Session 21bA

Quantum Phase Transition from a Superfluid to a Mott Insulator in an Ultracold Gas of Atoms

21bA1

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A quantum phase transition occurs when atoms from a Bose-Einstein condensate are loaded into a three dimensional optical lattice potential. For low potential depths the atoms are superfluid and delocalized over the entire lattice. For high potential depths the repulsive interactions between the atoms cause a transition to a Mott insulator phase. In this phase the atoms are localized to lattice sites with an exactly defined atom number per site. In recent experiments we have also been able to observe that ultracold collisions between atoms lead to a collapse, but then to a revival of the macroscopic wave function. The experiments directly demonstrate the quantisation of the matter wave field of a Bose-Einstein condensate. A new field of physics with ultracold atoms is entered.

A Bose-Einstein Condensate immersed in a Fermi Sea: observation of the simultaneous degeneracy in dilute atomic gases of ^{6}Li/^{7}Li

21bA2

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We report the formation of a mixture of bosonic and fermionic quantum systems in a dilute atomic gas. Two isotopes of lithium atoms are pre-cooled by the standard laser cooling technique and transferred into a magnetic trap. Then the evaporation cooling is performed selectively on the bosonic isotope (^{7}Li), while its fermionic contrepart (^{6}Li) is cooled sympathetically until the simultaneous quantum degeneracy is reached. ^{7}Li Bose-Einstein condensate contains very small fraction of thermal atoms and is in thermal equillibrium with ^{6}Li Fermi sea at the temperature of 1/5 of the Fermi temperature.

21bA3 Continuous Vortices and Collective Excitations in Ferromagnetic Spinor Bose-Einstein Condenstates

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Bose-Einstein condensates (BEC) realized in alkali atomic gases with the hyperfine state $F = 1$ keep "spin" states degenerate and active under an optical trap. These systems, so-called spinor BEC are analogous to the A-phase of the superfluid ^{3}He. Among various topological structures, the Mermin-Ho and Anderson-Toulouse vortices are proposed in superfluid ^{3}He-A phase. These are continuous defects and non-singular l-vector texture. We demonstrate by solving the extended Gross-Pitaevskii equation that these topological structures are thermodynamically stable in ferromagnetic spinor BEC under rotation. Furthermore, we show the collective modes for the various kinds of the vortices within Bogoliubov theory.

21bA4 Electron-spin resonance in quantum degenerate 2D atomic hydrogen gas

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We report on experiments where two-dimensional Bose gas of atomic hydrogen has been compressed thermally on the surface of a miniature cold spot covered with superfluid helium ^{4}He at temperatures below 100 mK. The maximum achieved surface densities, up to $\sigma \approx 5{\times}10^{12}$ cm^2, are well inside the quantum degeneracy regime with $\sigma\Lambda^2 \approx 2$. Detection of the adsorbed H$\downarrow$ atoms *in situ* by ESR yields direct information on the surface density and temperature profiles over the cold spot and on the mean dipolar field and interatomic interactions in the 2D gas. The latter are influenced by the onset of local coherence and 2D superfluidity.