Q 33: Quantengase: Bosonen

Zeit: Mittwoch 14:00–16:00 Raum: VMP 6 HS-A

Preisträgervortrag Q 33.1 Mi 14:00 VMP 6 HS-A

Von der Laserschwelle zum Quantenphasenübergang - und zurück — •Robert R. F. Graham — Fachbereich Physik, Universität Duisburg/Essen — Träger der Max-Planck-Medaille

Vortrag zur Verleihung der Max-Planck Medaille 2009

Seit Planck, Bose und Einstein wird Licht verstanden als ein Quantengas mit thermodynamischen Eigenschaften wie Energie und Entropie, und im thermodynamischen Gleichgewicht auch mit Temperatur und Druck. Nach Erfindung des Lasers lernten wir dann zu verstehen, dass noch eine weitere Quantenphase von Licht auftreten kann als Bose-Einstein Kondensat eines Gases von Photonen fester Frequenz. Die Quantenfluktuationen der Spontanemission treiben den Übergang zu diesem Zustand an der Laserschwelle, thermische Fluktuationen spielen dagegen keine signifikante Rolle. Es ist somit ein Quantenphasenübergang, doch kein solcher zwischen thermodynamischen Gleichgewichten, sondern zwischen getriebenen Fließgleichgewichten. Die neuen Fragen, die dies aufwirft, haben mich seitdem immer wieder beschäftigt. Einige davon werden im Vortrag thematisiert.

Mit der Realisierung von Bose-Einstein Kondensaten in Atomfallen im letzten Jahrzehnt hat sich nun ein Kreis geschlossen. Im Vordergrund stand diesmal zunächst Einsteins wohlbekannter Quantenphasenübergang. Doch ebenso wie beim Licht gibt es auch hier die andere, in diesem Kontext neue Seite des Phaenomens, die des Atomlasers. Sicherlich wird seine weitere Entwicklung in verschiedenen stationären und dynamischen Zuständen experimentell, aber auch theoretisch ein interessantes Thema für die nähere Zukunft bleiben.

Gruppenbericht Q 33.2 Mi 14:30 VMP 6 HS-A

Free expansion of a Bose-Einstein condensate in microgravity — •Wojciech Lewoczko-Adamczyk[1], Achim Peters[1], Tim van Zoest[2], Ernst Rasel[2], Wolfgang Ertmer[2], Anika Vogel[3], Kai Bongs[3], Klaus Sengstock[3], Endre Kajari[4], Reinhold Walser[4], Wolfgang Schleich[4], Thorben Könemann[5], Klaus Lämmerzahl[5], and Hansjörg Dittus[5] — [1]Institut für Physik, Humboldt Universität zu Berlin — [2]Institut für Quantenoptik, Leibniz-Universität Hannover — [3]Institut für Laserphysik, Universität Hamburg — [4]Institut für Quantenphysik, Universität Ulm — [5]ZARM, Universität Bremen

We report on the current status of the free fall Bose-Einstein condensate (BEC) experiment at the ZARM drop tower in Bremen. After the realization of the first BEC in microgravity, the dynamics of the condensate in the shallow, decompressed trap and during the free expansion were studied comprehensively. With the resulting knowledge and understanding of the relevant processes, a free expansion time up to one second has already been achieved. This unprecedented time of free evolution leads to new possibilities for the study of BEC-coherence. It can also be applied to enhance the sensitivity of inertial quantum sensors based on ultra-cold matter waves. Our compact and portable BEC-apparatus will be presented in detail. Special emphasis will be put on its robustness and reliability, which opens new routes to quantum optics experiments also on other microgravity platforms, like ballistic rockets or the International Space Station. This work was realized within the QUANTUS collaboration.

Q 33.3 Mi 15:00 VMP 6 HS-A

Towards a BEC of Strontium — •Simon Stellmer[1,2], Rudolf Grimm[1,2], and Florian Schreck[1] — [1]Institut für Quantenoptik und Quanteninformation, 6020 Innsbruck, Austria — [2]Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Austria

Atomic Strontium shows some remarkable atomic properties related to its electronic configuration as an alkaline earth metal. Very long-lived metastable states, narrow intercombination lines, and zero magnetic moment for the bosonic isotopes offer unique possibilities for optical clocks, employment of optical Feshbach resonances, quantum computation and quantum simulation. While the cooling of true alkaline earth atoms into quantum degeneracy has not been achieved so far, a new approach is taken by the Innsbruck group.

In this talk, we will sketch the cooling strategy used, report on the current status of the experiment, and illustrate some possible future applications.

Q 33.4 Mi 15:15 VMP 6 HS-A

Casimir energy of a BEC: from moderate interactions to the ideal gas — •Jürgen Schiefele and Carsten Henkel — Universität Potsdam, Institut für Physik und Astronomie, Karl-Liebknecht-Str. 24/25, 14 476 Potsdam, Germany

A pair of parallel conducting plates separated by vacuum imposes boundary conditions on the electromagnetic vacuum fluctuations. This causes a change in the (infinite) vacuum energy density, and leads to an attractive interaction between the two plates. The resulting force on the plates is known as the Casimir force.

When a weakly interacting dilute Bose-Einstein condensate (BEC) is confined between parallel plates, there is an analogous effect caused by the quantum fluctuations (Bogoliubov modes) on top of the ground state of the BEC. We derive a renormalized expression for the zero temperature Casimir energy of a BEC confined to a parallel plate geometry with periodic boundary conditions. Our expression is formally equivalent to the free energy of a bosonic field at finite temperature, with a nontrivial density of modes that we compute analytically. As a function of the interaction strength, it smoothly describes the transition from the weakly interacting Bogoliubov regime (phononic Casimir effect) to the non-interacting ideal BEC (no Casimir effect).

J. Schiefele and C. Henkel, J. Phys A (2009) in press.

Q 33.5 Mi 15:30 VMP 6 HS-A

Creation and detection of a mesoscopic gas in a non-local quantum superposition — •Christoph Weiss[1] and Yvan Castin[2] — [1]Institut für Physik, Universität Oldenburg — [2]Laboratoire Kastler Brossel, École Normale Supérieure, Paris

We investigate the scattering of a quantum matter wave soliton on a barrier in a one dimensional geometry and we show that it can lead to mesoscopic Schrödinger cat states, where the atomic gas is in a coherent superposition of being in the half-space to the left of the barrier and being in the half-space to the right of the barrier. We propose an interferometric method to reveal the coherent nature of this superposition and we discuss in details the experimental feasibility.

[1] Phys. Rev. Lett, in press; arXiv:0806.3395v1

Q 33.6 Mi 15:45 VMP 6 HS-A

Multi-resonant amplification in a trapped spinor condensate — •Gebremedhn Gebreyesus, Philipp Hyllus, and Luis Santos — Institut für Theor. Physik, Appelstr. 2, Leibniz Universität Hannover

We study theoretically spin changing collisions in a spinor condensate prepared initially in the $m_F = 0$ state. Due to the interplay between quadratic Zeeman effect, spin-changing collisions, and trap energy, the spin transfer into $m_F = \pm 1$ presents an intriguing dependence on the applied magnetic field. In particular, we show that the spin-transfer velocity reflects the instability of the corresponding Bogoliubov modes. Contrary to the case of an homogeneous gas, the spin transfer velocity is characterized by the appearance of marked resonances as a function of the applied magnetic field. We comment on the relevance of these results for recent experiments performed in Berkeley and in Hannover.