Physics, abstract
physics/0311045
Gravity-Sensitive Quantum Dynamics in Cold Atoms
Authors: Z.Y. Ma ,M.B. d'Arcy ,S.A. Gardiner
Comments: 4 pages, 2 figures
Subj-class: Atomic Physics
We subject a falling cloud of cold cesium atoms to periodic kicks from a sinusoidal potential created by a vertical standing wave of off-resonant laser light. Controllably accelerating the potential to vary the effective gravity experienced by the atoms, we show quantum accelerator mode dynamics to be highly sensitive to the gravitational acceleration when this is close to specific, resonant values. The high sensitivity of the quantum dynamics to variations in a control parameter is reminiscent of that associated with classical chaos.

Condensed Matter, abstract
cond-mat/0303626
Optically-induced lensing effect on a Bose-Einstein condensate expanding in a moving lattice
Authors: L. Fallani ,F. S. Cataliotti ,J. Catani ,C. Fort ,M. Modugno ,M. Zawada ,M. Inguscio
Subj-class: Soft Condensed Matter
We report the experimental observation of a lensing effect on a Bose-Einstein condensate expanding in a moving 1D optical lattice. The effect of the periodic potential can be described by an effective mass dependent on the condensate quasimomentum. By changing the velocity of the atoms in the frame of the optical lattice we induce a focusing of the condensate along the lattice direction. The experimental results are compared with the numerical predictions of an effective 1D theoretical model. We also show that the condensate can be used as a matter wave probe of the periodic structure provided by the optical lattice, thus allowing for a precise band spectroscopy.

Condensed Matter, abstract
cond-mat/0307440
Observation of molecules produced from a Bose-Einstein condensate
Authors: Stephan Dürr ,Thomas Volz ,Andreas Marte ,Gerhard Rempe
Comments: 4 pages, 4 figures, added a brief discussion about conversion efficiency as a function of ramp speed and density, added Refs.[27,31]
Molecules are created from a Bose-Einstein condensate of atomic 87Rb using a Feshbach resonance. A Stern-Gerlach field is applied, in order to spatially separate the molecules from the remaining atoms. For detection, the molecules are converted back into atoms, again using the Feshbach resonance. The measured position of the molecules yields their magnetic moment. This quantity strongly depends on the magnetic field, thus revealing an avoided crossing of two bound states at a field value slightly below the Feshbach resonance. This avoided crossing is exploited to trap the molecules in one dimension.

Condensed Matter, abstract
cond-mat/0304633
Unitarity-Limited Elastic Collision Rate in a Harmonically-Trapped Fermi Gas
Authors: M. E. Gehm ,S. L. Hemmer ,K. M. O'Hara ,J. E. Thomas
Comments: 4 pages, 2 figures, revTeX4, submitted to PRA
Subj-class: Statistical Mechanics; Superconductivity
We derive the elastic collision rate for a harmonically-trapped Fermi gas in the extreme unitarity limit where the s-wave scattering cross section is $\sigma (k) =4\pi/k^2$, with $\hbar k$ the relative momentum. The collision rate is given in the form $\Gamma=\gamma I(T/T_F)$--the product of a universal collision rate $\gamma =k_B

T_F/(6 \pi \hbar)$ and a dimensionless function of the ratio of the temperature T to the Fermi temperature T_F. We find I has a peak value of $\simeq4.6$ at $T/T_F\simeq0.4$, $I\simeq 82 (T/T_F)^2$ for $T/T_F\leq 0.15$, and $I\simeq 2(T_F/T)^2$ for $T/T_F>1.5$. We estimate the collision rate for recent experiments on a strongly-interacting degenerate Fermi gas of atoms.

Physics, abstract
physics/0303007
Prospects for Forbidden-Transition Spectroscopy and Parity Violation Measurements using a Beam of Cold Stable or Radioactive Atoms
Authors: S. Sanguinetti ,J. Guéna ,M. Lintz ,Ph. Jacquier ,A. Wasan ,M-A. Bouchiat (Laboratoire Kastler Brossel, Unité de Recherche de l'Ecole Normale Supérieure et de l'Université Pierre et Marie Curie, associé au CNRS)
Comments: 13 pages, 4 figures, 1 table
Subj-class: Atomic Physics
Laser cooling and trapping offers the possibility of confining a sample of radioactive atoms in free space. Here, we address the question of how best to take advantage of cold atom properties to perform the observation of as highly forbidden a line as the 6S-7S Cs transition for achieving, in the longer term, Atomic Parity Violation measurements in radioactive alkali isotopes. Another point at issue is whether one might do better with stable, cold atoms than with thermal atoms. To compensate for the large drawback of the small number of atoms available in a trap, one must take advantage of their low velocity. To lengthen the time of interaction with the excitation laser, we suggest choosing a geometry where the laser beam exciting the transition is colinear to a slow, cold atomic beam, either extracted from a trap or prepared by Zeeman slowing. We also suggest a new observable physical quantity manifesting APV, which presents several advantages:specificity, efficiency of detection, possibility of direct calibration by a parity conserving quantity of a similar nature. It is well adapted to a configuration where the cold atomic beam passes through two regions of transverse, crossed electric fields, leading both to differential measurements and to strong reduction of the contributions from the M_1-Stark interference signals, potential sources of systematics in APV measurements. Our evaluation of signal to noise ratios shows that with available techniques, measurements of transition amplitudes, important as required tests of Atomic Theory should be possible in cesium 133 with a statistical precision of 1/1000 and probably also in Fr isotopes for production rates of 10^6 Fr atoms/s.

High Energy Physics - Experiment, abstract
hep-ex/0309079
Proof of principle for a high sensitivity search for the electric dipole moment of the electron using the metastable a(1)[^3\Sigma^+] state of PbO
Authors: D. Kawall ,F. Bay ,S. Bickman ,Y. Jiang ,D. DeMille
Comments: 5 pages, 3 figures
The metastable a(1)[^3\Sigma^+] state of PbO has been suggested as a suitable system in which to search for the electric dipole moment (EDM) of the electron. We report here the development of experimental techniques allowing high-sensitivity measurements of Zeeman and Stark effects in this system, similar to those required for an EDM search. We observe Zeeman quantum beats in fluorescence from a vapor cell, with shot-noise limited extraction of the quantum beat frequencies, high counting rates, and long coherence times. We argue that improvement in sensitvity to the electron EDM by at least two orders of magnitude appears possible using these techniques.

Condensed Matter, abstract
cond-mat/0306226
Probing many-body states of ultra-cold atoms via noise correlations
Authors: Ehud Altman ,Eugene Demler ,Mikhail D. Lukin
Subj-class: Soft Condensed Matter; Strongly Correlated Electrons
We propose to utilize density-density correlations in the image of an expanding gas cloud to probe complex many body states of trapped ultra-cold atoms. In particular we show how this technique can be used to detect superfluidity of fermionic gases and reveal broken spin symmetries in Mott-states of atoms in optical lattices. The feasibility of the method is investigated by analysis of the relevant signal to noise ratio including experimental imperfections.

Quantum Physics, abstract
quant-ph/0308068
Controlling dipole-dipole frequency shifts in a lattice-based optical atomic clock
Authors: D. E. Chang ,Jun Ye ,M. D. Lukin
Comments: 14 pages, 4 figures
Motivated by the ideas of using cold alkaline earth atoms trapped in an optical lattice for realization of optical atomic clocks, we investigate theoretically the perturbative effects of atom-atom interactions on a clock transition frequency. These interactions are mediated by the dipole fields associated with the optically excited atoms. We predict resonance-like features in the frequency shifts when constructive interference among atomic dipoles occur. We theoretically demonstrate that by fine-tuning the coherent dipole-dipole couplings in appropriately designed lattice geometries, the undesirable frequency shifts can be greatly suppressed.

Quantum Physics, abstract
quant-ph/0307158
Discrete entanglement distribution with squeezed light
Authors: Barbara Kraus ,J. Ignacio Cirac
Comments: 5 pages, 4 figures
We show how one can entangle distant atoms by using squeezed light. Entanglement is obtained in steady state, and can be increased by manipulating the atoms locally. We study the effects of imperfections, and show how to scale up the scheme to build a quantum network.

Quantum Physics, abstract
quant-ph/0306006
Fast and robust two-qubit gates for scalable ion trap quantum computing
Authors: J. J. Garcia-Ripoll ,P. Zoller ,J. I. Cirac
We propose a new concept for a two-qubit gate operating on a pair of trapped ions based on laser coherent control techniques. The gate is insensitive to the temperature of the ions, works also outside the Lamb-Dicke regime, requires no individual addressing by lasers, and can be orders of magnitude faster than the trap period.

Quantum Physics, abstract
quant-ph/0309199
A One-Atom Laser in a Regime of Strong Coupling
Authors: J. McKeever ,A. Boca ,A. D. Boozer ,J. R. Buck ,H. J. Kimble
Comments: 5 pages, 4 figures (slightly longer version -- before editorial revisions)
Journal-ref: Nature 425, 268-271 (2003), supplementary information available at http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v425/n6955/abs/nature01974_fs.html

Although conventional lasers operate with a large number of intracavity atoms, the lasing properties of a single atom in a resonant cavity have been theoretically investigated for more than a decade. Here we report the experimental realization of such a one-atom laser operated in a regime of strong coupling. Our experiment exploits recent advances in cavity quantum electrodynamics that allow one atom to be isolated in an optical cavity in a regime for which one photon is sufficient to saturate the atomic transition. In this regime the observed characteristics of the atom-cavity system are qualitatively different from those of the familiar many atom case. Specifically, we present measurements of intracavity photon number versus pump intensity that exhibit "thresholdless" behavior, and infer that the output flux from the cavity mode exceeds that from atomic fluorescence by more than tenfold. Observations of the second-order intensity correlation function demonstrate that our one-atom laser generates manifestly nonclassical light that exhibits both photon antibunching and sub-Poissonian photon statistics.

Quantum Physics, abstract
quant-ph/0309187
Scalable photonic quantum computation through cavity-assisted interaction
Authors: L.-M. Duan ,H. J. Kimble
Comments: 5 pages, 2 figures
We propose a scheme for scalable photonic quantum computation based on cavity assisted interaction between single-photon pulses. The prototypical quantum controlled phase-flip gate between the single-photon pulses is achieved by successively reflecting them from an optical cavity with a single-trapped atom. Our proposed protocol is shown to be robust to practical nose and experimental imperfections in current cavity-QED setups.

Condensed Matter, abstract
cond-mat/0308384
Degenerate atom-molecule mixture in a cold Fermi gas
Authors: S.J.J.M.F. Kokkelmans ,G.V. Shlyapnikov ,C. Salomon
Comments: 5 pages, 3 figures
Subj-class: Statistical Mechanics
We show that the atom-molecule mixture formed in a degenerate atomic Fermi gas with interspecies repulsion near a Feshbach resonance, constitutes a peculiar system where the atomic component is almost non-degenerate but quantum degeneracy of molecules is important. We develop a thermodynamic approach for studying this mixture, explain experimental observations and predict optimal conditions for achieving molecular BEC.

Condensed Matter, abstract
cond-mat/0311172
A molecular Bose-Einstein condensate emerges from a Fermi sea
Authors: Markus Greiner ,Cindy A. Regal ,Deborah S. Jin
Subj-class: Statistical Mechanics; Soft Condensed Matter
The realization of fermionic superfluidity in a dilute gas of atoms, analogous to superconductivity in metals, is a long-standing goal of ultracold gas research. Beyond being a new example of this fascinating quantum phenomenon, fermionic superfluidity in an atomic gas holds the promise of adjustable interactions and the ability to tune continuously from BCS-type superfluidity to Bose-Einstein condensation (BEC). This crossover between BCS superfluidity of correlated atom pairs in momentum space and BEC of local pairs has long been of theoretical interest, motivated in part by the discovery of high Tc superconductors. In atomic Fermi gas experiments superfluidity has not yet been demonstrated; however recent experiments have made remarkable progress toward this goal. Starting from an ultracold Fermi gas experimenters have used Feshbach resonances to reversibly create molecules, i.e. composite bosons consisting of local

fermion pairs. Furthermore, the experiments have shown that the resulting diatomic molecules can have surprisingly long lifetimes. Here we report the conversion of a Fermi sea of atoms into a molecular BEC. In addition to being the first molecular condensate in thermal equilibrium, this BEC represents one extreme of the predicted BCS-BEC continuum.

Quantum Physics, abstract
quant-ph/0306121
Generation of Superposition Spin States in an Atomic Ensemble
Authors: S. Massar ,E. S. Polzik
Comments: 5 pages, 2 figures, accepted in Phys. Rev. Lett
A method for generating a mesoscopic superposition state of the collective spin variable of a gas of atoms is proposed. The state consists of a superposition of the atomic spins pointing in two slightly different directions. It is obtained by using off resonant light to carry out Quantum Non Demolition Measurements of the spins. The relevant experimental conditions, which require very dense atomic samples, can be realized with presently available techniques. Long-lived atomic superposition states may become useful as an off-line resource for quantum computing with otherwise linear operations.

quant-ph/0311092

Stationary pulses of light in an atomic medium

Authors: M. Bajcsy (1,2), A. S. Zibrov (1, 3, 4), M. D. Lukin (1) ((1) Physics Department, Harvard University, (2) Division of Engineering and Applied Sciences, Harvard University, (3)Harvard-Smithsonian Center for Astrophysics, (4) Lebedev Institute of Physics, Moscow)
Physical processes that could facilitate coherent control of light propagation are now actively explored. In addition to fundamental interest, these efforts are stimulated by possibilities to develop, for example, a quantum memory for photonic states. At the same time, controlled localization and storage of photonic pulses may allow novel approaches to manipulate light via enhanced nonlinear optical processes. Recently, Electromagnetically Induced Transparency (EIT) was used to reduce the group velocity of propagating light pulses and to reversibly map propagating light pulses into stationary spin excitations in atomic media. Here we describe and experimentally demonstrate a novel technique in which light propagating in a medium of Rb atoms is converted into an excitation with localized, stationary electromagnetic energy, which can be held and released after a controllable interval. Our method creates pulses of light with stationary envelopes bound to an atomic spin coherence, raising new possibilities for photon state manipulation and non-linear optical processes at low light levels.

physics/0311057

Coherent Anti-Stokes Raman Scattering Heterodyne Interferometry

Authors: J. S. Bredfeldt (1), D. L. Marks (1), C. Vinegoni (1), S. Hambir (1), S. A. Boppart (1,2 and 3) ((1) Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, (2) Dept. of Electrical and Computer Engineering (3) College of Medicine)
Subj-class: Optics; Medical Physics
A new interferometric technique is demonstrated for measuring Coherent Anti-Stokes Raman Scattering (CARS) signals. Two forward-directed CARS signals are generated, one in each arm of an interferometer. The deterministic nature of the CARS process allows for these two signals, when spatially and temporally overlapped, to interfere with one another. Heterodyne detection can therefore be employed to increase the sensitivity in CARS signal detection. In addition, nonlinear CARS interferometry will facilitate the use of this spectroscopic technique for molecular contrast in Optical Coherence Tomography (OCT).

quant-ph/0311089

Microscopic Origin of Spatial Coherence and Wolf Shifts

Authors: Girish S. Agarwal

We show that the vacuum of electromagnetic field has intrinsic partial spatial coherence in frequency domain which effectively extends over regions of the order of wavelength λ. This spatial coherence leads to a dynamical coupling between atoms and is the cause of source correlations and Wolf shifts. We show how the source spatial correlations can lead to tailor made coherent emissions. We discuss the universality of source correlation effects and presents several application.

quant-ph/0311076

Enhancement of field generation via maximal atomic coherence prepared by fast adiabatic passage in Rb vapor

Authors: V.A. Sautenkov, C.Y. Ye, Y.V. Rostovtsev, G.R. Welch, M.O. Scully
We have experimentally demonstrated the enhancement of coherent Raman scattering in Rb atomic vapor by exciting atomic coherence with fractional stimulated Raman adiabatic passage. Experimental results are in good agreement with numerical simulations. The results support the possibility of increasing the sensitivity of CARS by preparing atomic or molecular coherence using short pulses.

physics/0311039

From: Kalle-Antti Suominen <kalle-antti.suominen@utu.fi>
Date: Mon, 10 Nov 2003 12:18:26 GMT (33kb)

Radiative collisional heating at the Doppler limit for laser-cooled magnesium atoms

Authors: J. Piilo (1), E. Lundh (2), K.-A. Suominen (1) ((1) Univ. of Turku, Finland, (2) KTH, Stockholm, Sweden)

We report Monte Carlo wave function simulation results on cold collisions between magnesium atoms in a strong red-detuned laser field. The Doppler limit heating rate due to radiative collisions is calculated for Mg-24 atoms in a magneto-optical trap based on the singlet S_0 - singlet P_1 atomic laser cooling transition. We find that radiative heating does not seem to affect the Doppler limit in this case. We also describe a channelling mechanism due to the missing Q branch in the excitation scheme, which could lead to a suppression of inelastic collisions, and find that this mechanism is not present in our simulation results due to the multistate character of the excitation process.

quant-ph/0311099

Coupling Efficiencies in Single Photon On-Demand Sources

Authors: Stefania Castelletto, I.P. Degiovanni, Michael Ware, Alan Migdall
Comments: 9 pages, 5 figures
Many quantum computation and communication schemes require, or would significantly benefit from, true sources of single photon on-demand (SPOD). Unfortunately, such sources do not exist. It is becoming increasingly clear that coupling photons out of a SPOD source will be a limiting factor in many SPOD implementations. In particular, coupling these source outputs into optical fibers (usually single mode fibers) is often the preferred method for handling this light. We investigate the practical limits to this coupling as relates to parametric downconversion, an important starting point for many SPOD schemes. We also explored whether it is possible to optimize the engineering of the downconversion sources to improve on this coupling. We present our latest results in this area.