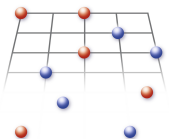


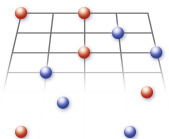
Cooperative Phenomena

Frankfurt am Main	Kaiserslautern	Mainz
B1, B2, B4, B6, B13 _N	A7, A9, A12	A10, B5, B8
<i>Materials Design - Synthesis & Modelling</i>		
A3, A8, B1, B2, B4, B6, B9, B11, B13 _N	A5, A7, A9, A12, B3	A10, B5, B8, B12
<i>Cooperative Phenomena</i>		
A3, A8, B1, B2, B4, B6, B9, B11, B13 _N	A5, A7, A9, A12, B3	A10, B5, B8, B12
<i>Excitations & Interactions</i>		

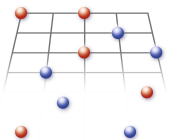
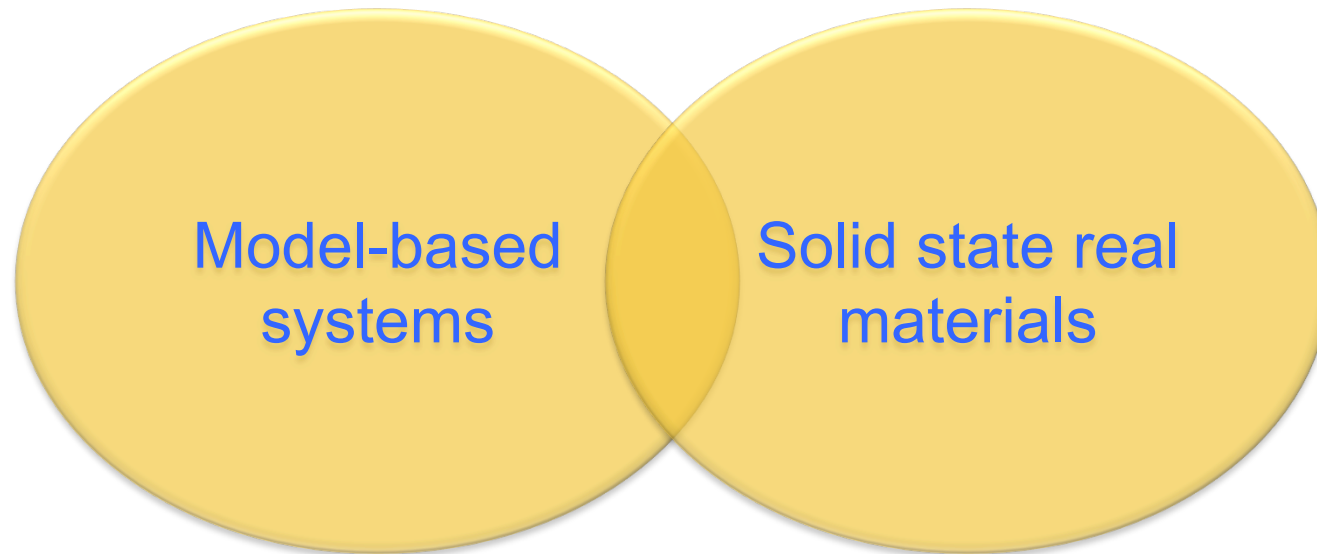


Cooperative Phenomena

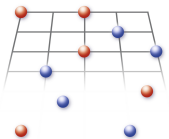
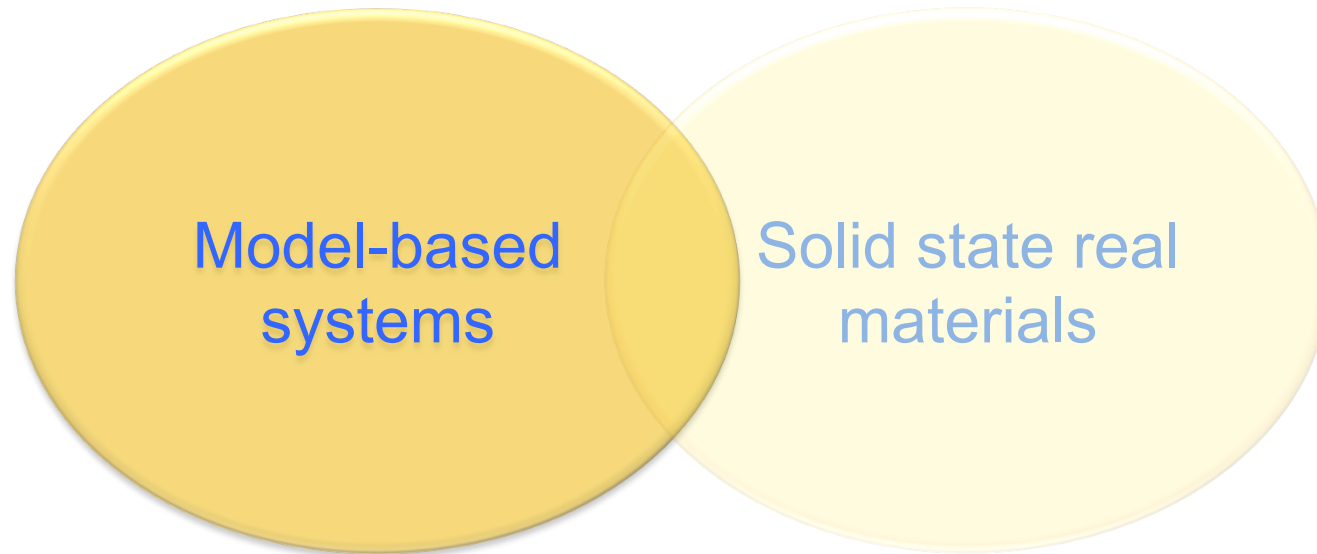
- **critical phenomena**
- **non-equilibrium dynamics**
- **quantum magnetism**
- **phonon & polaron physics**
- **Mott transition**
- **superconductivity**
- **spin liquids**



Cooperative Phenomena



Cooperative Phenomena



Cooperative Phenomena

Experiment

A7 Collective effects and instabilities of a magnon gas

A9 Ultracold Bose gases with variable interactions

A10 Designing spin-spin interactions in cold ion crystals

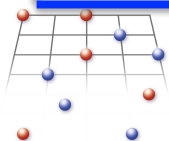
A12 Multi-polaron effects with spinless and spinful impurities in a bosonic quantum gas

Theory

A3 Inhomogeneous quantum phases and dynamics in ultracold gases and hybrid atom-ion systems

A5 Advanced numerical methods for correlated quantum gases

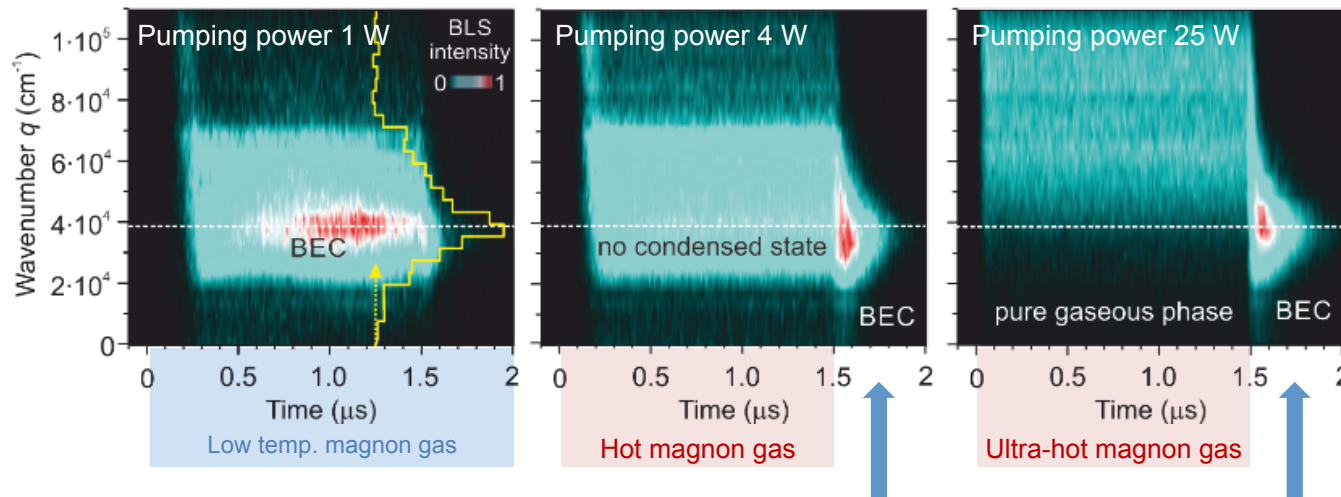
A8 Interacting magnons and critical behaviour of bosons



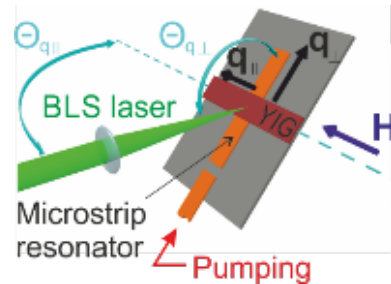
Critical phenomena & dynamics

Bose-Einstein condensation in an ultra-hot gas of pumped magnons

A7



Experimental method
Time-, space- and wavevector-resolved BLS spectroscopy



evaporative supercooling
→ formation of magnon BEC after pumping is switched off

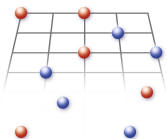
Nature Commun. **5**, 4452 (2014)

A7

A8

magnon-phonon scattering → different thermalization rates and **two magnon temperature**

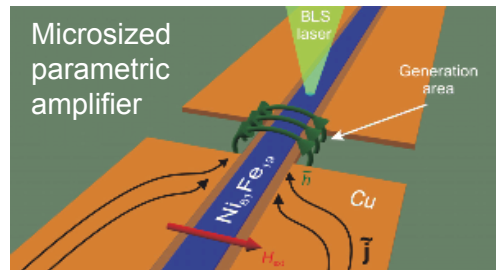
PRB **89**, 184413 (2014)



Critical phenomena & dynamics

Dynamics of magnon gases in spatially confined structures

A7



APL **99**, 162501 (2011) APL **103**, 142415 (2013)
APL **104**, 092418 (2014) APL **104**, 202408 (2014)
APL **105**, 232409 (2014)

→ toolbox for magnon BECs in micro-sized samples

Next:

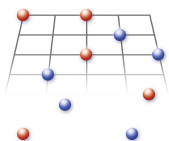
Spatially confined magnon condensates and coherent magnon transport

A7

Coherent interactions & phase transitions in magnon gases

Theory of magnon-phonon interaction and non-equilibrium dynamics

A8

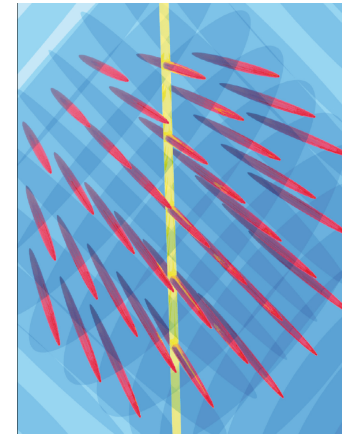
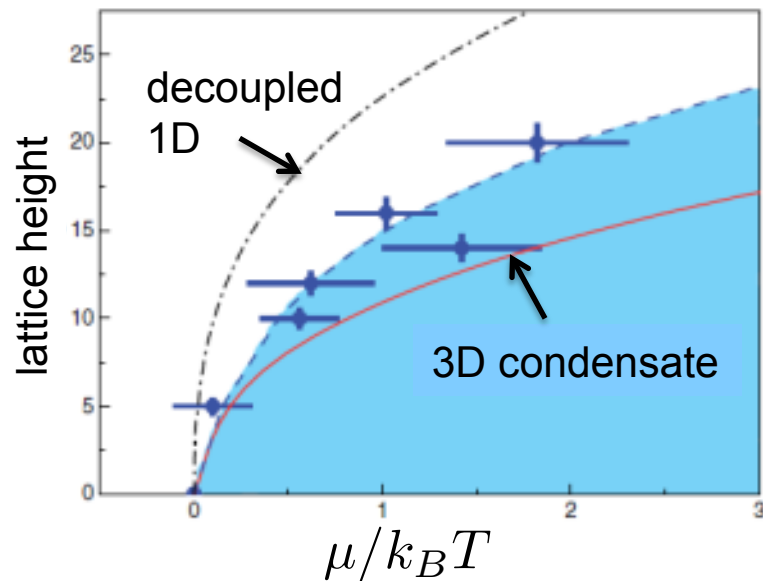


Critical phenomena & dynamics

Dimensional phase transition from 1D to 3D

A9 B3

- study coupled 1D Bose gases \rightarrow 3D condensation
- extract phase diagram & comparison with theory



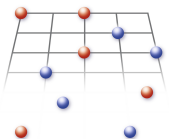
ultracold bosons
in an optical lattice

PRL 113, 215301 (2014)

Next: *Transport in mixed dimensions*

A9 B3

- superimpose lattice in longitudinal direction
- \rightarrow coupled 1D Mott insulators



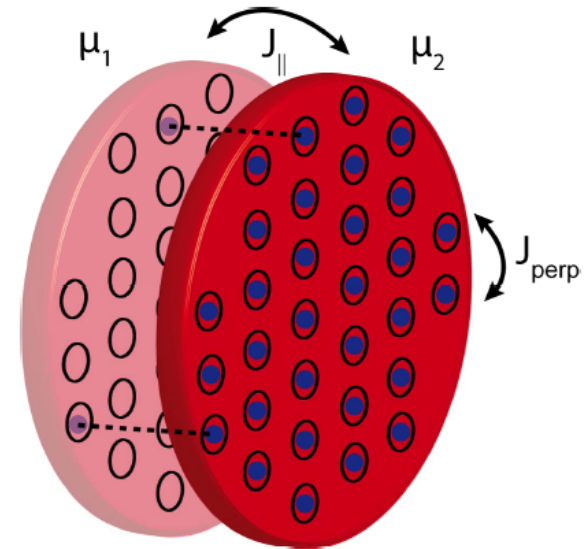
Transregio 49
Frankfurt / Kaiserslautern / Mainz

Critical phenomena & dynamics

Next: *Strongly correlated mass transport*

A3 A9

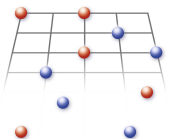
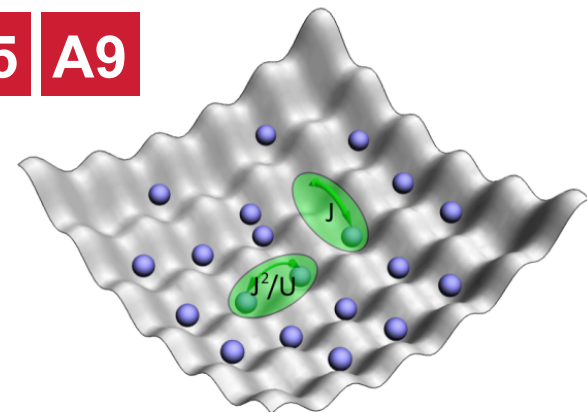
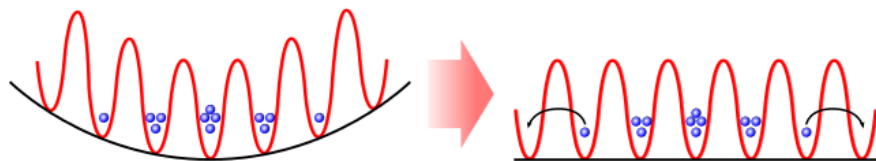
non-equilibrium tunneling
transport of atoms in a Mott
insulator state



Quench dynamics of strongly correlated bosons in 2d, 3d

dynamical arrest

A3 A5 A9

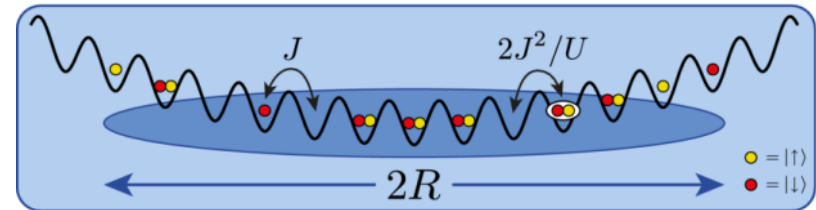


Critical phenomena & dynamics

Dynamical arrest & quantum distillation

A3 A5

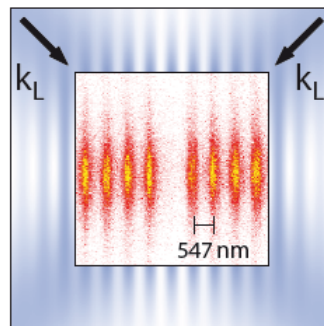
- non-adiabatic evolution during lattice ramp
- fermions [Phys. Rev. Lett. 110, 075302 \(2013\)](#).
- bosons, 1D [Phys. Rev. A 110, 013615 \(2012\)](#).



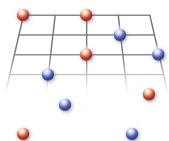
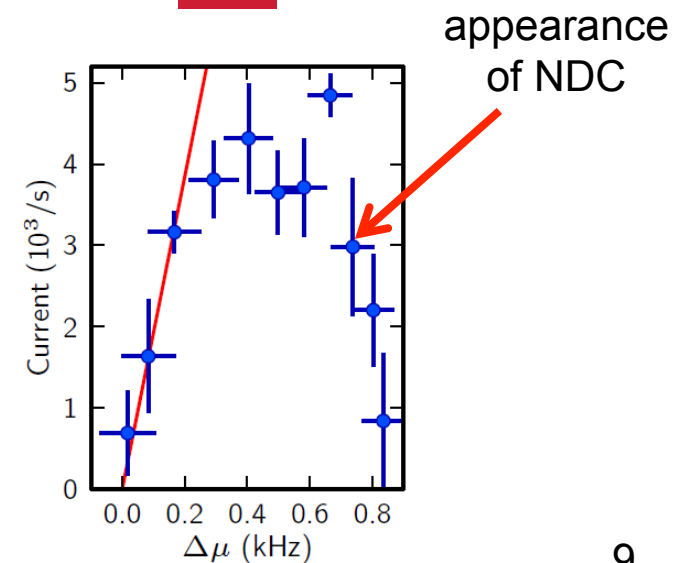
Negative differential conductivity

A9

- non-equilibrium initial condition



- current-voltage characteristics



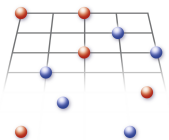
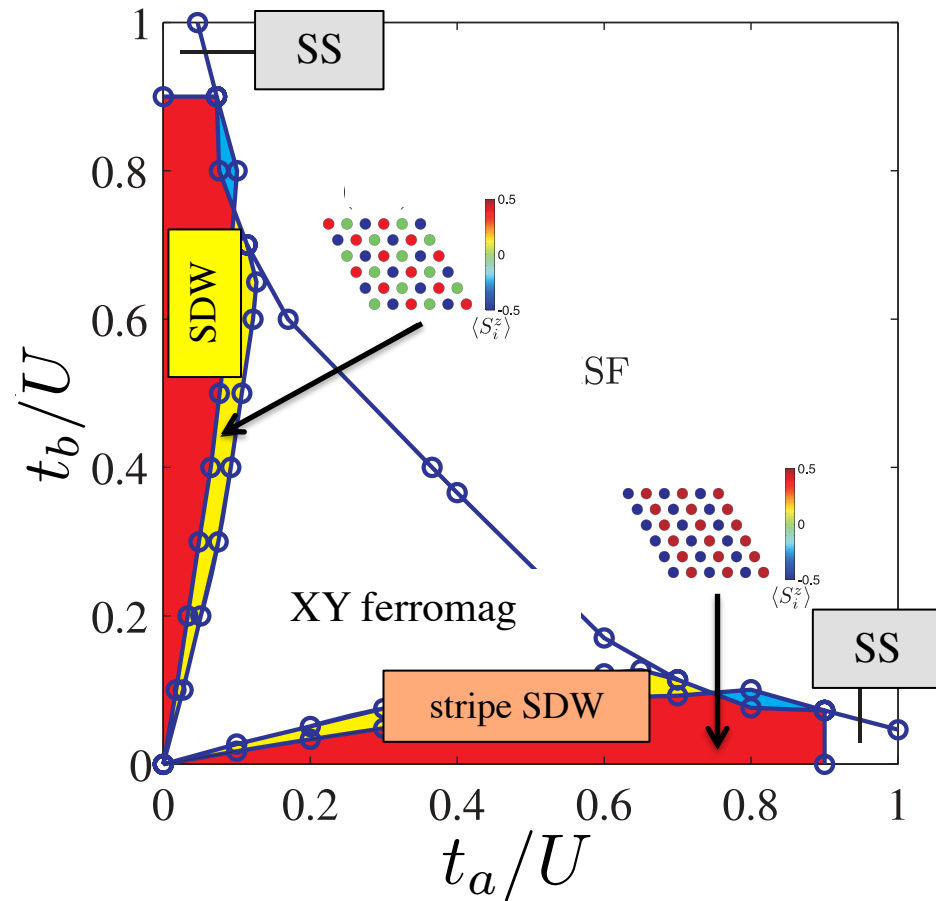
Quantum Magnetism

Tunable magnetic order

A3

- bosonic magnetism on triangular lattice
- frustration

Phys. Rev. A 86, 043620 (2012)



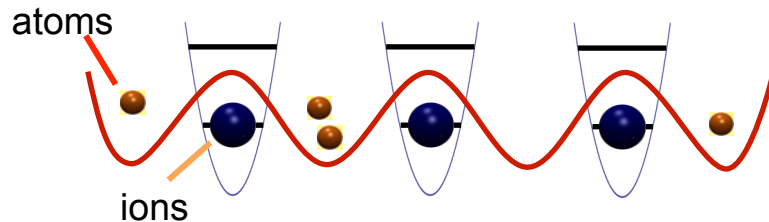
Phonon and Polaron physics

Hybrid quantum simulator

A3 A10

- ultracold atoms in a dynamical lattice of trapped ions emulating electronic solids including phonons

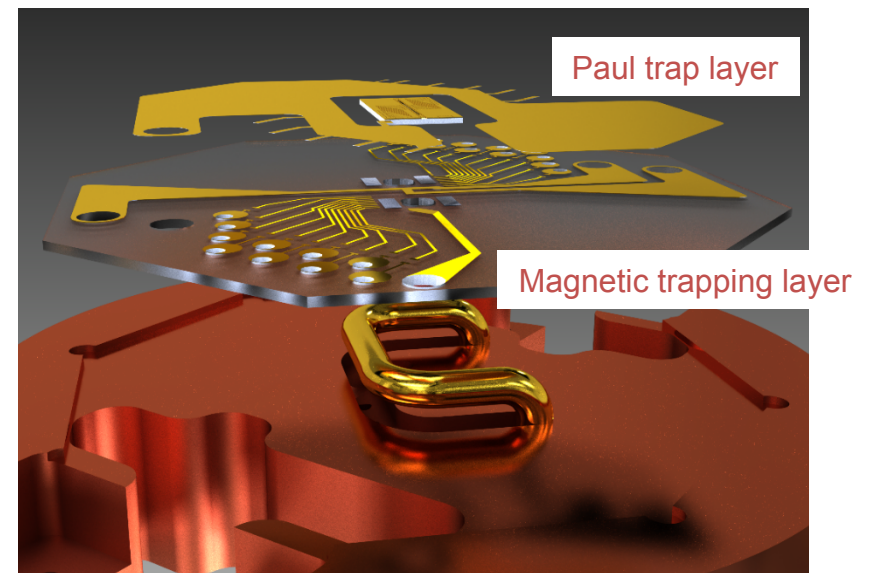
Phys. Rev. Lett. 111 , 080501 (2013)



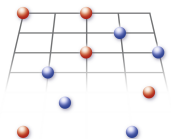
Next:

A10

- planar Paul trap with Yb^+ crystal
- magnetic trap for Rb BEC
- tight confinement \rightarrow 1D atom-ion system

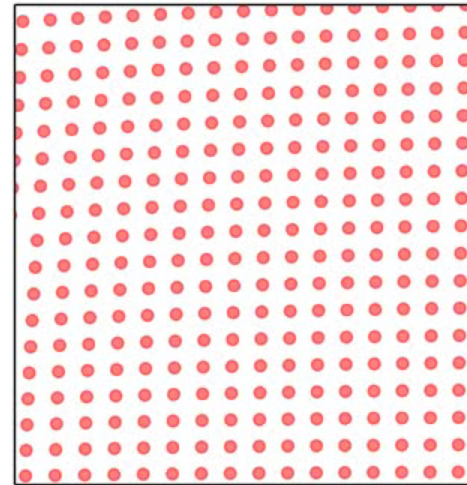
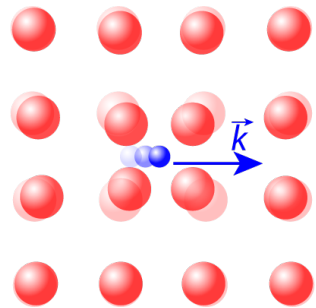


A3 A5 A9



Phonon and Polaron physics

Polaron in solid-state physics

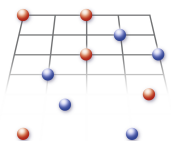
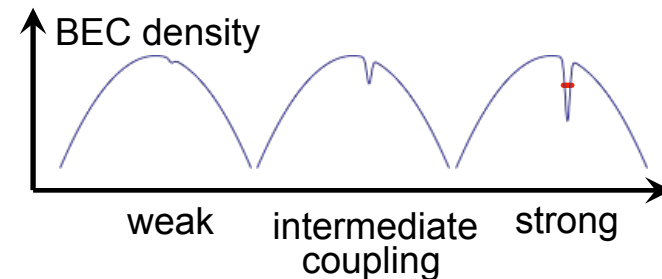
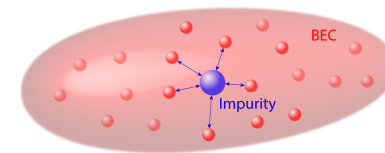


Next:

Bose-polaron of neutral impurities in a BEC

- simulate Fröhlich polaron with tunable impurity-BEC interactions
- spectroscopy on weak and strongly coupled polarons
- lattice-polaron or quasi free-polaron dynamics

A12



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A3 A5 A10

Phonon and Polaron physics

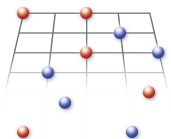
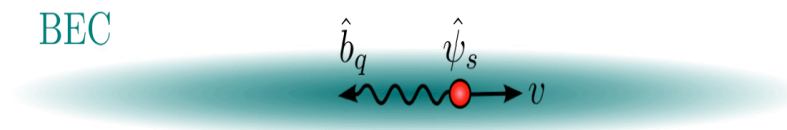
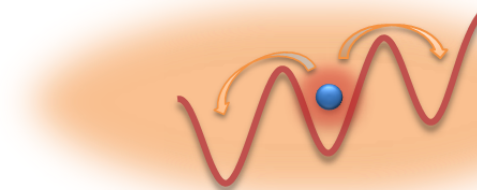
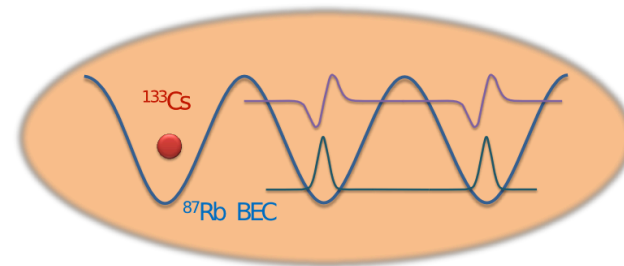
Next:

Theory of polarons & impurity dynamics in lattices and BECs

A3

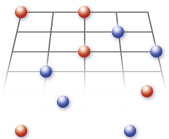
A5

- Bloch oscillations, multiband physics
- detection of polaron by RF spectroscopy
- many-polaron phases
- relaxation dynamics of supersonic impurity in BEC



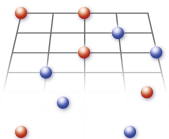
Cooperative Phenomena

- **critical phenomena**
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- **Mott transition**
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Cooperative Phenomena

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Cooperative Phenomena

