

Harvard University Physics 284

Strongly correlated systems in atomic and condensed matter physics

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Course Meetings

TTh, 10:00 - 11:30 in Lyman 330

Due to construction the first few lectures will be held in Jefferson 453

Course Grade

Grading will be based on class presentations.

Tentative Course Outline

I. Review of atomic physics. Basics of trapping and cooling of atoms. Bose-Einstein condensation of weakly interacting atomic gases.

II. Bosonic Hubbard model. Quantum phase transition between the superfluid and insulating Mott phases.

III. Student presentations

(1) *Shell structure in a parabolic trap.*

G. Campbell et al.; cond-mat/0606642. S. Foelling et al., cond-mat/0606592.

(2) *Excitations in superfluid and Mott phases.*

G. M. Greiner et al., Nature 415, 39 (2002); M. Kohl et al., Journal of Low Temperature Physics 138, 635 (2005); Schori et al., Phys. Rev. Lett. 93:240402 (2004).

(3) *Collapse and revival of coherence.*

M. Greiner et al., cond-mat/0207196.

(4) *Residual coherence in the Mott phase.*

F. Gerbier et al., Phys. Rev. Lett. 95, 050404 (2005), Phys. Rev. A 72, 053606 (2005).

(5) *Dynamic instability.*

A. Smerzi et al., Phys. Rev. Lett. 89, 170402 (2002); L. Fallani et al., Phys. Rev. Lett. 93, 140406 (2004); A. Polkovnikov et al., Phys. Rev. A 71, 063613 (2005); C. Fertig et al., Phys. Rev. Lett. 94, 120403 (2005).

IV. Multicomponent bosonic systems in optical lattices. Quantum magnetism. Dynamics of coupled spin systems.

V. Student presentations

(1) *$S=1$ atoms in a single trap.*

T.L. Ho PRL 81, 742 (1998); C. Law et al., PRL 81, 5257 (1998); D. Stamper-Kurn, W. Ketterle, cond-mat/0005001.

(2) *Dynamics of spinor condensates.*

J. Kronjager et al., cond-mat/0509083.

(3) *Domains in spinor condensates.*

L. Sadler et al., cond-mat/0605351.

(4) *S=1 atoms in an optical lattice.*

A. Imambekov et al., Phys.Rev.A 68, 063602 (2003).

(5) *Spin dynamics in lattices.*

A.M. Rey et al., preprint.

VI Quantum noise in optics, atomic and solid state physics.

VII Student presentations

(1) *Noise correlations experiments with cold atoms as a detection tool for many body phases.*

E. Altman et al., Phys. Rev. A 70, 013603 (2004).

(2) *Interference of an array of independent Bose-Einstein condensates.*

Hadzibabic et al., Phys. Rev. Lett. 93 (2004) 180403.

(3) *HBT experiments with atoms in optical lattices.*

S. Foelling et al., Nature 434, 481-484 (2005); I. Spielman et al., cond-mat/0606216; Mainz experiments on HBT with fermions (preprint).

(4) *Single atom detectors. HBT experiment with neutral atoms.*

M. Kohl et al., cond-mat/0607172.

(5) *HBT experiments with He.* C. Westbrook et al., quant-ph/0609019.

VIII Quasi-condensates in low dimensions. Kosterlitz-Thouless transition in two dimensional systems.

IX Rotating condensates. Classical and quantum vortices.

X Student presentations

(1) *Experimental observation of the KT transition.*

Z. Hadzibabic et al., Nature 441 1118 (2006)

(2) *Experiments with rotating condensates.*

V. Schweikhard et al., cond-mat/0308582.

(3) *Fractional quantum Hall effect with cold atoms.*

N. Cooper et al., Phys. Rev. Lett. 87, 120405 (2001)

XI Non-perturbative effects of interactions in one dimensional systems. Luttinger liquids. Bosonization and Bethe ansatz solution.

XII Student presentations

(1) *Observation of a One-Dimensional Tonks-Girardeau Gas.*

T. Kinoshita et al., Science 305, 1125 (2004).

(2) *Local Pair Correlations in 1D Bose gases*

T. Kinoshita, T. R. Wenger and D. S. Weiss, Phys. Rev. Lett. 95, 190406 (2005)

(3) *Classical phase fluctuations in elongated traps.*

S. Dettmer et al., Phys. Rev. Lett. 87, 160406 (2001)

XIII Fermions. Feshbach resonance. Fermionic Hubbard model and the problem of high temperature superconductivity in cuprates.

XIV Student presentations

(1) *Condensation of molecules. BCS to BEC crossover.*

M. Greiner et al., cond-mat/0502539; M. Bartenstein et al., cond-mat/0412712; M. Zwierlein et al., Phys. Rev. Lett. 91, 250401 (2003).

(2) *Probing Pair-Correlations using shot noise.*

M. Greiner et al., cond-mat/0502411.

(3) *Imbalanced fermionic mixtures.*

M. Zwierlein et al., Science 311 492 (2006); G. Partridge et al., Science 311, 503 (2006).

(4) *Confinement induced molecules.*

H. Moritz et al., Phys. Rev. Lett. 94, 210401 (2005); K. Gunter et al., Phys. Rev. Lett. 95, 230401 (2005).

(5) *Fermions in an optical lattice.*

M. Kohl et al., Phys. Rev. Lett. 94, 080403 (2005)

(6) *Bose-Fermi mixtures in optical lattices.*

K. Gunter et al., Phys. Rev. Lett. 96, 180402 (2006) S. Ospelkaus et al., Phys. Rev. Lett. 96, 180403 (2006)