Workshop on

"Self-assembling of Particles into Longitudinal and Transverse Structures"

Porquerolles, France, October 8th - 11th 2007

Organizing Commitee :
Robin Kaiser (Nice, France)
Gian-Luca Lippi (Nice, France)
Antonio Politi (Florence, Italy)
Philippe Courteille (Tübingen, Germany)

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1 Announcement

Self-organization of nanoparticles or cold atoms is attracting increasing interest in view of possible applications for self-assembling large scale patterns with a high degree of periodicity. Self-organization is particularly interesting when it is induced by incident light fields giving rise to collective coupling and allowing for a dynamic control of the organization process. The workshop on "Self-assembling of Particles into Longitudinal and Transverse Structures" at Porquerolles, France joins experimentalists and theorists, accredited experts in this field, with the aim to shed light on fundamental aspects of the collective dynamics.

2 Programme

	Monday, October 8th	**Day I: Cold atoms in optical cavities** *Chairman: Robin Kaiser*
9:00	Nicola Piovella	Quantum effects in collective atomic recoil lasing
9:30	Sebastian Slama /Philippe Courteille	Collective atomic recoil lasing and superradiance in ultracold atomic clouds
10:00	Gordon Robb	Collective scattering of partially coherent light by cold atoms
10:30	*coffee break*	
11:00	Julien Javaloyes	Cold atoms in an electromagnetic field: Phase transitions, spontaneous ordering and instabilities
11:30	Antonio Politi	CARL dynamics as a synchronization transition
12:00	Helmut Ritsch	Classical versus quantum aspects of selfordering of cold atoms in optical lattices
12:30	*lunch*	

	Tuesday, October 9th	**Day II: Correlations in optical lattices & theoretical models** *Chairman: Antonio Politi*
9:00	Péter Domokos	Collective excitations and instability of an optical lattice due to unbalanced pumping
9:30	Julian Klinner /Malik Lindholdt	Optical lattice in a high-Q ring cavity
10:00	Igor Mekhov	Quantum optics with quantum gases: Influence of ultracold atom statistics on light
10:30	*coffee break*	
11:00	Stefano Ruffo	Quasi-stationary states in mean-field dynamics
11:30	Francesco Papoff	Modelling micro particle interaction
12:00	Matteo Cristiani	Cold ytterbium atoms in high-finesse optical cavities
12:30	*lunch*	

	Wednesday, October 10th	**Day III: Instabilities in clouds of atoms** *Chairman: Philippe Courteille*
9:00	José Tito Mendonça	Collective processes in cold atom physics
9:30	Philippe Verkerk /Daniel Hennequin	Instabilities in the magneto-optical trap
10:00	Robin Kaiser	Collective mechanical effects in MOTs with a large number of atoms: results and questions
10:30	*coffee break*	
11:00	Juan Jose Saenz	Unusually strong optical interactions between particles in quasi-one-dimensional geometries
11:30	Günther Werth	Collective oscillations of ion clouds in Paul- and Penning traps
12:00	Gabriele De Chiara	Low dimensional Wigner crystals of ions
12:30	*lunch*	

	Thursday, October 11th	**Departure**

3 Participants

Name	eMail	Affiliation
Simone Bux	bux@pit.physik.uni-tuebingen.de	Universität Tübingen, Germany
Caroline Champenois	caroline.champenois@univ-provence.fr	University de Provence, Marseille, France
Philippe Courteille	courteille@pit.physik.uni-tuebingen.de	Universität Tübingen, Germany
Matteo Cristiani	matteo.cristiani@icfo.es	The Institute of Photonic Sciences, Spain
Gabriele De Chiara	gabriele.dechiara@uab.cat	Universitat Autònoma de Barcelona, Spain
Péter Domokos	domokos@szfki.hu	Hungarian Academy of Sciences, Hungaria
Gian Luca Gattobigio	giovanni-luca.gattobigio@inln.cnrs.fr	Institut Non Linéaire de Nice, France
Mario Gattobigio	mario.gattobigio@inln.cnrs.fr	Institut Non Linéaire de Nice, France
William Guerin	william.guerin@inln.cnrs.fr	Institut Non Linéaire de Nice, France
Julien Javaloyes	julien.javaloyes@imedea.uib.es	Institut Mediterrani d'Estudis Avançats, Spain
Daniel Hennequin	daniel.hennequin@univ-lille1.fr	Université de Lille 1, France
Robin Kaiser	robin.kaiser@inln.cnrs.fr	Institut Non Linéaire de Nice, France
Julian Klinner	jklinner@physnet.uni-hamburg.de	Institut für Laser-Physik, Hamburg, Germany
Malik Lindholdt	malik@fys.ku.dk	Institut für Laser-Physik, Hamburg, Germany
Igor Mekhov	igor.mekhov@uibk.ac.au	Universität Innsbruck, Austria
José Tito Mendonça	titomend@ist.utl.pt	Universidade Técnica de Lisboa, Portugal
Franck Michaud	franck.michaud@inln.cnrs.fr	Institut Non Linéaire de Nice, France
Francesco Papoff	francesco.papoff@phys.strath.ac.uk	University of Strathclyde, UK
Nicola Piovella	nicola.piovella@mi.infn.it	Università degli Studi di Milano, Italy
Antonio Politi	antonio.politi@isc.cnr.it	Istituto Nazionale di Ottica Applicata, Italy
Helmut Ritsch	helmut.ritsch@uibk.ac.at	Universität Innsbruck, Austria
Gordon Robb	g.r.m.robb@strath.ac.uk	University of Strathclyde, UK
Stefano Ruffo	stefano.ruffo@gmail.com	Università degli Studi di Milano, Italy
Juan Jose Saenz	juanjo.saenz@uam.es	Universidad Autónoma de Madrid, Spain
Sebastian Slama	slama@pit.physik.uni-tuebingen.de	Universität Tübingen, Germany
Hugo Tercas	htercas@cfif.ist.utl.pt	Universidade Técnica de Lisboa, Portugal
Philippe Verkerk	philippe.verkerk@univ-lille1.fr	Université de Lille 1, France
Günter Werth	werth@uni-mainz.de	Johannes-Gutenberg-Uni, Mainz, Germany
Matthias Wolke	wolke@physnet.uni-hamburg.de	Institut für Laser-Physik, Hamburg, Germany

4 Abstracts

Low dimensional Wigner crystals of ions

Gabriele De Chiara
Departament de Fisica, Universitat Autònoma de Barcelona, Spain

A chain of singly-charged particles, confined by a harmonic potential, exhibits a sudden transition to a zigzag configuration when the radial potential reaches a critical value, depending on the particle number. This structural change is a phase transition of second order, whose order parameter is the crystal displacement from the chain axis. We study analytically the transition using Landau theory and find full agreement with numerical predictions by J. Schiffer [1] and Piacente et al. [2]. Our theory allows us to determine analytically the system's behaviour at the transition point.

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Cold ytterbium atoms in high-finesse optical cavities: Status report of the experiment

M. Cristiani, T. Valenzuela, Q. Glorieux, and J. Eschner
ICFO - The Institute of Photonic Sciences, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain

We report about the status of the cold atom and cavity QED experiment that we are building up at ICFO. The apparatus will allow us to study collective effects of cold and ultra-cold atomic samples coupled with the mode of a high-finesse optical cavity. Modularity and versatility are the guidelines of the set-up design, in view of future implementation of state-of-the-art technologies with only minor changes. As long term goal we want to also realize single atom - single photon interfaces as a resource for quantum optics, quantum computing, and quantum information experiments.

Collective excitations and instability of an optical lattice due to unbalanced pumping

Janos K. Asbóth, Helmut Ritsch, and Péter Domokos
Research Institute of Solid State Physics and Optics, Hungarian Academy of Sciences, H-1525 Budapest P.O. Box 49, Hungary

We solve self-consistently the coupled equations of motion for trapped particles and the field of a one-dimensional optical lattice. Optomechanical coupling creates long-range interaction between the particles, whose nature depends crucially on the relative power of the pump beams. For asymmetric pumping, traveling density wavelike collective oscillations arise in the lattice, even in the overdamped limit. By increasing the lattice size or pump asymmetry, these waves can destabilize the lattice.

Cold Atoms in an electromagnetic field: Phase transitions, spontaneous ordering and instabilities

Julien Javaloyes,[1] M. Perrin,[2] G.-L. Lippi,[3] and A. Politi[4]

[1] *Institut Mediterrani d'Estudis Avançats, CSIC-UIB, C/ M. Marques, 21, 07190 Esporles, Spain*

[2] *Laboratoire PhLAM, UMR-CNRS 8523 IRCICA, 59655 Villeneuve d'Ascq cedex, France*

[3] *Institut Non Linéaire de Nice, UMR 6618 CNRS/UNSA, 06560 Valbonne, France*

[4] *Istituto dei Sistemi Complessi, CNR, via Madonna del Piano 10, I-50019 Sesto Fiorentino, Italy*

Collective phenomena are frequently encountered in optics, lasing and optical bistability being prominent examples thereof. The underlying physical mechanisms governing these phenomena can effectively be described in terms of out-of-equilibrium statistical mechanics. Ensembles of atoms subject to coherent unidirectional pumping represent a further example of spontaneously emerging macroscopic order. Here, the collective behavior is triggered by atomic recoil which contributes to modulating the atomic density, thereby giving rise to a coherent backward field. In this problem, the atomic position in the standing wave and the backward-field amplitude play the roles of an oscillator's phase and of a mean-field coupling, respectively. Accordingly, this problem is akin to the onset of synchronization in globally coupled oscillators, a phenomenon widely studied in biological systems (e.g., fireflies) and in plasma physics [1]. This effect was predicted several years ago and is known as Collective Atomic Recoil Laser (CARL) [2]. In its original form, the CARL can be understood as a generalization of the Jaynes-Cummings model to the inclusion of the kinetic degrees of freedom. Preliminary studies were conducted in the limit of zero temperature and the assumption of a monocinetic atomic ensemble discloses the paternity of the CARL with the Free Electron Laser. As a consequence, the CARL model was only able to predict a transient amplification of the backward-field amplitude. On the contrary, preliminary experiments demonstrated the existence of a steady retro-diffused field. At the time, the strong simplifying hypotheses in the model as well as the possible existence of competing mechanisms in the experiments forbid to draw any conclusion.

A better understanding of this system can be gained by a proper modeling of the thermalization mechanisms [3]. In this way, we will show that is possible to identify the existence of a genuine non-equilibrium phase-transition occurring at sufficiently low temperatures corresponding to the appearance of a well defined steady state for the retro-diffused field. We will show that, beside the seek CARL transition, another transition akin to a special form of lasing action is possible, thereby shedding some light onto the preliminary experiments.

These results motivated a new experiment where it was convincingly shown that CARL action can be observed in a Rubidium molasses [4]. We will show that a model, expanding on [2] is able to capture a semi-quantitative description of the experimental results [5]. In this model, for a sufficiently large forward field, a spontaneously generated density grating at half the optical wavelength is self-strengthened by giving rise to a larger backward-field through back scattering of the impinging light. Below threshold, instead, atomic diffusion unavoidably connected with optical molasses washes out the grating. Accordingly, the CARL transition can be interpreted as a Gas/Bragg-Mirror transition. This description allowed us to reproduce all the experimental features observed so far: threshold, red-shifted emission, and the dependencies with respect to the atoms number, interaction strength, and distance from threshold. Furthermore, we will show that above the first CARL threshold of amplification, other regimes are possible where the atomic cloud enters a self-pulsing regime.

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Collective mechanical effects in MOTs with a large number of atoms: results and questions

G. Labeyrie, G. L. Gattobigio, F. Michaud, T. Pohl, T. Ackemann, G. L. Lippi, and R. Kaiser
Institut Non Linéaire de Nice, UMR 6618, 1361 route des Lucioles, F-06560 Valbonne, France

Dynamical systems of globally coupled oscillators can exhibit a large variety of collective effects in most different situations. Long range interactions can induce such global coupling and are be at the origin of collective effects in gravitational and plasma physics. Collective effects based on an interplay between repulsive long range interaction and a screened compression mechanism can lead to self sustained continuous oscillations. We have observed and analysed such an oscillation in a trap of laser cooled atoms with up to $N = 10^{10}$ atoms, where the long range interaction is due to radiation pressure and the screening is due to the opacity of the cloud. The effect of multiple scattering on the dynamics of the atoms is well known in the community of laser cooling of cold atoms, as multiple scattering has been a mayor limitation to obtain Bose-Einstein condensation in dilute atomic vapours. With a different perspective, multiple scattering of light in cold atoms has been studied in the context of coherent light transport and the connection to mesoscopic physics and wave localisation in random media [1]. This has lead to an investigation of unexplored regimes of cold atomic clouds, in particular the limit of very large number of atoms in the presence of quasi-resonant light. Here we present results in this regime, where we do not focus on the properties of the scattered light but on the mechanical effects of this light on the atoms. We will present a survey of our experimental results on the collective effects, which are modifying the average MOT size, the motion of the centre of mass and the most intriguing result of the dynamics of the MOT size, i.e. the self-sustained collective oscillations. A simple theoretical model can explain most of the qualitative behaviour we have observed in the experiment [2] and has been tested by numerical simulations [3]. Beyond these mechanical instabilities, collective effects in large clouds of cold atoms can also be expected in the optical response, considering the cloud of cold atoms as a non linear medium. We expect transverse pattern to form above a certain threshold and experiments along this line of research have been initiated in the past [4] and could now become successful with the larger MOTs we are able to produce. These research lines and related questions will be addressed during this presentation.

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Optical lattice in a high-Q ring cavity

J. Klinner, M. Lindholdt, B. Nagorny, and A. Hemmerich
Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

A novel regime of atom-cavity physics is explored, arising when large atom samples dispersively interact with high-finesse optical cavities. A stable far detuned optical lattice (FOL) of several million rubidium atoms is formed inside an optical ring resonator by coupling equal amounts of laser light to each propagation direction of a longitudinal cavity mode. An adjacent longitudinal mode, detuned by about 3 GHz, is used to perform probe transmission spectroscopy of the system. The atom-cavity coupling is dispersive and dissipation results only from the finite photon-storage time. The observation of two well-resolved normal modes demonstrates the regime of strong cooperative coupling. The details of the normal mode spectrum reveal mechanical effects associated with the retroaction of the probe upon the optical lattice [1]. Our system appears ideal for implementing cavity-mediated cooling independent of the internal atomic structure, or for preparing bound atom-cavity systems involving Bose-Einstein condensates, thus bringing together the worlds of cavity quantum electrodynamics and quantum degenerate gases.

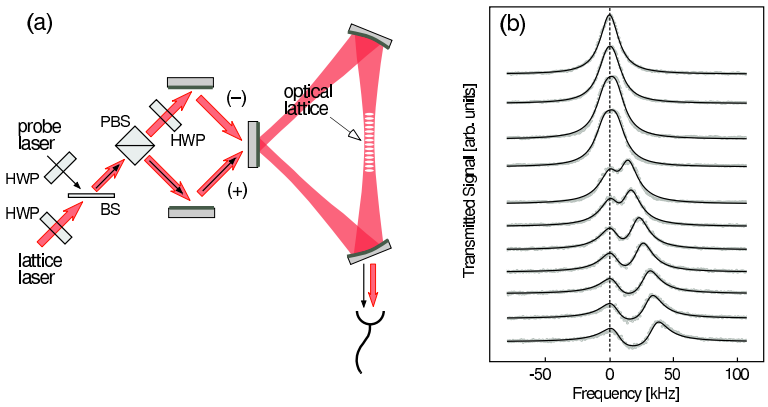


Figure 1: (a) The FOL is formed by symmetrically coupling a laser beam (lattice laser) to both propagation directions (denoted by (+) and (−)) of some longitudinal cavity mode (Finesse = 185 000, linewidth 17 kHz). A probe beam (thin arrow) is coupled to the (+)-direction of the adjacent longitudinal mode. BS = non-polarizing beam splitter, PBS = polarizing beam splitter, HWP = half wave plate. (b) Normal mode spectra for atom numbers in the lattice increasing top down (grey circles = observations, solid lines = theory).

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Quantum optics with quantum gases: Influence of ultracold atom statistics on light

Igor Mekhov
Institut für Theoretische Physik, Universität Innsbruck, Austria

Various quantum phases of atoms in optical lattices exhibit radically different light scattering. This allows studying quantum degenerate gases beyond the mean-field approximation by observing light and provides QND schemes for measuring atomic variables. Combining the setups of ultracold gases and cavity QED will allow the direct mapping of the atom-number distribution function on the transmission spectrum of a high-Q cavity. Quantum dynamics of light and matter, e.g., spatial self-ordering of atoms in a cavity, also strongly depends on the atomic quantum state. Even without high-Q cavities, some information about atom statistics is accessible by angle-resolved light measurements. The physics of different light scattering consists in the entanglement between the light and many-body atomic state, which arises during the interaction.

Collective processes in cold atom physics

José Tito Mendonça
GoLP, Institute Superior Técnico, Lisboa, Portugal and CfFP, Rutherford Appleton Laboratory, Didcot, U.K.

We discuss collective processes that can be associated with a neutral cold atom gas under the action of cooling laser beams. We use both fluid and kinetic descriptions. We compare the cold neutral atom behavior with that of an isotropic plasma. A new kind of wave mode, which can be called a plasma-acoustic mode, is identified. The influence of boundary conditions is discussed, and the associated Mie and Tonks-Dattner resonances are established. Using the kinetic description of the cold neutral atom gas we are also able to describe resonant interaction between waves and atoms, which is the basis of Landau damping. The relevance of this theoretical approach to the interpretation of present and future experiments is critically examined.

Modelling micro particle interaction

G. D'Alessandro
School of Mathematics, University of Southampton, Southampton SO17 1BJ, UK
G.-L. Oppo and F. Papoff
Department of Physics, University of Strathclyde, 107 Rottenrow, Glasgow G4 0NG, UK

In our modelling of the interaction between microparticles, we compute the scattered field from the incident field using a matrix transformation (the T-matrix [1]). The coefficients of the T-matrix are surface integrals that depend only on the shape and properties of the scatterer and not on the incident field. Over the years, many T-matrix-based algorithms have been developed (see [2] for an extremely comprehensive list of references) and have been applied to the study of single microparticles, e.g. [3, 4] or collections of particles, e.g. [5].

This approach allows us to model interacting particles as a system of coupled nonlinear stochastic integro-differential equations for the positions of the centres of mass of the particles, with dissipation terms due to the presence of a liquid. The equilibria of the particles are the points where the forces vanish: from this point of view, transition from amorphous or disordered phases to crystalline phases are determined by changes in the stability of the equilibria. More importantly, this approach will allow us to study cases in which all static equilibria are unstable and the stable configurations are dynamic, e.g. some or all particles move along closed orbits [6]. By adding small stochastic terms we can determine the variance of the particle coordinates near the equilibria and assess the presence of local variations in the effective temperature. We expect that the stability operators do not commute with their adjoint. This will, in some cases, lead to very strong response both to small noise terms and to small external perturbations periodic in time [7, 8]. For the largest ensembles that will be studied (order one hundred particles) we will also introduce an effective medium description based on the density of particles.

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Quantum effects in collective atomic recoil lasing

Nicola Piovella
Dipartimento di Fisica, Università Degli Studi di Milano, Italy

I will review the quantum aspects of collective atomic recoil laser (CARL) in an ultacold atomic sample, discussing the semi-classical and the quantum regimes in the good-cavity and superradiance mode operation of CARL. Between them, I will discuss the production of entangled atom-atom or atom-photon pairs and novel transverse dynamical effects predicted in the CARL process.

CARL dynamics as a synchronization transition

Antonio Politi
Istituto dei Sistemi Complessi, Firenze, Italy

The behaviour of cold atoms subject to the action of a coherent electromagnetic field in a bidirectional cavity is discussed. We discuss analogies and differences with the onset of synchronization transition in globally coupled oscillators (including the Kuramoto model). In particular we discuss a secondary transition beyond which the forward field unlocks and amplitude oscillations of the two fields spontaneously arise. The relationship between this latter behaviour and that one predicted in some other systems (including a neural network) is analyzed.

Classical versus quantum aspects of selfordering of cold atoms in optical lattices

Helmut Ritsch
Institut für Theoretische Physik, Universität Innsbruck, Austria

We study quantum particles at zero temperature in an optical lattice coupled to a resonant cavity mode. The cavity field substantially modifies the particle dynamics in the lattice, and for strong particle-field coupling leads to self-organization of the particles, a configuration with only every second site occupied. We study the growth of this order out of a homogeneous initial distribution for few particles. Simulations reveal that the growth dynamics crucially depends on the initial quantum many-body state of the particles and can be monitored via the cavity fluorescence. Studying the relaxation time of the ordering reveals inhibited tunnelling due to the interaction with the cavity field. However, the relaxation becomes very quick for strong coupling.

Collective scattering of partially coherent light by cold atoms

Gordon Robb
Department of Physics, University of Strathclyde, Scotland

Theoretical studies of collective scattering processes such as the Collective Atomic Recoil Laser (CARL) instability usually assume a coherent pump laser field. I will present an analysis of the CARL model for cases where the phase of the pump field fluctuates stochastically and is modulated periodically, and demonstrate the effect of pump phase fluctuations/modulation on the evolution of the scattered light.

Quasi-stationary states in mean-field dynamics

Stefano Ruffo
Dipartimento di Energetica "S. Stecco", Universitá di Firenze, INFN and CSDC, via s. Marta, 3 50139 Firenze, Italy

Systems with mean-field like interactions display a short-time relaxation towards Quasi Stationary States (QSSs), whose lifetime increases with system size. Besides that, these states are "attractive", since one observes convergence towards them from a different generic initial state. They are robust to external and stochastic perturbations and persist when a weak short-range interaction is added. Examples of systems where such states appear are: the Hamiltonian Mean-Field (HMF) model, the free-electron laser and wave-particle Hamiltonians. Recently, the use of Lynden-Bell entropy has been advocated to describe such states. In this talk, I will discuss the merits and drawbacks of this approach.

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Unusually strong optical interactions between particles in quasi-one-dimensional geometries

Juan Jose Saenz
Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid, Spain

By fashioning proper optical field gradients it is possible to trap and manipulate small particles with optical tweezers [1]. Intense optical fields can also induce significant forces "between" particles [2]. In analogy with atomic physics, the resonant modes of a single particle play the role of electronic orbitals [3] and, like their electronic counterparts, could lead to bonding and antibonding interactions between neighboring particles [3]. Unfortunately, in absence of absorbing or "Mie"-like resonances, light forces on atoms, molecules, and nanometer-sized particles are, in general, very small.

In this talk we will first introduce some basic concepts of light scattering, radiation pressure and polarization forces on small particles. As we will show, when the fields are confined in quasi-one-dimensional (Q1D) waveguide structures, the coupling of the scalar dipolar field with the waveguide modes leads to a resonant total reflection close to the threshold of a new propagating mode [4]. Similar resonances appear in very different contexts under the label of Fano or Feshbach geometric resonances and, in particular, play an important role in the interaction of electromagnetic waves with structured surfaces [5].

We will see that at the resonance, a small particle in a waveguide is strongly accelerated along the guide axis while it's highly confined in a narrow zone of the cross section of the guide [4]. The optically induced interaction between particles in a waveguide will also be discussed. We will see that these resonant modes lead to unusual strong optical interactions "between" particles [6].

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Collective atomic recoil lasing and superradiance in ultracold atomic clouds

Sebastian Slama, Simone Bux, Gordon Krenz, and Philippe W. Courteille
Physikalisches Institut, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We present experiments with ultracold and Bose-Einstein condensed (BEC) atoms interacting with the optical modes of a laser-driven high-finesse ring cavity [1]. In a magnetic trap ^{87}Rb atoms are evaporatively cooled to ultralow temperatures and moved into the mode volume of a ring cavity. Subsequently, one of the cavity modes is pumped with laser light. Pump light which is scattered from the atoms suddenly builds up a light field in the reverse mode with exponential gain. A characteristic sequence of light pulses emitted by the reverse mode is a signature of Collective Atomic Recoil Lasing (CARL) [2], a phenomenon which has been introduced more than ten years ago as an instability in the density distribution of an atomic gas under the influence of incident light [3]. The spontaneous arrangement of the atoms into a grating is indeed observed in our experiments.

Superradiant Rayleigh Scattering (SRyS) from BECs is a closely related phenomenon. The signature of SRyS, exponential gain for the scattered optical and BEC recoil modes, has been explained through Bose-enhancement [4]. Via a dramatic reduction of the finesse of the ring cavity, our experiment has access to the SRyR regime allowing for the first observation of cavity-enhanced SRyS. The fact that we observe SRyS for temperatures as high as several tens of μK clearly demonstrates that SRyS does not rely on quantum statistics, but on cooperative behavior of the atoms.

Our experiments represent the first realization of BEC inside an optical resonator. We argue that this system is very appealing, because it is capable of providing Bose-Einstein condensates with dissipative forces based on cavity cooling mechanisms [5].

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Instabilities in the magneto-optical trap

Djamel Deghiche, Saïd Outioua, Daniel Hennequin, and Philippe Verkerk
Laboratoire PhLAM, Bat P5 - USTL, 59655 Villeneuve d'Ascq Cedex, France

Cold atoms became in the last decades a fantastic tool for atomic physics. They allowed huge breakthrows, as for instance the achievement of Bose-Einstein condensation in dilute gases. These atoms are first cooled and trapped with a magneto-optical trap (MOT), the principle of which is well understood. However, it is known from the very beginning that such magneto-optical traps can become unstable [1]. These instabilities are usually avoided by the experimentalists, with a proper choice of the parameters. And the origin of the instabilities is not fully elucidated. In a MOT with retroreflected beams, we have shown that the origin of the instabilities could be either stochastic [2] or deterministic [3]. In the first case (stochastic instabilities), a resonance associated with a fold in the phase space amplifies the technical noise. On the other hand, the deterministic instabilities are in most case periodic and are independent of any external source of noise. We have developed a theoretical 1D model, as simple as possible, that reproduces the general behaviour of the system. The basic ingredient to explain the instabilities is the "shadow effect" due to the absorption of the beams when they travel across the cloud of cold atoms. In this case of retroreflected beams, the cloud of cold atoms was supposed to be

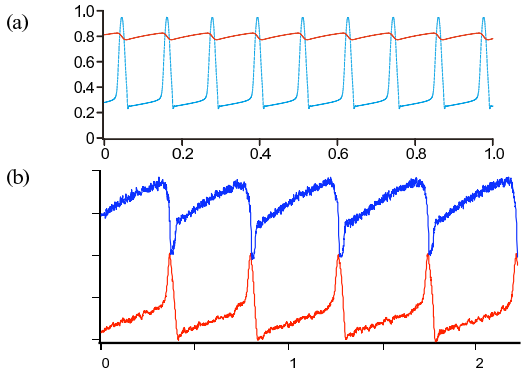


Figure 2: Deterministic instabilities in the MOT (a) theory and (b) experiment.

homogeneous with a constant density. This hypothesis follows the treatment of the multiple scattering, with almost handwaving arguments, and experimental results from the same period [4]. However, nowadays, the experiments are mainly done with independent forward and backward beams, which was not accounted for in the previous model. The cloud is not anymore homogeneous and the local atomic density changes with time. We are trying to describe this situation with a 1D theoretical model, as simple as possible, with only the two above mentioned phenomena : shadow effect (compression) and multiple scattering (repulsion). For experiments, we are planning to use a new geometry that fits the model, with 1D instabilities.

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Collective oscillations of ion clouds in Paul- and Penning traps

Günter Werth
Johannes-Gutenberg-Universität, D-55099 Mainz, Germany

The oscillation of ions stored in radio-frequency (Paul) or static (Penning) quadrupole traps can be excited by a radio-frequency field applied to the trap electrodes. At low amplitudes of this field resonances are observed which correspond to individual ion oscillations. When the amplitude exceeds a critical value, a second resonance appears which can be attributed to a collective oscillation of the ion cloud. The threshold value depends as $N^{-1/3}$ on the stored ion number N. The resonance shape exhibits the typical form of a driven anharmonic oscillator. Solutions of the equation of motion of the ions under the assumption of damping by ion-neutral collisions agree well with the observations. For a certain frequency range of the exciting rf field bistability between the collective and non-collective resonance is observed. In practise the trap potential deviates from the ideal quadrupolar shape. Then instabilities of the ion motion appear, when the eigenfrequencies of the ion oscillations in different directions are linear dependent. Operating the trap near one of the instable points in the presence of damping, e.g. by collisions or by a cooling laser, leads to collective oscillations of the ion cloud, observed by variations in the laser-induced fluorescence (Figure 3). The frequency of this oscillation can vary from many minutes in case of low damping to the second range for strong damping.

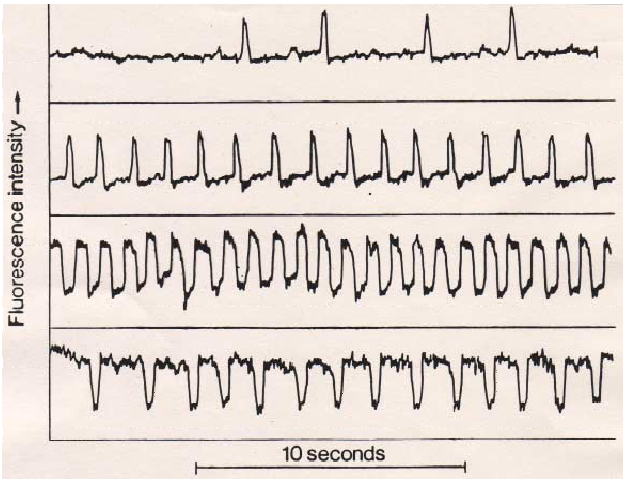


Figure 3: Oscillations in laser induced fluorescence from an ion cloud confined in a Paul trap when operated near an unstable working point.

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5 Venues

Name	Arrival	Departure
Simone Bux	sunday 14h25 Marseille airport (LH4348)	thursday with Ph.Courteille
Caroline Champenois	monday from Marseille	thursday to Marseille
Philippe Courteille	sunday from Marseille	thursday to Marseille
Matteo Cristiani	monday	thursday
Gabriele De Chiara	monday afternoon	thursday
Péter Domokos	sunday 11h30 Marseille airport	thursday 17h30 Marseille airport
Gian Luca Gattobigio	sunday from Nice by car	thursday to Nice by car
Mario Gattobigio	sunday	thursday
William Guerin	sunday from Nice by car	thursday to Nice by car
Daniel Hennequin	sunday 16h15 Toulon train station	thursday by car with C.Champenois
Julien Javaloyes	sunday from Nice by car	thursday to Nice by car
Robin Kaiser	sunday from Nice by car	thursday to Nice by car
Julian Klinner	sunday 14h50 Toulon-St-Trop	thursday 15h15 Toulon-St-Trop
Malik Lindholdt	sunday 15h50 Marseille	thursday 11h30 Marseille
Igor Mekhov	sunday	thursday
José Tito Mendonça	sunday from Nice by rented car	thursday or friday to Nice by rented car
Franck Michaud	sunday	thursday
Francesco Papoff	sunday 14h10 Nice airport (KL1265)	thursday 14h55 Nice airport
Nicola Piovella	sunday	thursday
Antonio Politi	sunday from Nice by car	thursday to Nice by car
Helmut Ritsch	sunday 12h10 Marseille (LH4362)	thursday 13h05 Marseille
Gordon Robb	sunday 14h10 Nice airport (KL1265)	thursday 14h55 Nice airport
Stefano Ruffo	monday afternoon from Hyéres	wednesday to Nice
Juan Jose Saenz	sunday 11h40 Marseille airport (IB8914)	thursday 12h15 Marseille airport
Sebastian Slama	sunday from Marseille	thursday from Marseille
Hugo Tercas	sunday	thursday
Philippe Verkerk	sunday 16h15 Toulon train station	thursday with C.Champenois
Günter Werth	sunday 9h25 Marseille airport (LH4350)	friday 18h55 Marseille airport
Matthias Wolke	sunday 15h50 Marseille	thursday 11h30 Marseille

6 Repas

Nom	**Arrivé**	Premier repas	Dernier repas	**Depart**
Simone Bux	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Caroline Champenois	lundi matin	lundi midi	jeudi petit déjeuner	jeudi matin
Philippe Courteille	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Matteo Cristiani	lundi après-midi	lundi soir	jeudi petit déjeuner	jeudi matin
Gabriele De Chiara	lundi après-midi	lundi soir	jeudi petit déjeuner	jeudi matin
Péter Domokos	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Gian Luca Gattobigio	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Mario Gattobigio	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
William Guerin	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Daniel Hennequin	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Julien Javaloyes	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Robin Kaiser	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Julian Klinner	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Malik Lindholdt	dimanche soir	lundi matin	jeudi petit déjeuner	jeudi matin
Igor Mekhov	dimanche soir	lundi matin	jeudi petit déjeuner	jeudi matin
José Tito Mendonça	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Franck Michaud	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Francesco Papoff	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Nicola Piovella	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Antonio Politi	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Helmut Ritsch	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Gordon Robb	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Stefano Ruffo	dimanche soir	lundi matin	mercredi midi	mercredi matin
Juan Jose Saenz	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Sebastian Slama	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Hugo Tercas	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Philippe Verkerk	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Günter Werth	dimanche	dimanche soir	jeudi petit déjeuner	jeudi matin
Matthias Wolke	dimanche soir	lundi matin	jeudi petit déjeuner	jeudi matin