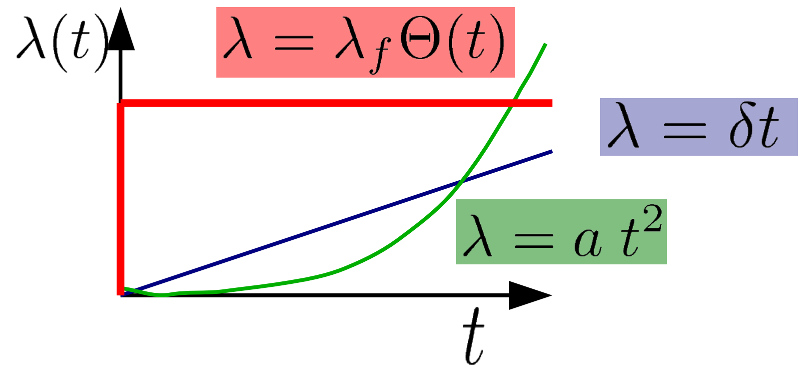
BOSTON UNIVERSITY

$$H(\lambda) = H_0 + \lambda V$$

external parameter

QUENCH

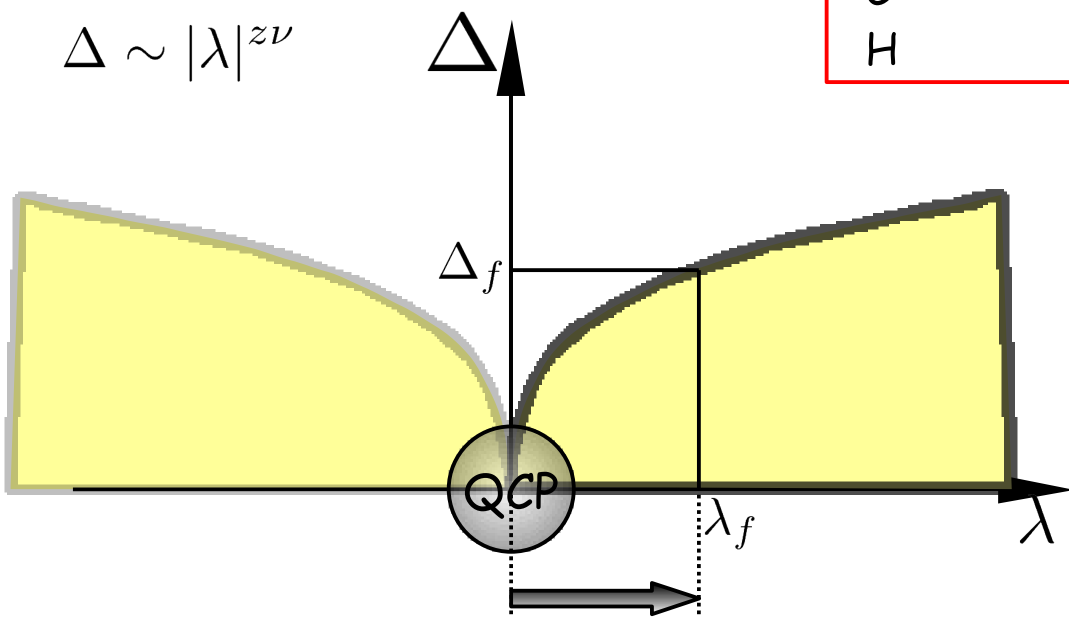
$$\lambda = 0 \;\Downarrow\; \lambda = \lambda_f$$



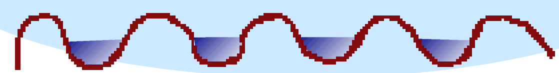
Compare different power laws dependence in time

$$\lambda(t) = \upsilon \frac{t^r}{r!}\Theta(t)$$

$\Delta \sim |\lambda|^{z\nu}$



Applications to 1D Bose gases are discussed (sine-Gordon model)



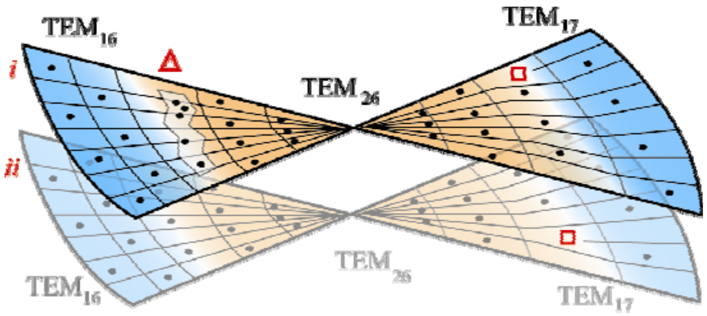
Scaling of the number of excitations due to the quench:

RESULTS

quadratic scaling · system size · dimension · r=power of the quench

$$n_{\rm ex} \sim \begin{cases} \upsilon^2 L^{2/\nu - d + 2zr} & \xi(\upsilon) \gg L \\ |\upsilon|^{d\nu/(z\nu r+1)} & \xi(\upsilon) \ll L \end{cases}$$

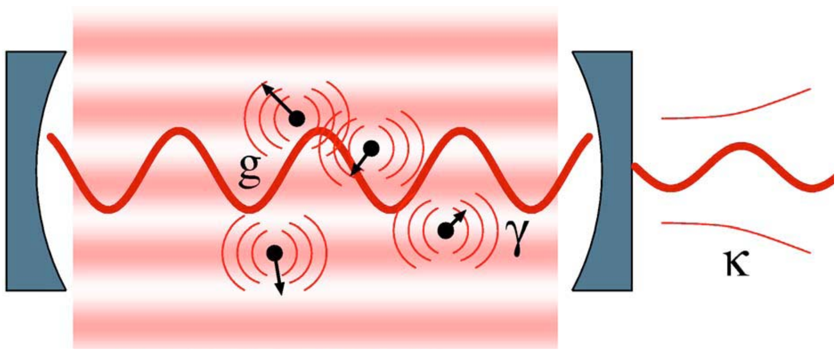
Kibble-Zurek scaling



Solidity and frustration in multimode optical cavities

Sarang Gopalakrishnan
(with Benjamin Lev, Paul Goldbart)
University of Illinois at Urbana-Champaign

Crystallization in cavities

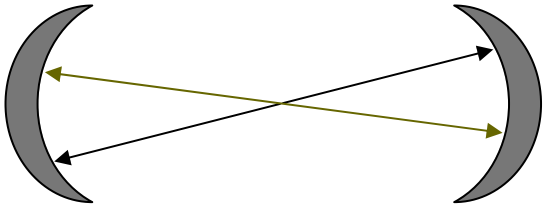


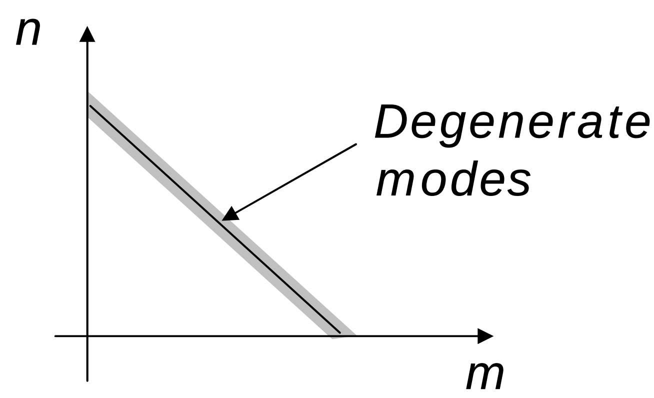
Domokos, Ritsch (PRL, 2002)
Asbóth et al (PRA, 2005)

- Red-detuned lasers **transverse** to cavity, high-field-seeking atoms
- Atoms scatter light coherently between pump and cavity
- Atoms one wavelength apart emit in phase
- Photons trap atoms at even/odd antinodes
- Spontaneous even/odd symmetry breaking

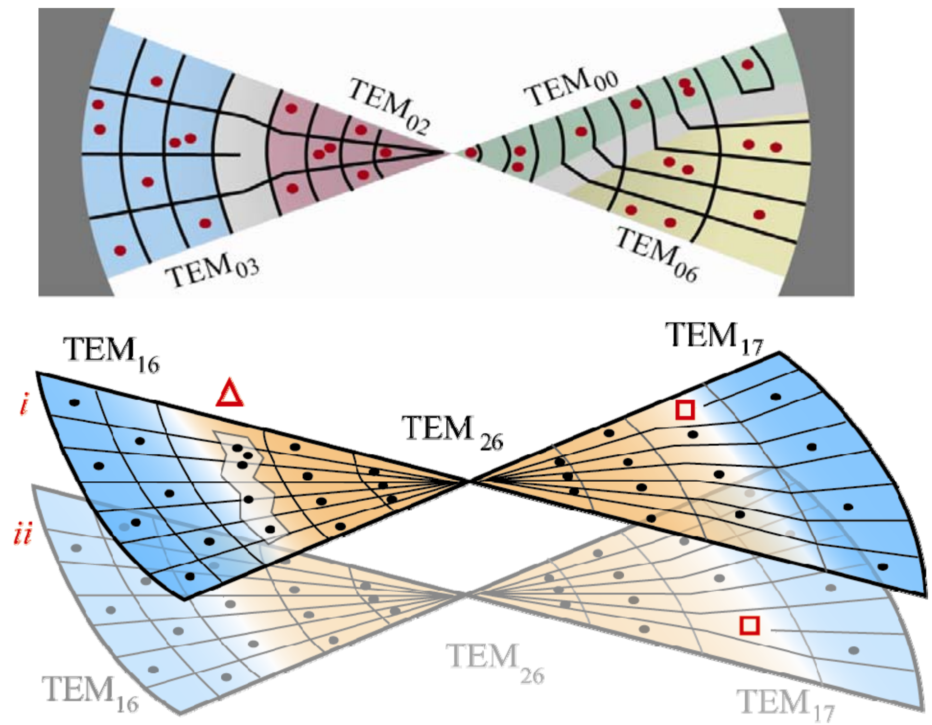
Multimode cavities

(ring, confocal, **concentric**)



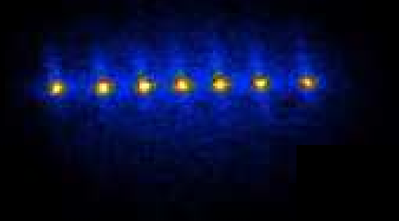


- Many more possibilities for ordering
- 2D case realizes Brazovskii's transition
- Ordered state expected to have defects, dislocations
- In 3D, frustration
  - Center and edge must order differently
  - Forces dislocations, etc.
- Supersolidity? Glassiness?



arxiv:0903.2254

Chain of trapped ions



Quantum simulator →

Spin model

$$H = J_z \sum_{i<j} \frac{1}{|i-j|} S_i^z S_j^z + J_{xy} \sum_{i<j} \frac{1}{|i-j|} \left(S_i^x S_j^x + S_i^y S_j^y \right) - \mu \sum_i S_i^z$$

with dipolar interaction and tunneling

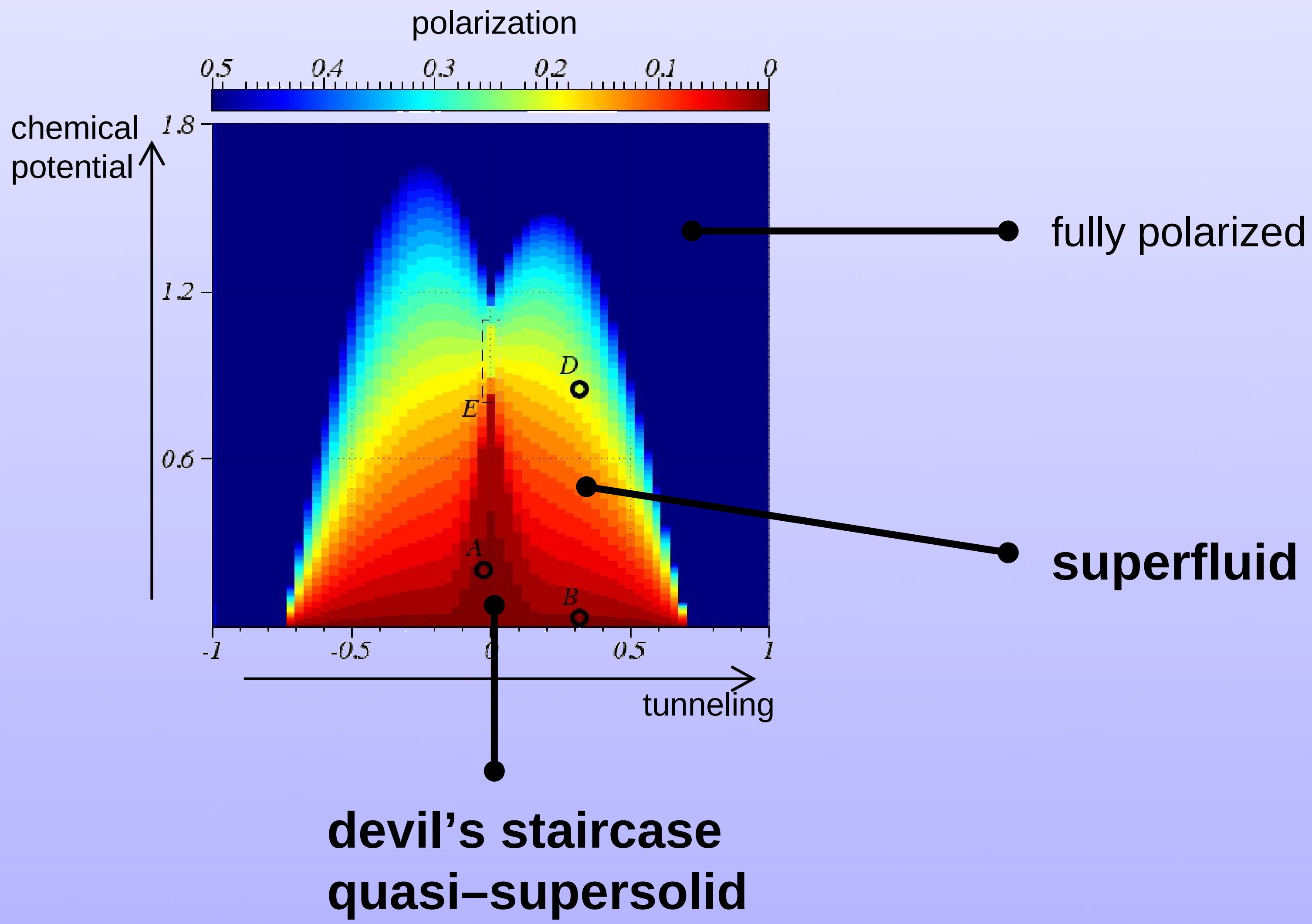
Philipp Hauke, F. M. Cucchietti, M. Lewenstein (ICFO)

A. Müller-Hermes, M.-C. Bañuls, J. I. Cirac (MPQ)

arXiv:1008.2945, 2010

ICFO Institut de Ciències Fotòniques | MPQ | QUAGATUA | TOQATA | NAMEQUAM | aqute | caixaManresa | QT Quantum Optical Information Technology

A quasi-supersolid phase emerges



Density ripples in expanding low-dimensional gases as a probe of correlations

Adilet Imambekov, Rice University

Theory: PRA 80, 033604 (2009), A. Imambekov et. al.

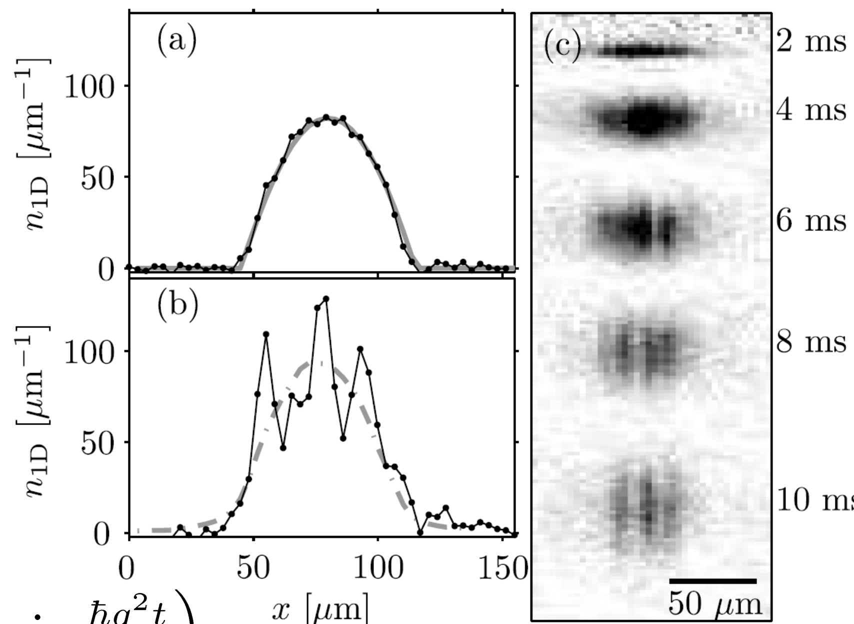
1D Experiment: PRA 81, 031610(R) (2010) , S. Manz et. al.

TOF in "Infinite size" limit: $t \ll \frac{mL^2}{\hbar} \sim 10s$

velocity fluctuations + expansion

$\Downarrow$

density ripples



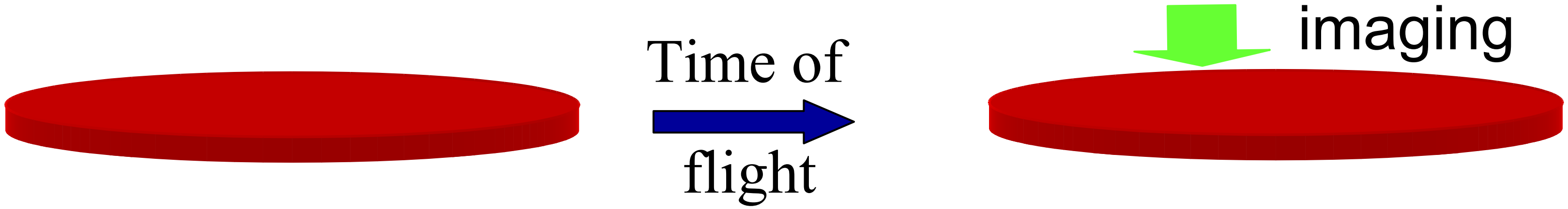
$$\frac{\langle|\rho(q)|^2\rangle}{n_{1D}^2\xi_h} \approx \frac{\lambda_T q - e^{\frac{-2\hbar q t}{m\lambda_T}}\left(\lambda_T q \cos\frac{\hbar q^2 t}{m} + 2\sin\frac{\hbar q^2 t}{m}\right)}{q\xi_h\left(1+\lambda_T^2 q^2\right)}$$

2D: Probe of BKT transition

$$\left\langle \hat{\psi}^\dagger(\mathbf{r},0)\hat{\psi}(0,0)\right\rangle \approx n_{2D}\left(\frac{\lambda_{2D}}{r}\right)^\eta \text{ for } r \gg \lambda_{2D}$$

η <1/4 , algebraic decay of correlations

η =1/4 , vortex unbinding, exponential decay above that T



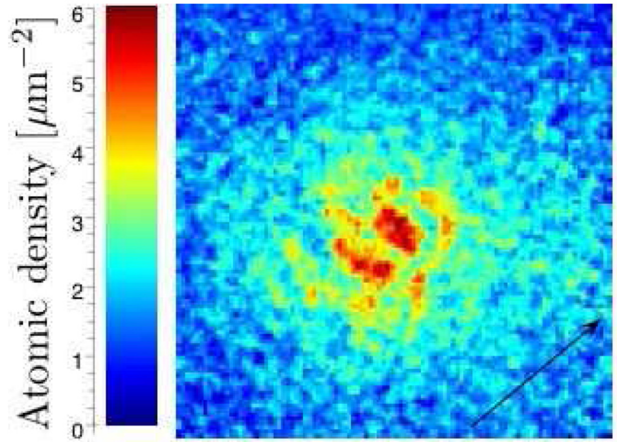
Theory:

$$y = \frac{\hbar q^2 t}{m}$$

$$\langle|\rho(q)|^2\rangle \approx n_{2D}^2\lambda_{2D}^2\left(\frac{\hbar t}{m\lambda_{2D}^2}\right)^{1-\eta} F(\eta,y)$$

Scaling:

$$\int_0^{\sqrt{\frac{2\pi m}{\hbar t}}} dq\,\langle|\rho(q)|^2\rangle \propto t^{1/2-\eta}$$



Thermodynamics in an Unitary Fermi Gas

Kaijun Jiang

Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan, China; Laboratoire Kastler Brossel, Ecole normale supérieure, Paris, France

Exploring the thermodynamics of ultracold atoms

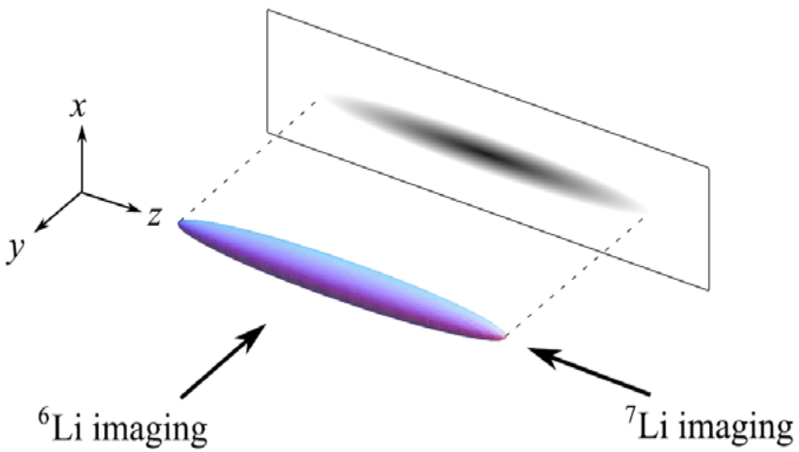
$$P(\mu_1,\mu_2,T) = P(\mu_1,T)\,h\left(\eta=\frac{\mu_2}{\mu_1},\varsigma=\exp\left(\frac{-\mu_1}{k_BT}\right)\right)$$

Method and technique

LDA $$\mu_{iz} = \mu_i^0 - V(z) = \mu_i^0 - \frac{m\omega_z^2 z^2}{2}$$

Local pressure $$P(\mu_1,\mu_2,T) = \frac{m\omega_r^2}{2\pi}(n_{1z}+n_{2z})$$

Temperature: **Bosonic Li^7 colliding with Li^6 to equilibrium**



1, Balanced Fermi Gas with Finite Temperature

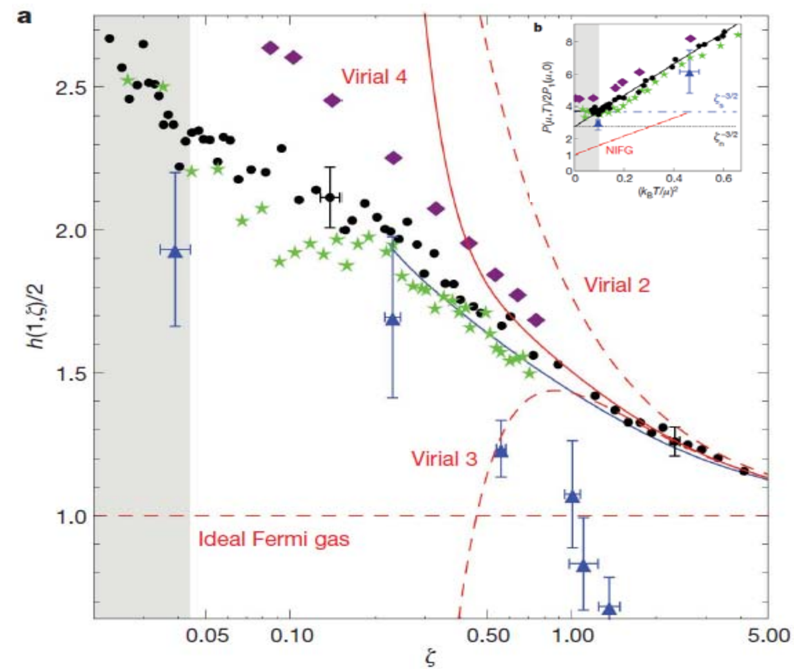
High temperature: Virial expansion

$$\frac{h(1,\varsigma)}{2}=\frac{\sum_{k=1}^{\infty}((-1)^{k+1}k^{-5/2}+b_k)\varsigma^{-k}}{\sum_{k=1}^{\infty}(-1)^{k+1}k^{-5/2}\varsigma^{-k}}$$

Low temperature: Phase transition

$T>T_c$, Fermi liquid

$$P(\mu,T)=P(\mu,0)\left(\xi_n^{-3/2}+\frac{5\pi^2}{8}\xi_n^{-1/2}\frac{m^*}{m}\left(\frac{k_BT}{\mu}\right)^2\right)$$



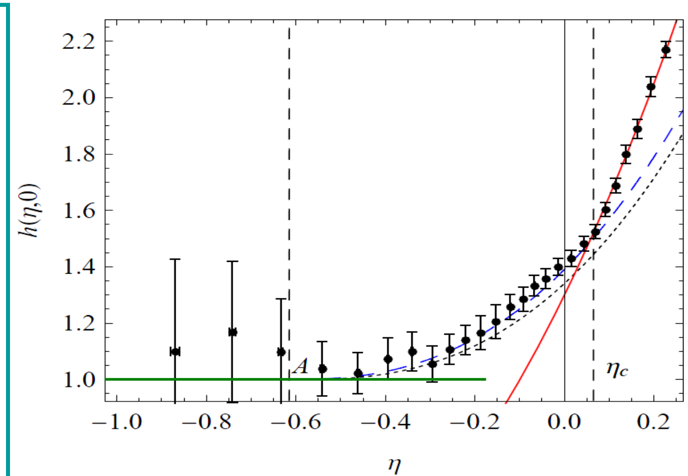
2, Imbalanced Fermi Gas with Zero Temperature

Superfluid: $\eta>\eta_c$ $\quad h_s(\eta,0)=\frac{1}{(2\xi_s)^{3/2}}(1+\eta)^{5/2}$

Normal mixture $A>\eta>\eta_c$

$$h_n(\eta,0)=1+\left(\frac{m_p^*}{m}\right)^{3/2}(\eta-A)^{5/2}$$

Full polarized ideal gas: $\eta<A$ $\quad h_i(\eta)=1$

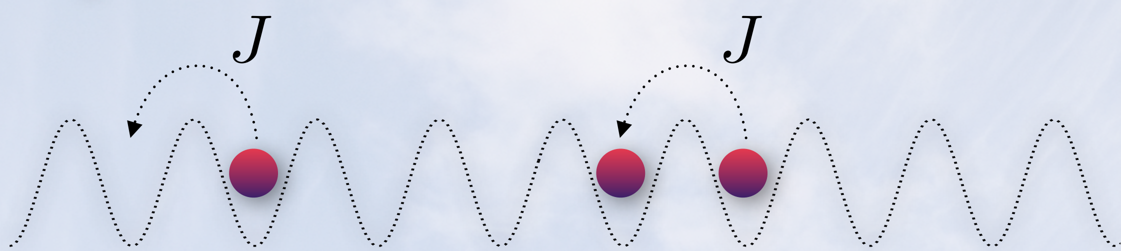


arXiv:1009.2036v1

Statistically induced Phase Transitions

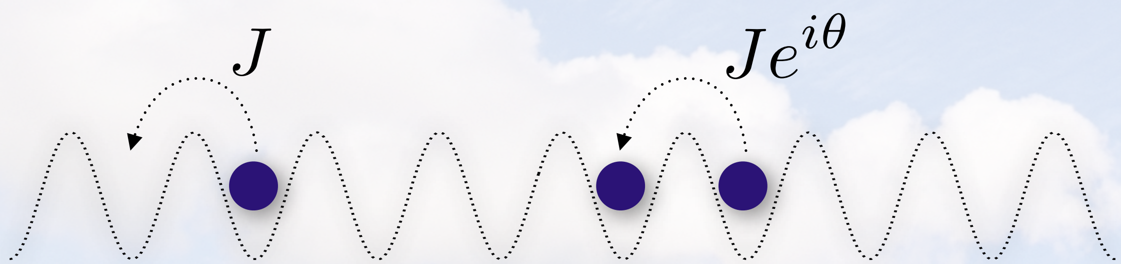
Tassilo Keilmann[1,2], Simon Lanzmich[2], Ian McCulloch[3] & Marco Roncaglia[2,4]
1: LMU Munich | 2: MPQ Garching | 3: Queensland University | 4: ISI Foundation Torino

Anyons in 1D

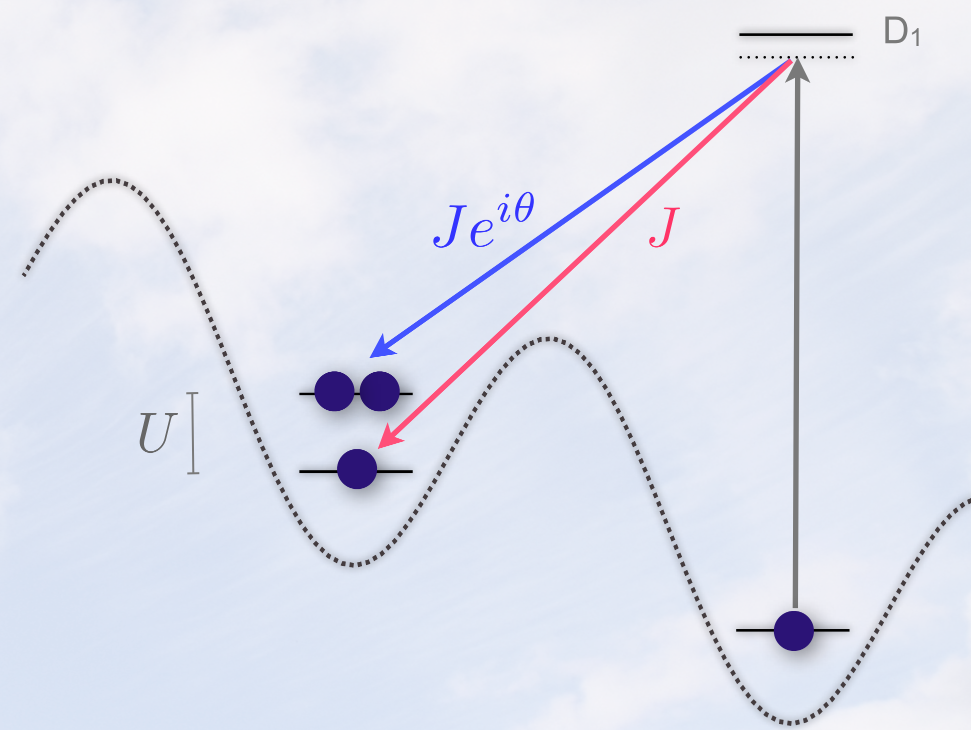


1:1 mapping

Bosons in 1D



Experimental proposal



Statistically induced Phase Transitions

arXiv:1009.2036v1

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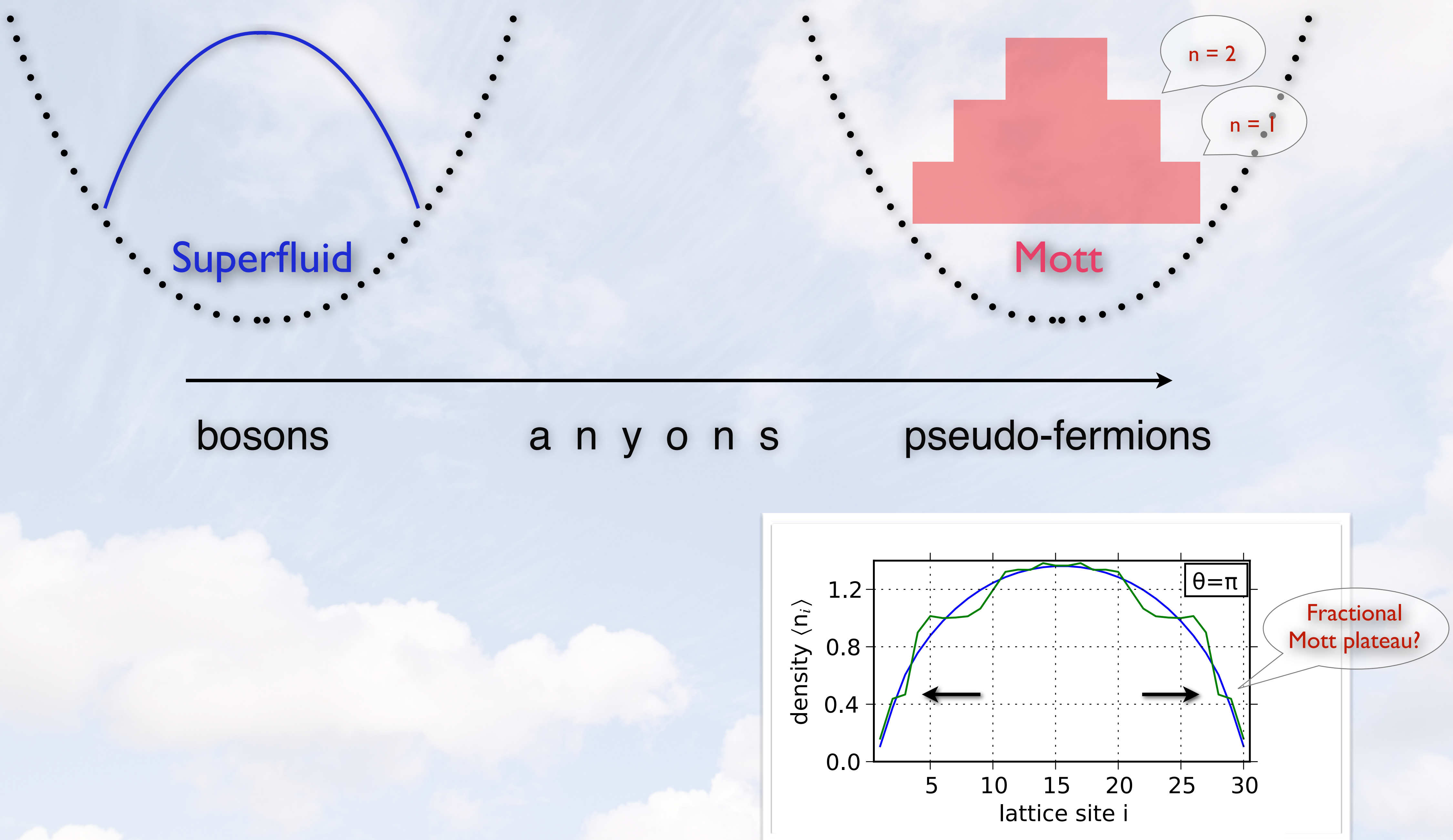


Dynamical Gauge Fields on Optical Lattices :
A Lattice Gauge Theorist Point of View

Yannick Meurice, University of Iowa

- Dynamical gauge fields are essential to recover the main features of strong interactions (confinement, mass gap, chiral symmetry breaking, asymptotic freedom) in lattice gauge theory simulations.

- "Pure gauge" (no fermions or scalars) MC simulations are fast and easy but simulations involving fermions are very demanding (calculations of determinants and propagators). Simulations at real time or with a chemical potential have a sign problem. I propose two strategies to use optical lattices to mimic lattice gauge theory simulations.

- Strategy I: Engineer *quantum* link variables with plaquette interactions. They would play the role of (dynamical) hopping parameters for the atoms located at the sites of the optical lattice. An underlying local gauge invariance is highly desirable.

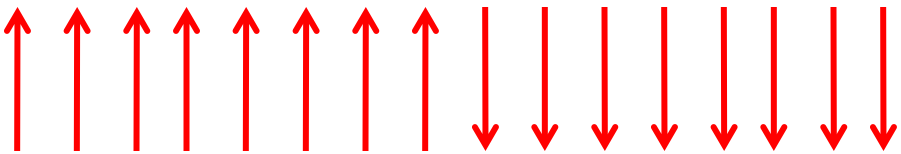
- Strategy II: Use numerical link variables as obtained in a MC simulation and replace the classical calculations of the fermion determinants and propagators in a fixed gauge background by measurements of fermion correlations on the optical lattice. This possibility requires the ability to manipulate locally the hopping parameters.

Challenges

- Relativistic fermions with global color (from hyperfine levels).
- Dynamical link variables as condensates: $U^{ab}_{\mathbf{x},\mathbf{e}_i} = {\phi^{\star}}^{a}_{\mathbf{x}}\phi^{b}_{\mathbf{x}+\mathbf{e}_i}$.
- Local manipulation of hopping parameters.
- Local symmetry and plaquette interactions.

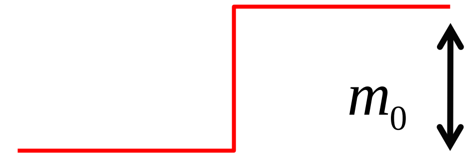
TIME EVOLUTION OF AN INITIAL DOMAIN WALL PROFILE IN THE XX MODEL

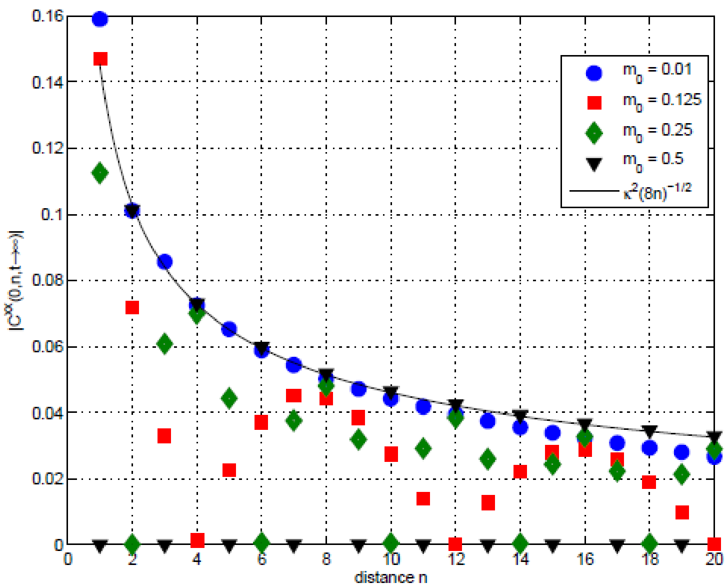
t=0



Initial Energy density

$$\frac{E}{L} = \frac{1}{\pi}\cos(\pi m_0)$$



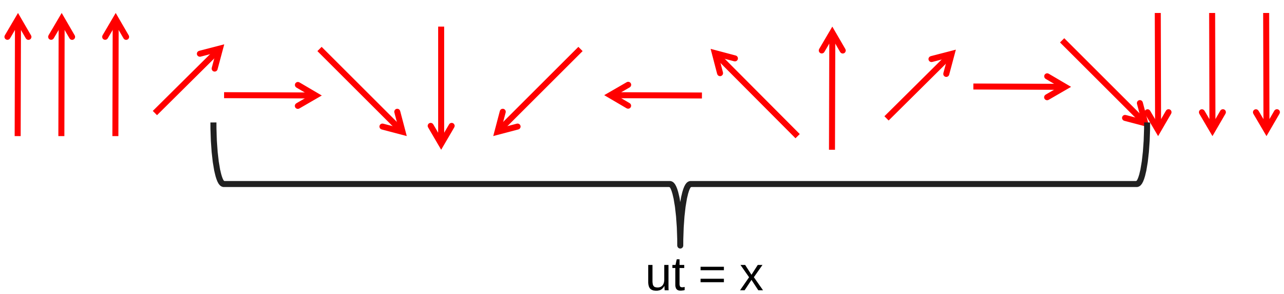


Wavelength of the inhomogeneity depends on the initial domain wall height

$$C^{xx}(j, j+n, t) \xrightarrow{t\to\infty} C^{xx}_{eq}(n)\cos\left(\frac{2\pi n}{\lambda}\right)$$

$$\lambda = \frac{2}{m_0} \qquad C^{xx}_{eq}(n) \approx \frac{1}{\sqrt{8n}}\kappa^2$$

Energy density of the XX model $= 2C^{xx}(n=1) = \dfrac{1}{\pi}\cos(\pi m_0)$



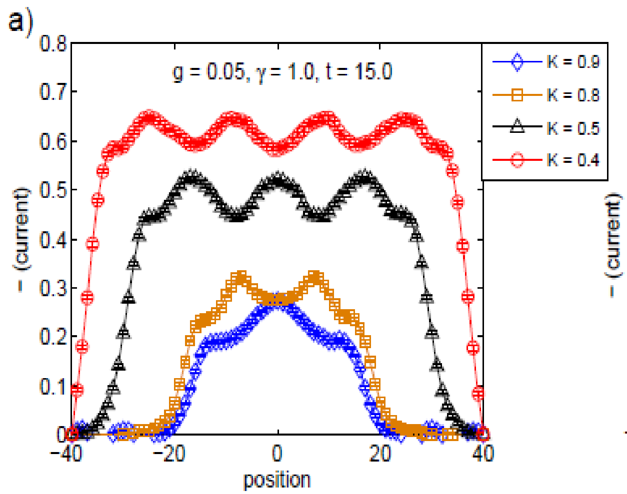
$$\frac{dS^z}{dt} = -\frac{dj}{dx}$$

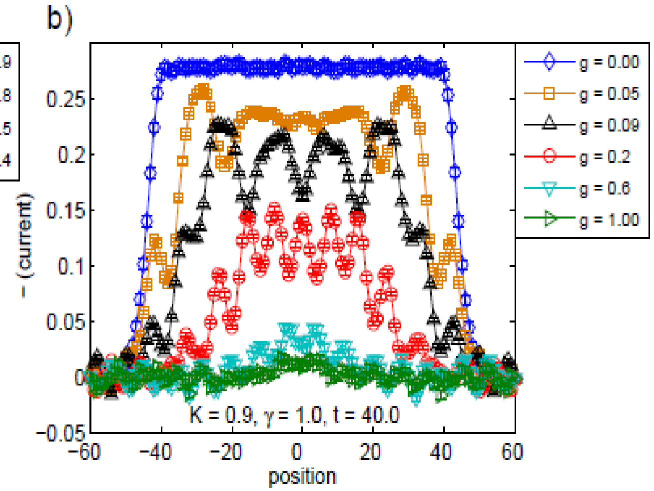
$$j_l = iJ\left[S_l^+ S_{l+1}^- - S_l^- S_{l+1}^+\right]$$

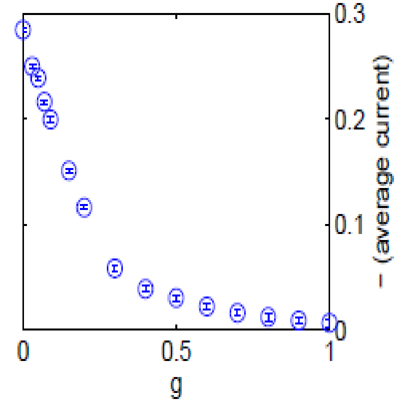
Net spin current $\dfrac{J}{\pi}\sin[\pi m_0]$

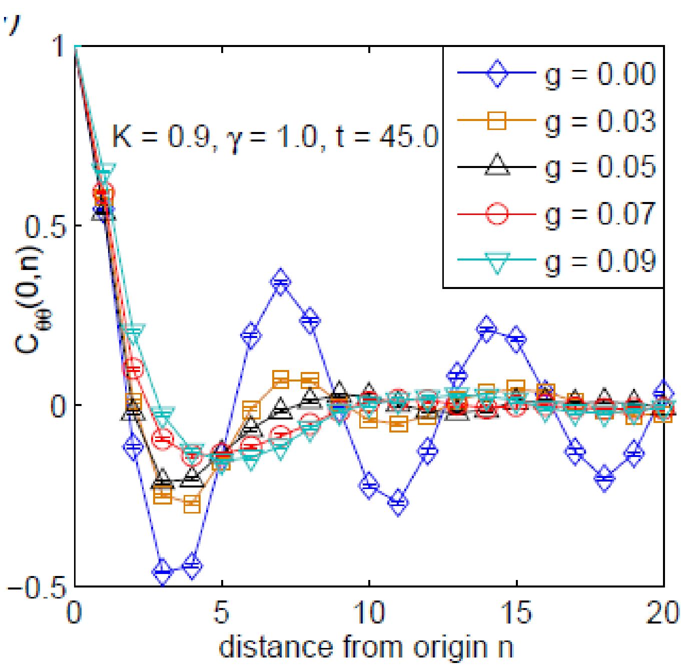
Lancaster and Mitra: PRE 2010

TIME EVOLUTION OF AN INITIAL DOMAIN WALL PROFILE IN THE QUANTUM SINE-GORDON MODEL USING TRUNCTATED WIGNER APPROXIMATION









Current persists even in the presence of a back-scattering interaction. Consistent with quench at the Luther-Emery point

$$H'_f = H'_i(\mu=0) \quad + \quad m\int dx\left[\psi^\dagger_R(x)\psi_L(x) + \psi^\dagger_L(x)\psi_R(x)\right]$$

$$j = u\left[\psi^\dagger_R\psi_R - \psi^\dagger_L\psi_L\right]$$

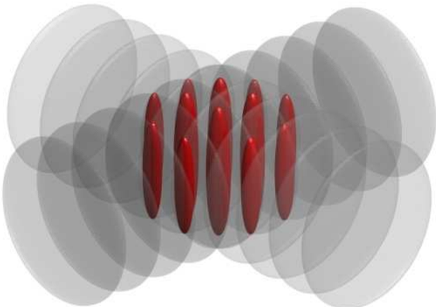
$$j_0 = \mu/\pi$$

$$j = j_0 \; - \; (m/\pi)\tan^{-1}(j_0\pi/m)$$

Lancaster, Gull and Mitra: arxiv.1009.3918

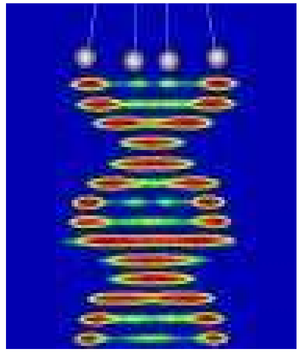
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

Dynamics of repulsively and attractively interacting bosons in 1D after an interaction quench



Dominik Muth, Michael Fleischhauer

New J. Phys. 12, 083065 (2010)
Phys. Rev. Lett. 105, 150403 (2010)

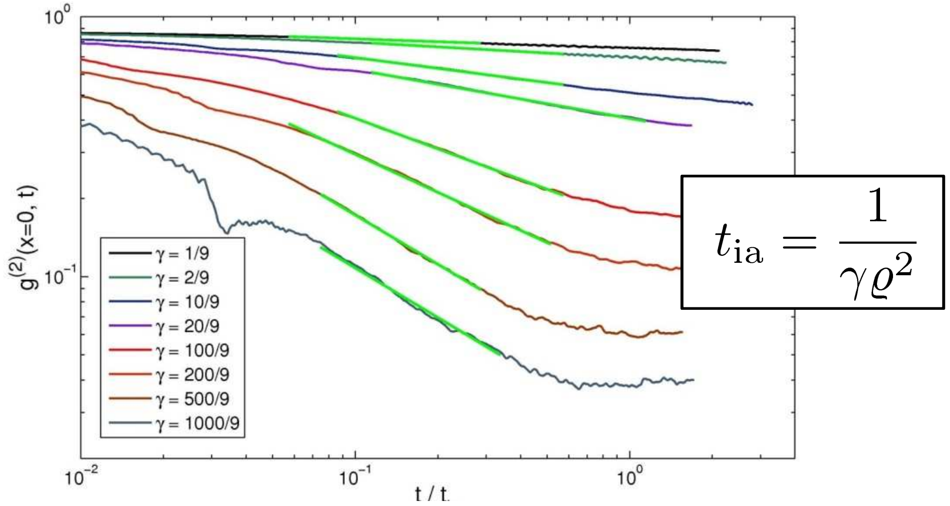


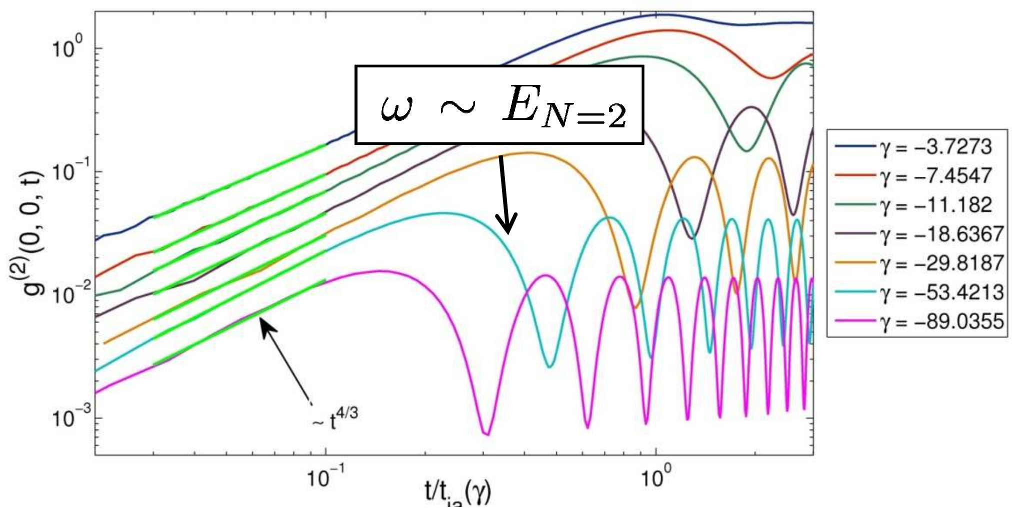
- quench dynamics of strongly interacting systems
- thermalisation of local quantities?

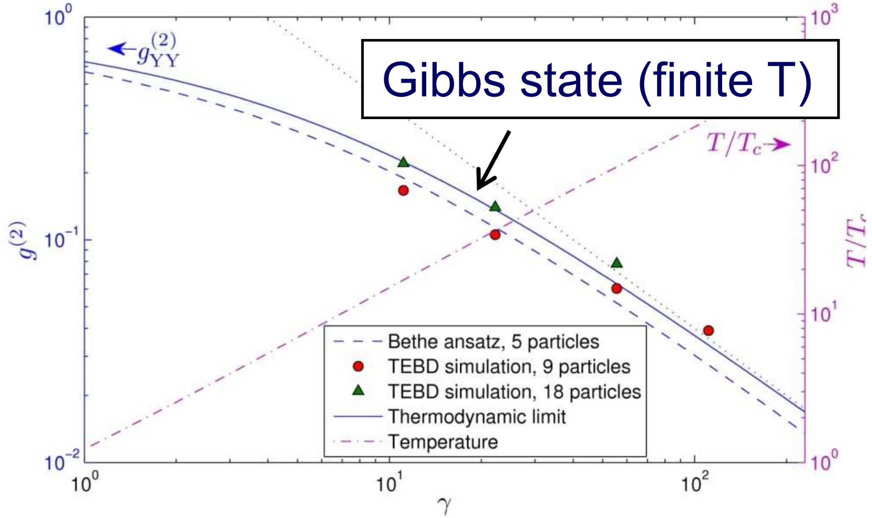
method: TEBD (strong interactions) adapted to continuous systems, lattice approximation with L > 1000

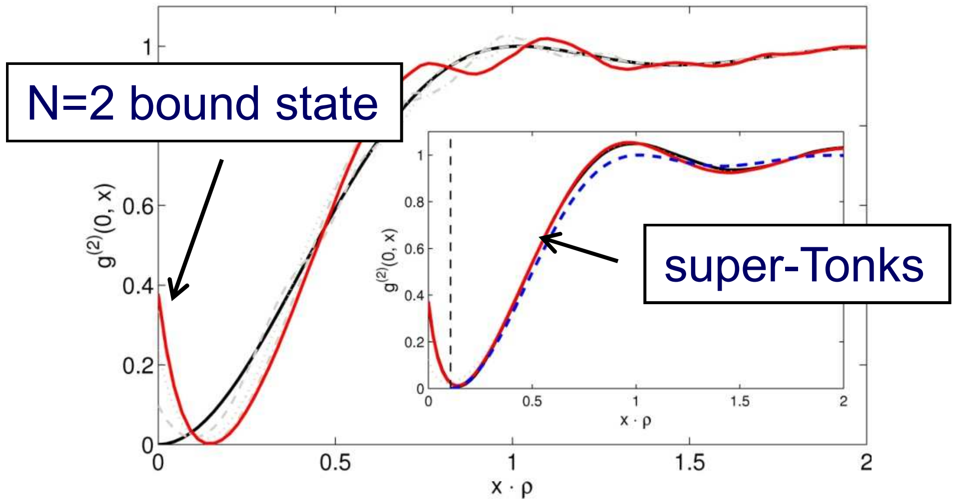
$\gamma = 0 \longrightarrow \gamma \gg 1$

$\gamma = +\infty \longrightarrow \gamma \ll -1$









fast thermalization of local quantities

superposition sTG + bound pairs

Universal Fermi gases in *mixed* dimensions

Dimensionality of space can be controlled
in cold atom experiments by strong optical lattices

✓ 3D → 2D → 1D   and more ?

Universal Fermi gases in *mixed* dimensions

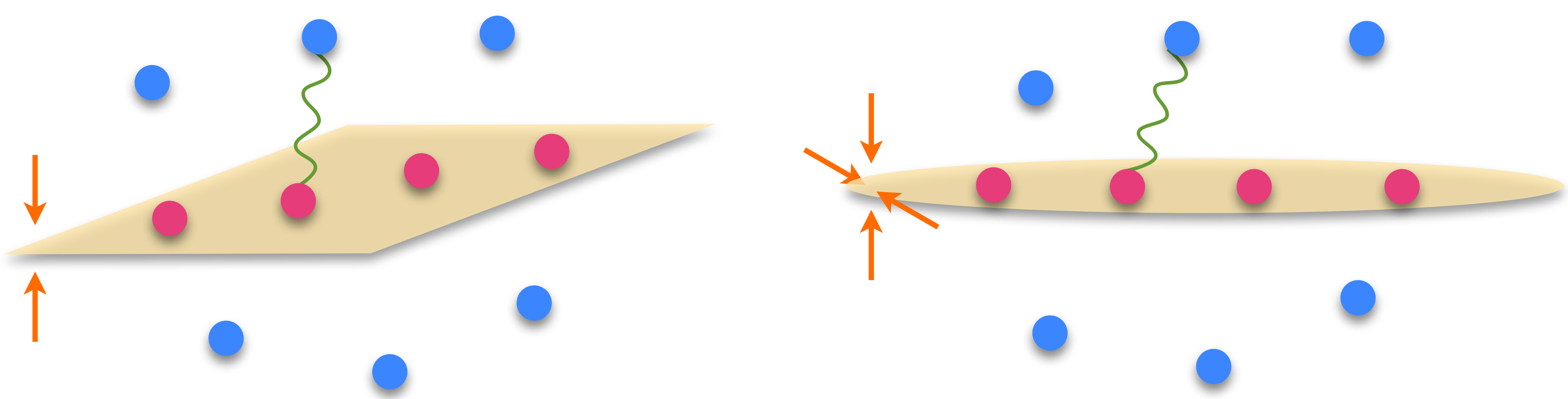
Dimensionality of space can be controlled
in cold atom experiments by strong optical lattices

✓ 3D → 2D → 1D   and more ?

✓ mixed dimensions

2D-3D mixture

1D-3D mixture



Universal Fermi gases in *mixed* dimensions

✓ 2-body physics

✓ 3-body physics

✓ many-body physics

Universal Fermi gases in *mixed* dimensions

✓ 2-body physics

S-wave Feshbach resonance in a free space

- ➡ s-wave, p-wave, d-wave, ... resonances in mixed D
- ➡ long-lived BEC of p-wave molecules

✓ 3-body physics

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Universal Fermi gases in *mixed* dimensions

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Efimov effect for fermions occurs for $m_A/m_B > 13.6$ in a free space

- $m_A/m_B > 6.35$ in 2D-3D & $m_A/m_B > 2.06$ in 1D-3D
- realization of the Efimov effect for fermionic ^{40}K-^{40}K-^{6}Li

✓ many-body physics

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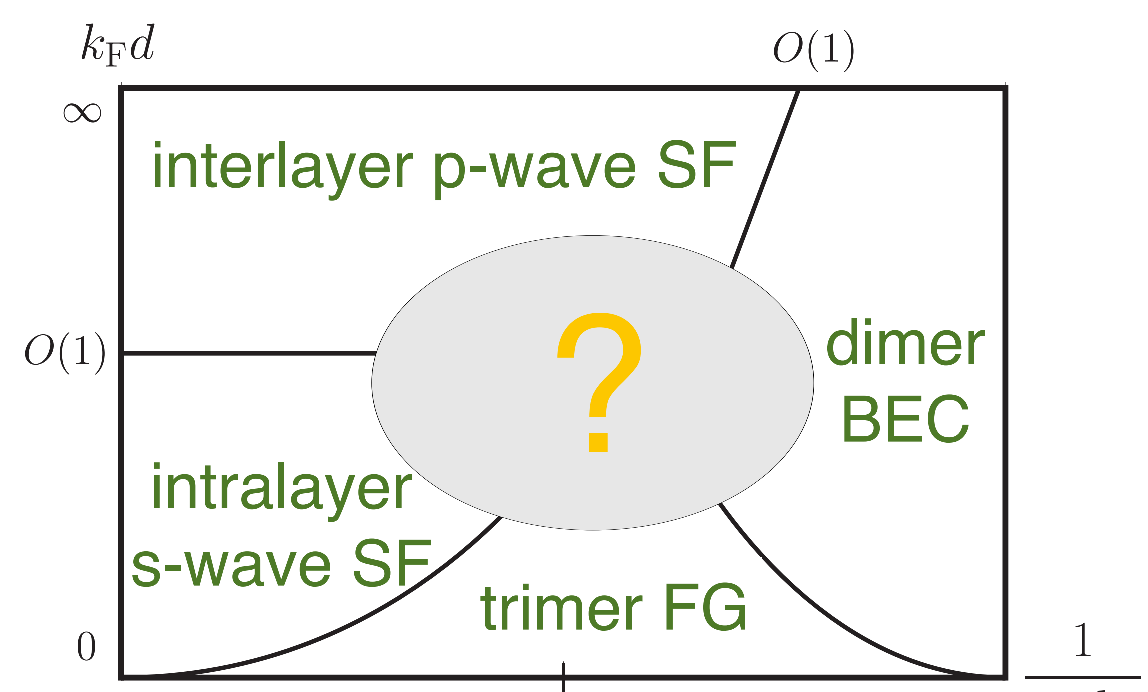
- ➡ realization of the Efimov effect for fermionic ^{40}K-^{40}K-^{6}Li

✓ many-body physics

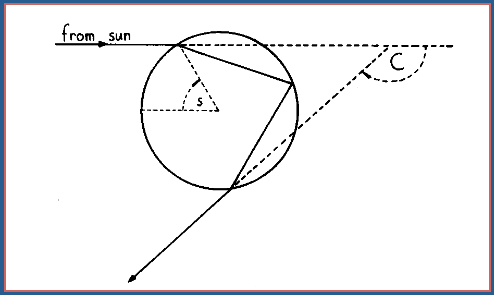
Bilayer Fermi-Fermi mixture

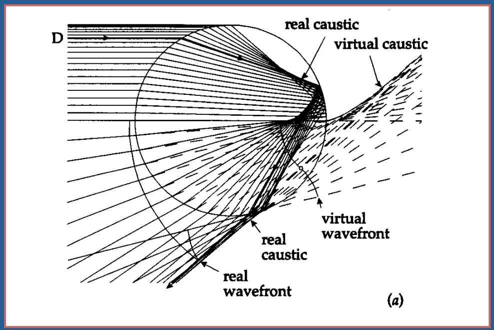
shows very rich phase diagram



Rainbows in the atomic Josephson Junction

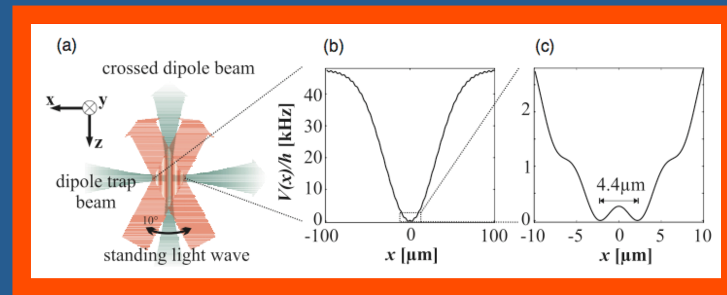
Duncan O'Dell
McMaster University



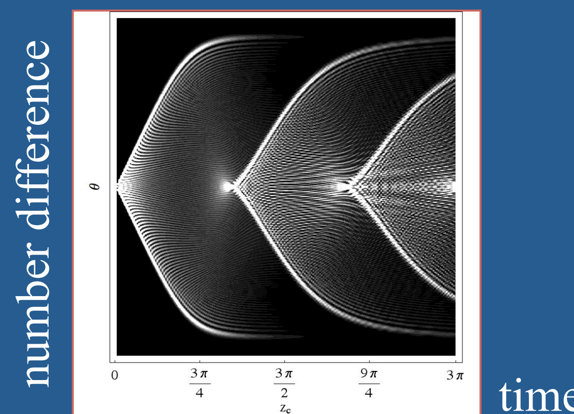


Rainbows in the atomic Josephson Junction

Atomic Josephson junction setup of Oberthaler group, Heidelberg. For review see R. Gati and M.K. Oberthaler, J. Phys. B **40**, R61 (2007).

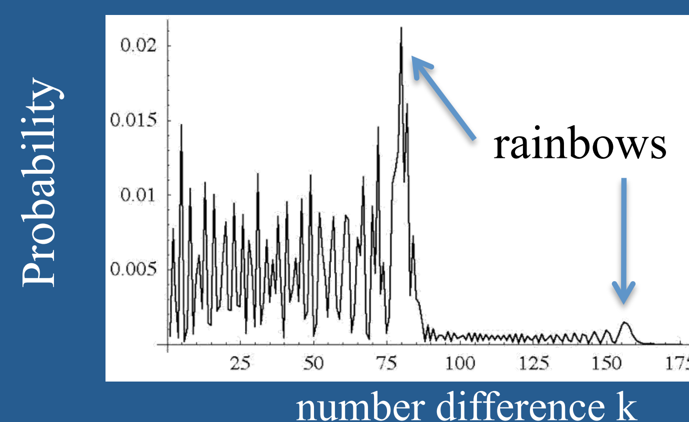


Time dynamics of number difference between two wells when two BECs are suddenly brought into contact.



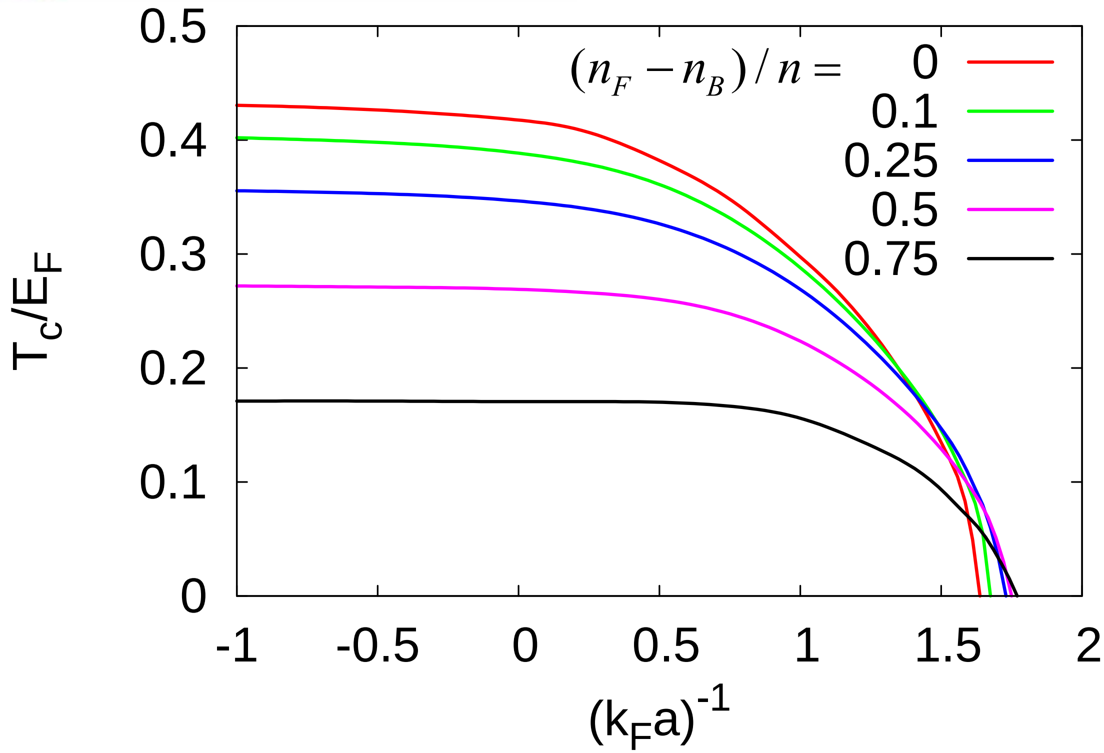
Classical field theory (GPE) diverges at particular values of number difference (the rainbow). Divergence is cured by 2nd quantizing.

$$\Psi(k_{\rm rainbow}) \sim \mathcal{O}(1/\hbar^{1/3})$$



Pairing and condensation in a resonant Bose-Fermi mixture

Elisa Fratini and Pierbiagio Pieri
University of Camerino, Italy



$k_F \equiv (3\pi^2 n)^{1/3}$

$n = n_F + n_B$

$E_F \equiv k_F^2/(2m_F)$

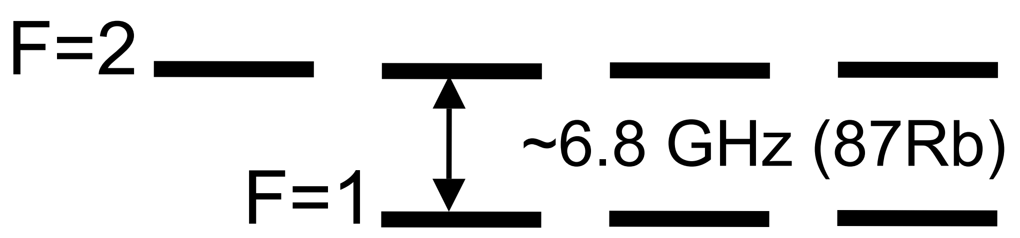
$m_F = m_B$

Boson condensation critical temperature vs Bose-Fermi coupling

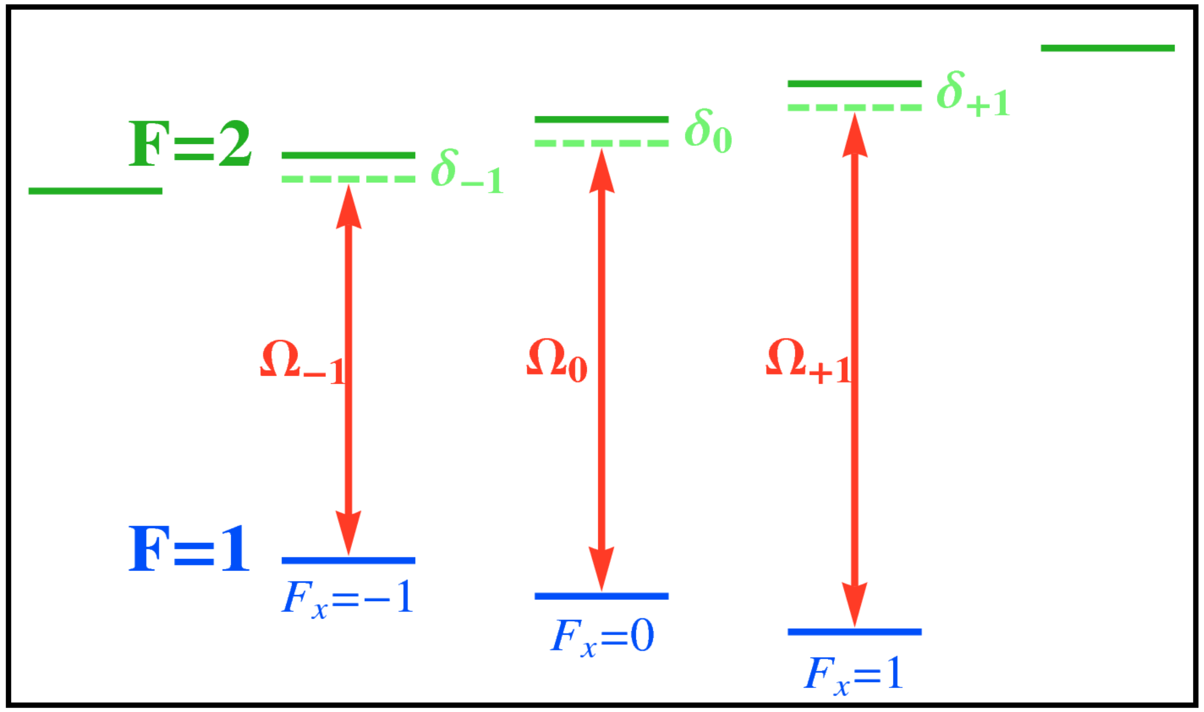
Quantum Simulations with Optical Superlattices

L.Mazza, M.Rizzi, M.Lewenstein, J.I.Cirac

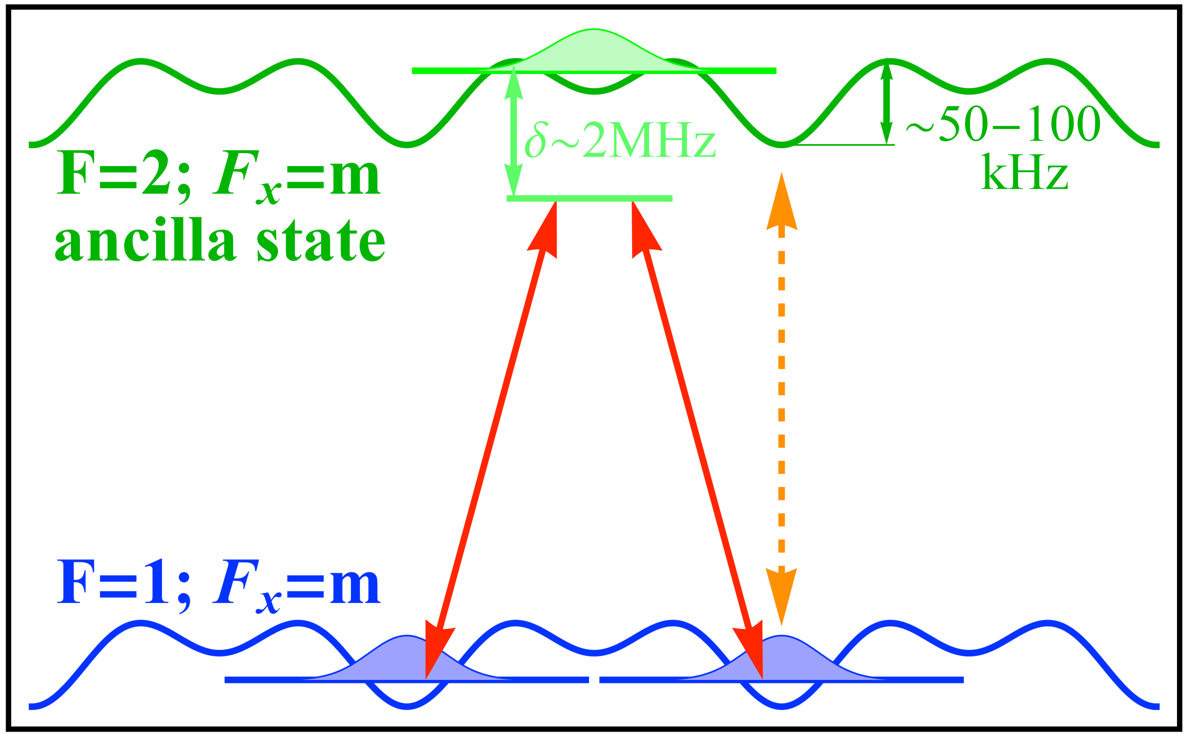
spin-independent optical superlattices



Zeeman effect allows for spin-dep. control



Raman realisation of non-trivial hopping operators



It works in principle in 1D, 2D, 3D!

Extendable to all the alkalis!

Fermions and Bosons!

Original idea conceived with Ulrich Schneider

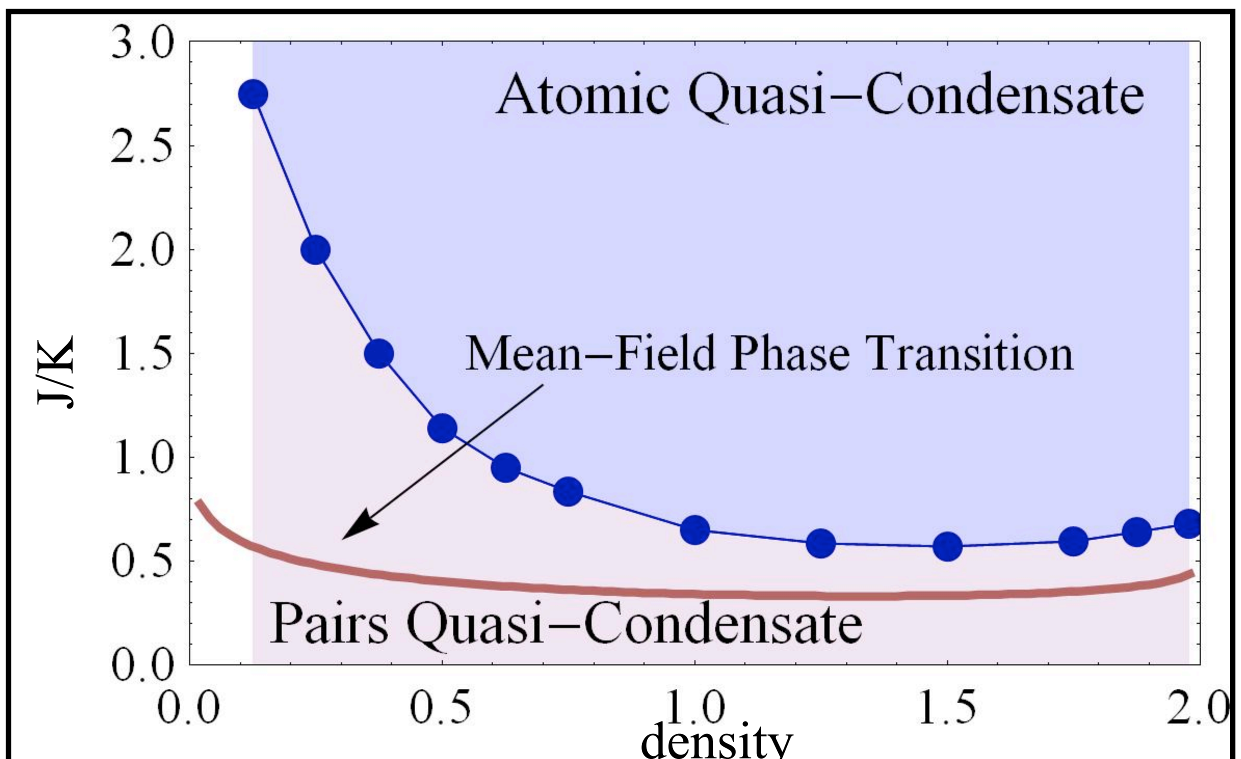
1D 3-hardcore bosons $(a_i^+)^3 = 0$

$$H = -J\sum_i a_i^+ a_{i+1} - K\sum_i (a_i^+)^2 a_{i+1}{}^2 + H.c.$$

density ↔ *magnetization* of the spin condensate

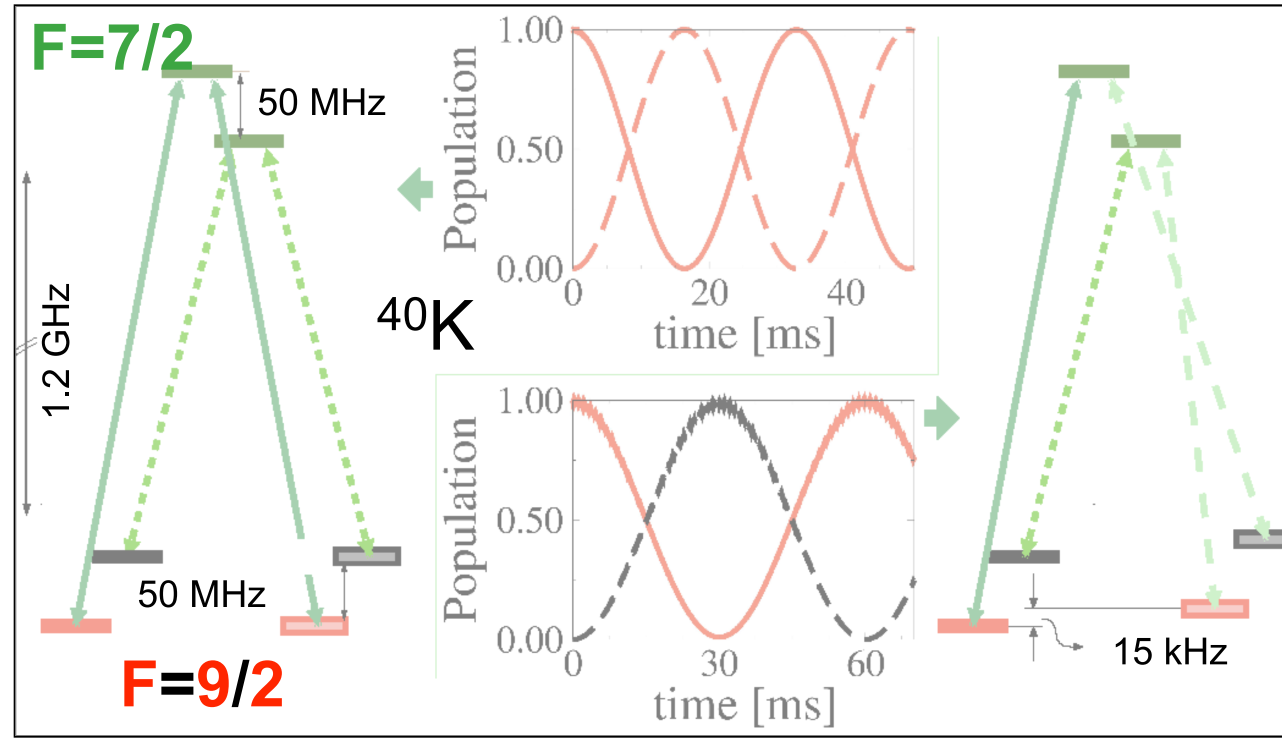
J/K tuned modifying the hopping of m_z=0 species

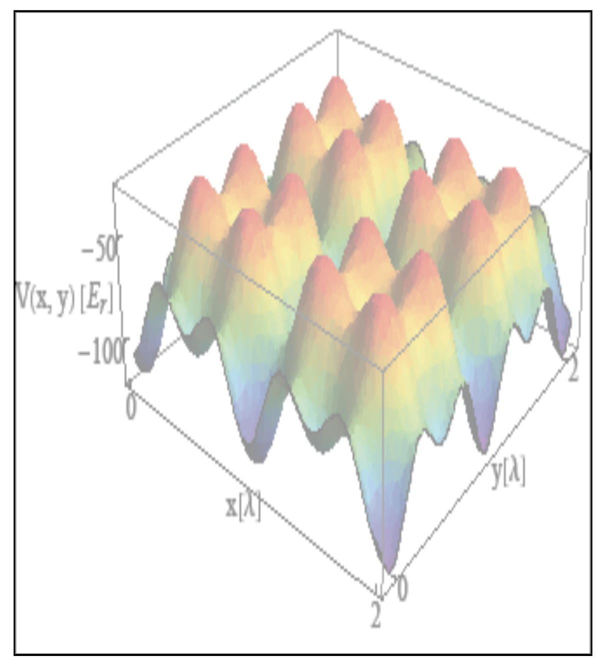
	$\langle a_i^+ a_{i+\delta} \rangle$	$\langle (a_i^+)^2 a_{i+\delta}^2 \rangle$
AQC	algebraic in δ	
PQC	exponential in δ	algebraic in δ



Mazza, Rizzi, Lewenstein, Cirac
arXiv:1007.2344 (PRA)

Fermionic Models & Non-diagonal Hopping





Goals

- -3D Dirac fermions
- -Massive Fermions
- -Wilson Fermions
- -Axion Electrodynamics

Bermudez, Mazza, Rizzi, Goldman, Lewenstein, Martin-Delgado
arXiv:1004.5101 (PRL)

Localized and Extended States in Disordered Traps

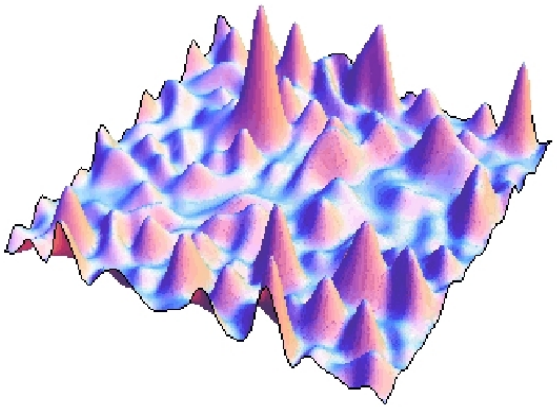
Luca Pezzè and Laurent Sanchez-Palencia

Institut d'Optique and CNRS
(Palaiseau, France)

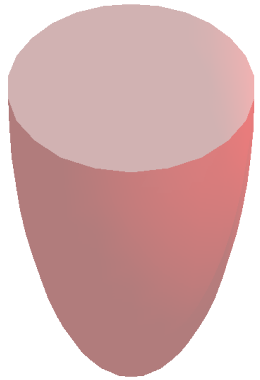
arXiv:1006:4049

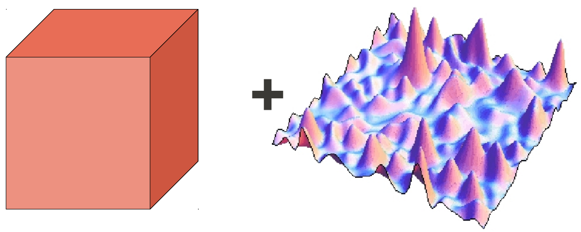
$$\hat{H} = -\hbar^2\boldsymbol{\nabla}^2/2m + \underline{V(\boldsymbol{r})} + \underline{V_{\mathrm{T}}(\boldsymbol{r})}$$

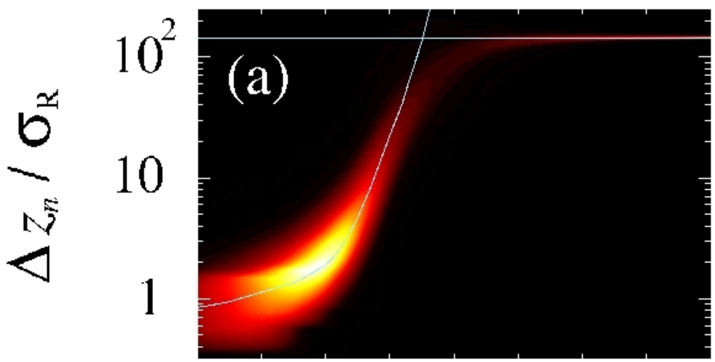
Disordered potential
(*eg.* speckle field)



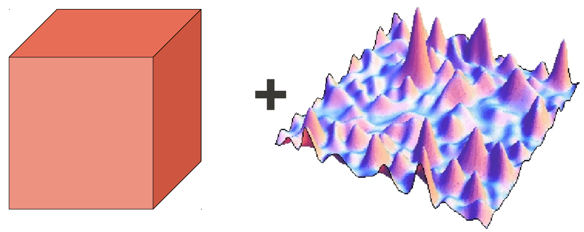
inhomog. trap

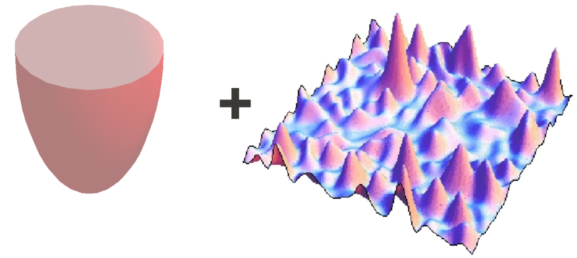


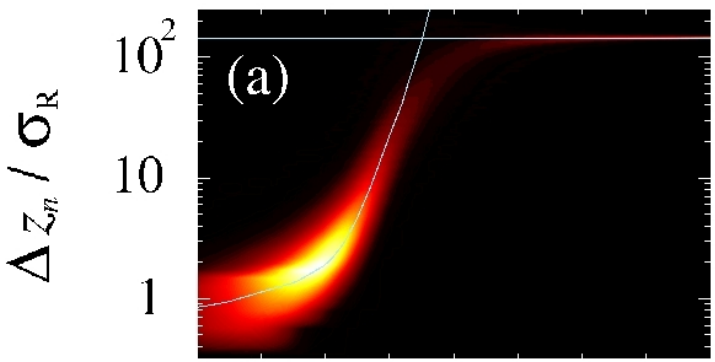


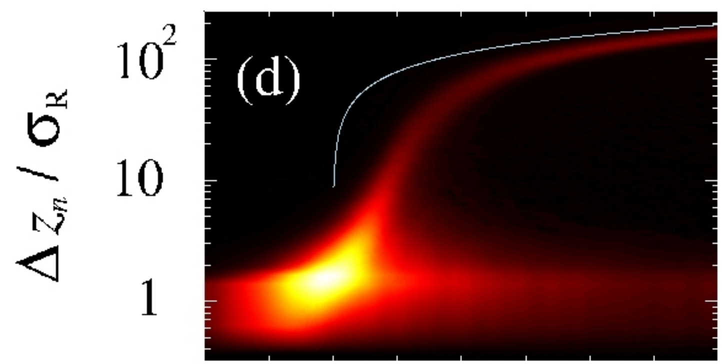


- $L_{loc} \nearrow$ with V_R
- No coexistence of localized & extended states
- Mott's argument









- $L_{loc} \nearrow$ with V_R
- No coexistence of localized & extended states
- Mott's argument

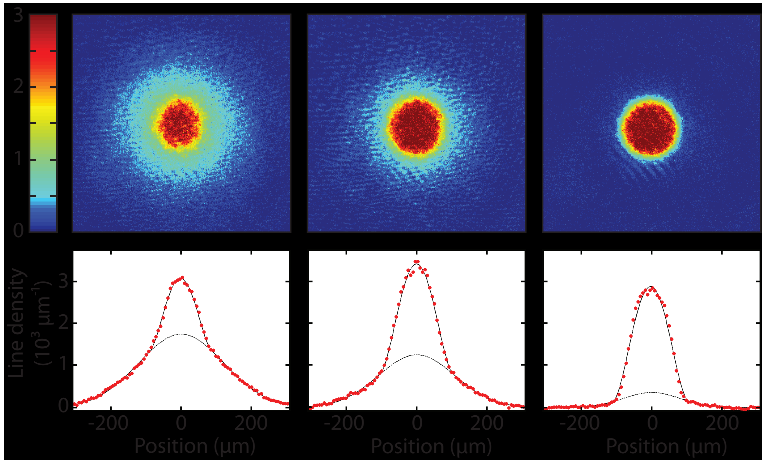
- Coexistence of localized & extended states
- Beyond finite-size effect

Degenerate Bose Gases With Tuneable Interactions

R. Smith, R. Campbell, N. Tammuz, S

Beattie, S. Moulder and Z. Hadzibabic

- Recently ^{39}K has proved a promising candidate for a Bose gas with tuneable interactions
- Unfortunately ^{39}K is difficult to cool to degeneracy; this had only been achieved in one group [1]
- We describe the second experimental apparatus to produce a ^{39}K BEC and the optimisation which allowed us to increase the condensate number to over 4×10^5.

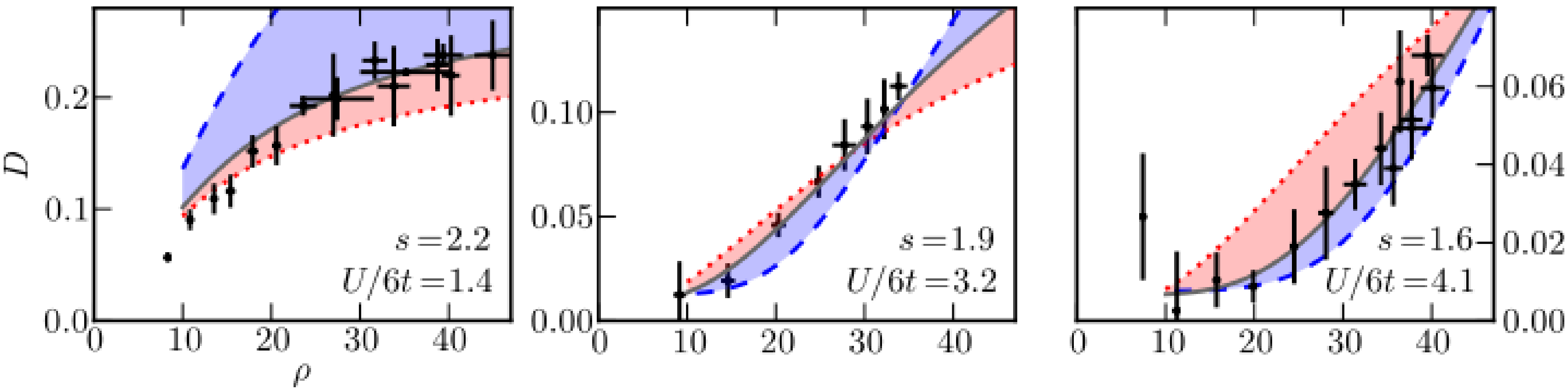


Quantitative study of the metal-Mott insulator transition with ultracold fermions in an optical lattice

Leticia Tarruell, ETH Zürich

Probe: occupation of lattice sites

Mott insulator: reduced number fluctuations → reduced double occupancy



Metal **Intermediate** **Mott insulator**

Quantitative agreement with DMFT and high temperature series expansions

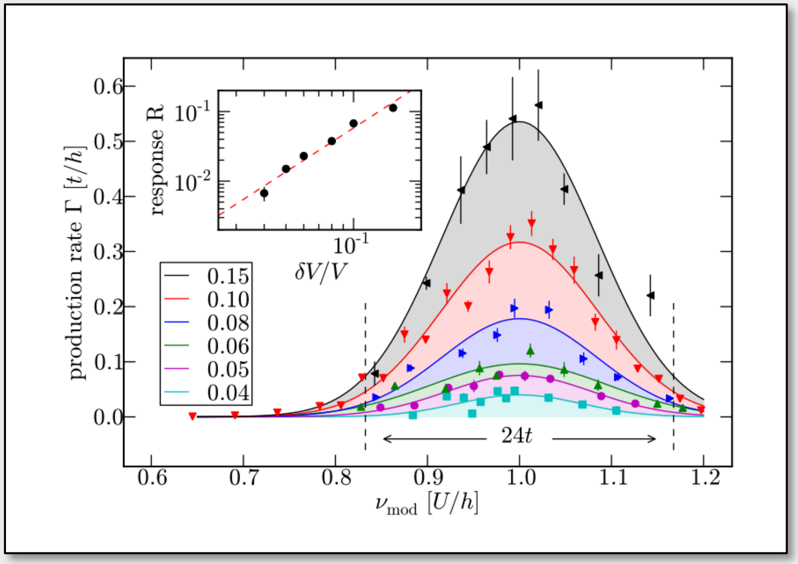
Determine entropy in the lattice

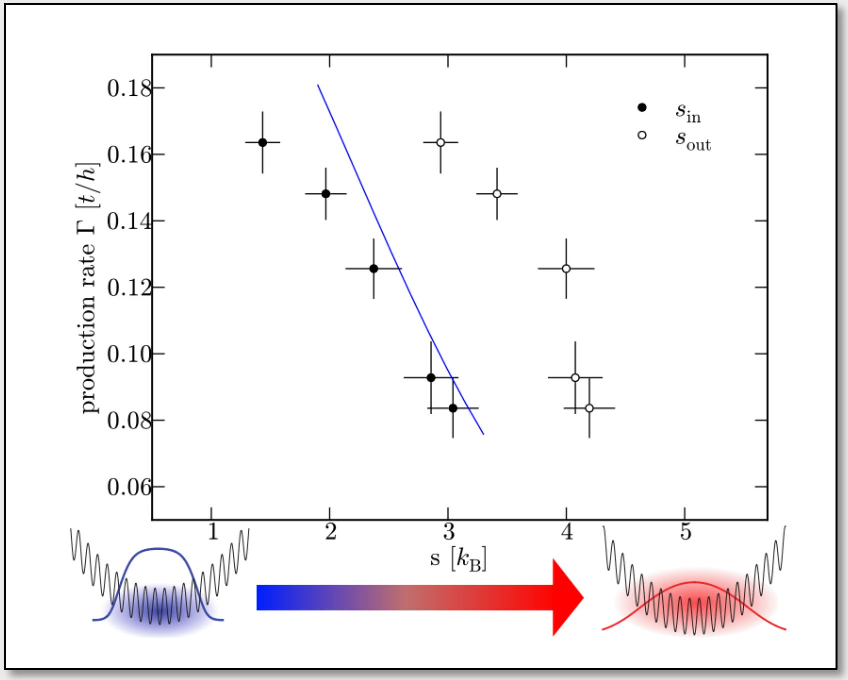
Probing nearest-neighbor correlations

Modulation of the lattice depth
in the ***perturbative regime***

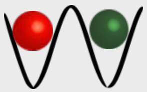
2nd order perturbation theory

Response: doublon production rate





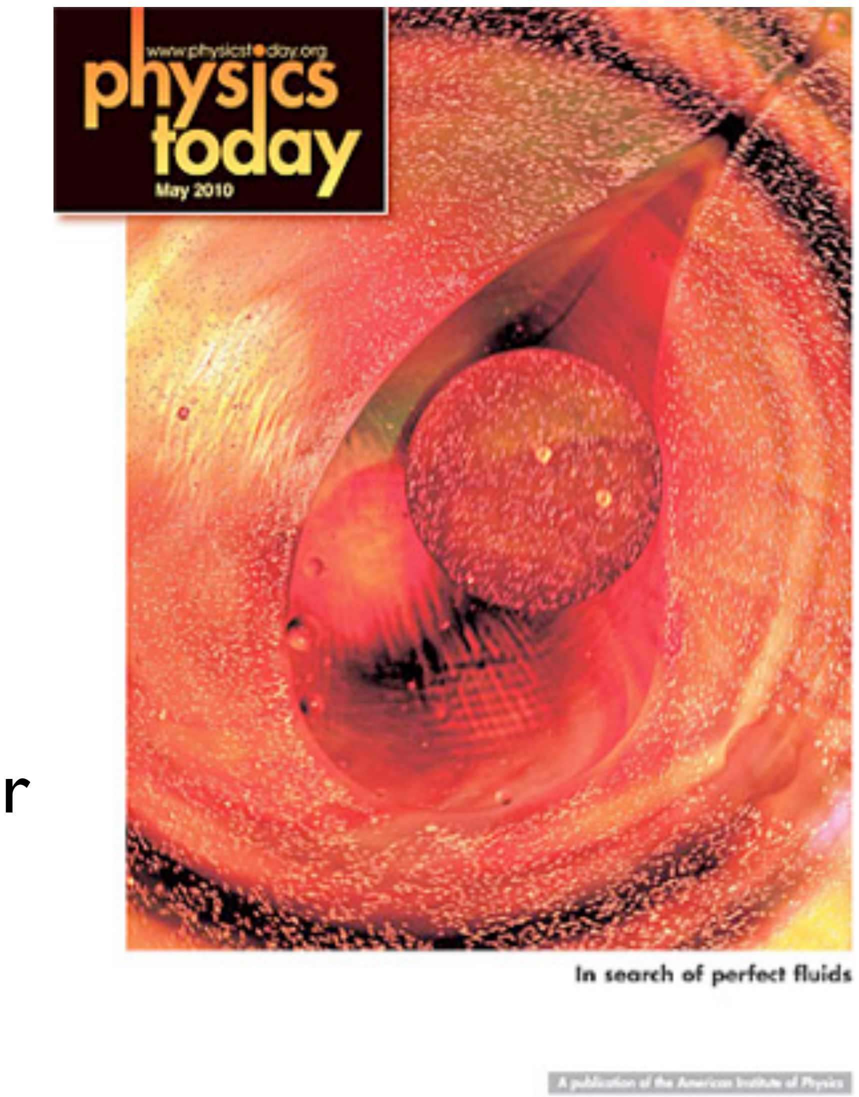
Determine nearest-neighbor density and spin correlation function



Useful for thermometry

Viscosity sum rules and spectral functions

Edward Taylor
The Ohio State University



- We derive sum rules for the frequency dependent shear η and bulk ζ viscosities in a dilute Fermi gas:

$$\frac{1}{\pi}\int_0^{\infty} d\omega \left[\eta(\omega) - \frac{C}{10\pi\sqrt{m\omega}}\right] = \frac{\varepsilon}{3} - \frac{C}{10\pi m a}$$

$$\frac{1}{\pi}\int_0^{\infty} d\omega \zeta(\omega) = \frac{1}{72\pi m a^2}\left(\frac{\partial C}{\partial a^{-1}}\right)_s$$

- *C* = contact (prob. of finding two fermions close together); *a* = *s*-wave scattering length; ε = energy density.

ET & Mohit Randeria, PRA **81**, 053610 (2010)

Bulk viscosity

$$\frac{1}{\pi}\int_0^{\frac{1}{mr_0^2}} d\omega\zeta(\omega) = \frac{1}{72\pi m a^2}\left(\frac{\partial C}{\partial a^{-1}}\right)_s$$

- Bulk viscosity is zero at unitarity at all frequencies (scale invariance of w.f.):

$$\zeta(\omega) = 0 \ \ \forall\omega \ \ (|a| = \infty)$$

- Contact is a monotonically increasing through the crossover:

$$\partial C/\partial a^{-1} \geq 0 \ \ \forall a$$

- At unitarity, shear viscosity can be measured by e.g., Bragg scattering:

$$\eta(\omega) = \lim_{q\to 0}\frac{3\omega}{4q^4}\mathrm{Im}\chi_{\rho\rho}(q,\omega)$$

Shear viscosity

$$\frac{1}{\pi}\int_0^{\frac{1}{mr_0^2}} d\omega\left[\eta(\omega) - \frac{C}{10\pi\sqrt{m\omega}}\right] = \frac{\varepsilon}{3} - \frac{C}{10\pi m a}$$

- We prove that $\rho_n=0 \Rightarrow \eta(0)=0$.

- High-frequency $C/\sqrt{\omega}$ tail:
  - Generic feature of high-ω response (RF, Bragg, neutron,...): At large energies, momentum conservation ⇒ virtual *pair* excitations. Contact (*C*) physics.

- At unitarity: area under ``Drude peak'' = energy. *Also for N=4 SSYM, where* $\eta(0) = s/4\pi$.

Päivi Törmä

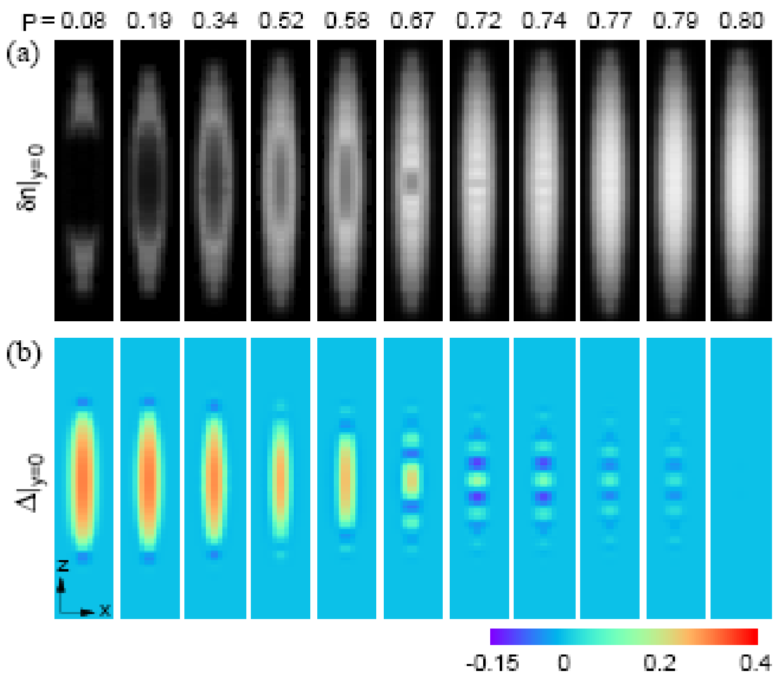
Aalto University School of Science and Technology

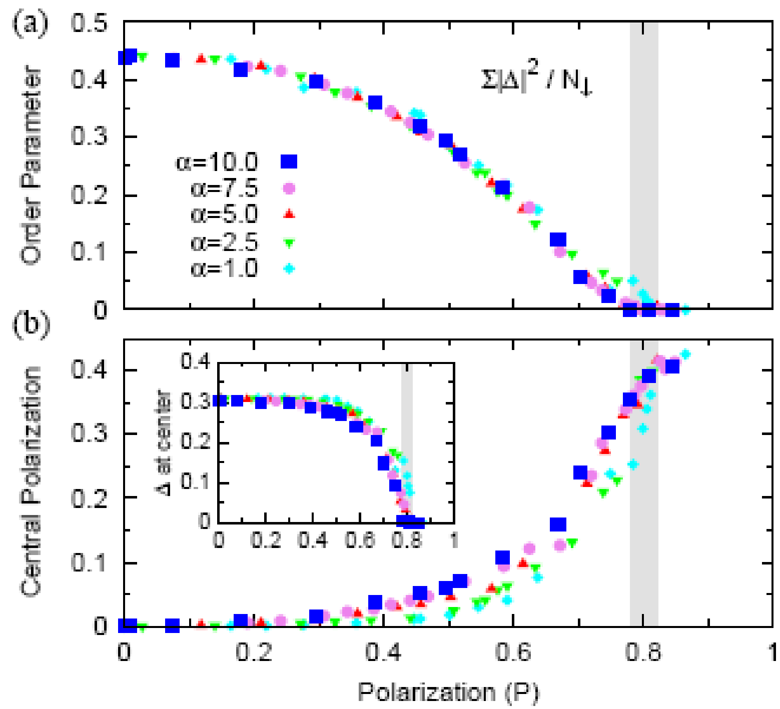
(Helsinki University of Technology)

Aalto University
School of Science
and Technology

POSTER 1:

1. DMFT for imbalanced Fermi gas in elongated traps (arXiv:1009.5676)

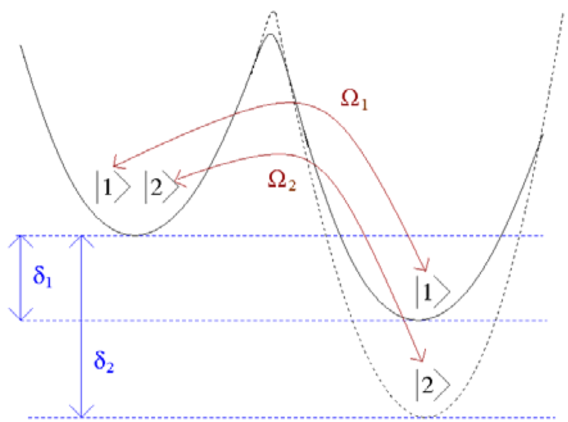


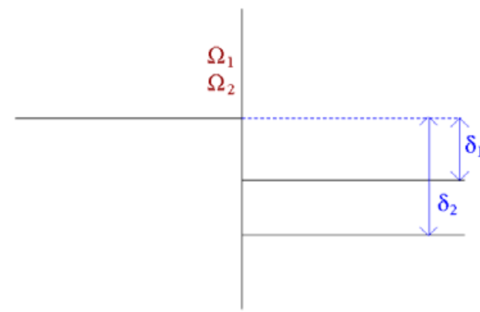


2. Signatures of FFLO by hopping modulation (TEBD) (PRL 2010)

Aalto University
School of Science
and Technology

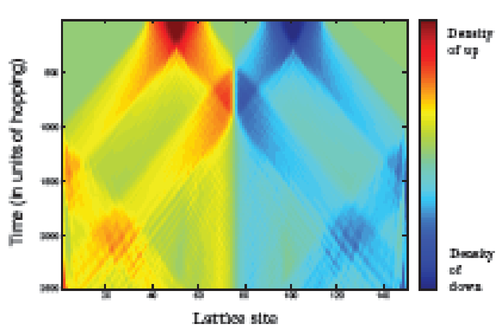
POSTER 2:
1. Spin-asymmetric Josephson effect (arXiv:0911.4678)

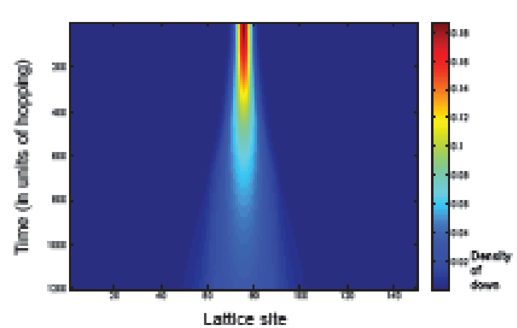




2. Speed of sound in a FFLO state (in preparation)

POSTER 3:
Dynamics (TEBD) of 1D Fermi gases (in preparation)





Bose-Fermi solid and its quantum melting in a one-dimensional optical lattice

Bin Wang1, Daw-Wei Wang2, and Sankar Das Sarma1

1 CMTC, Department of Physics, University of Maryland, College Park, Maryland 20742, USA

2 Physics Department and NCTS, National Tsing-Hua University, Hsinchu 30013, Taiwan

Ground state phase diagram