Q 17: Quantengase: Bosonen Dynamik / Disorder

Zeit: Dienstag 10:30–12:30 Raum: VMP 6 HS-A

Q 17.1 Di 10:30 VMP 6 HS-A

Bose-Einstein condensates in time dependent rotating traps — •Endre Kajari, Daniela Denot, Reinhold Walser, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

Recent experiments on the time evolution of Bose-Einstein condensates in free fall, accomplished by the QUANTUS collaboration [1] at the drop tower facility in Bremen (ZARM), revealed a rotation of the harmonic trap at very small trapping frequencies. Since the scaling approach provided in the seminal articles [2,3] is not applicable to time dependent rotating traps, an extension of their formalism is necessary.

We recall a natural generalization [4] of their scaling approach, which allows for an efficient description of the macroscopic wave function in time dependent rotating traps. The limitations of this generalization are explored by comparison to three-dimensional numerical simulations of the time dependent Gross-Pitaevskii equation.

[1] A. Vogel et al., Appl. Phys. B **84**, 664 (2006).
[2] Yu. Kagan et al., Phys. Rev. A. **54**, R1753 (1996).
[3] Y. Castin and R. Dum, Phys. Rev. Lett. **77**, 5315 (1996).
[4] P. Storey and M. Olshanii, Phys. Rev. A **62**, 033604 (2000).

Q 17.2 Di 10:45 VMP 6 HS-A

Dynamical aspects of Bose-Einstein condensation — •Alexej Schelle[1,2], Thomas Wellens[1], Dominique Delande[2], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Laboratoire Kastler-Brossel, Université Pierre et Marie Curie-Paris 6, ENS, CNRS; 4 Place Jussieu, F-75005 Paris, France

We present a non-phenomenological, particle number conserving quantum master equation theory for trapped Bose-Einstein condensates out of thermal equilibrium. Based on the separation of time scales between the condensate and non-condensate dynamics, the condensate master equation is derived taking into account all possible two-particle interaction processes. We study the so obtained times scales for non-equilibrium dynamics in the dilute gas limit, and show that they are determined with negligible corrections by properties of a non-interacting gas. As a fundamental application, we study the process of Bose-Einstein condensation quantitatively, which reduces to an evolution equation for the condensate particle number distribution in a gas of exactly N particles.

Q 17.3 Di 11:00 VMP 6 HS-A

Dynamics of Solitons in Bose-Einstein condensates — •Eva-Maria Richter[1], Christoph Becker[1], Parvis Soltan-Panahi[1], Mathis Baumert[2], Sören Dörscher[1], Simon Stellmer[3], Jochen Kronjäger[2], Kai Bongs[2], and Klaus Sengstock[1] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]MUARC, School of Physics and Astronomy, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom — [3]Institut für Quantenoptik und Quanteninformation Technikerstr. 21a A-6020 Innsbruck Austria, Europe

We present the results of numerical calculations solving the 1D Gross-Pitaevskii equation and discuss the dynamics of dark and dark-bright solitons in Bose-Einstein condensates, particularly with regard to their collisions [1,2]. By tracing phase and densitydistribution of the condensate during the interaction, several types of collisions, depending on the depths of the solitons, can be distinguished. We compared these simulations with our results of the experimental observations of dark and dark-bright solitons in Bose-Einstein condensates. [1] C. Becker et. al., Nature Physics 4, 496-501 (2008); [2] S. Stellmer et. al., Phys. Rev. Lett. 101, 120406 (2008)

Q 17.4 Di 11:15 VMP 6 HS-A

Comparison of stochastic theories for the dynamics of Bose gases — Stuart Cockburn[1], •Carsten Henkel[2], Antonio Negretti[3], and Nikolaos Proukakis[1] — [1]School of Mathematics and Statistics, Newcastle University, United Kingdom — [2]Institut für Physik und Astronomie, Universität Potsdam, Germany — [3]Institut für Quanten-Informationsverarbeitung, Universität Ulm, Germany

Theoretical modelling of ultracold Bose gases at finite temperature is based on a variety of different techniques, and the precise relation between these approaches is not yet established [1]. In this work, we compare two numerical simulation schemes that combine propagation according to the Gross-Pitaevskii equation with different initial states: the number-conserving Bogoliubov method [2] and the stochastic Gross-Pitaevskii equation [3,4]. In the latter method, the state is prepared by coupling a heat bath to the atomic quantum field. We compare the initial data, looking at diagnostics such as condensate statistics. Dynamical observables after releasing the initial state at different temperatures are analyzed: we focus on the cases that the heat bath is removed [5] or not.

[1] N.P. Proukakis and B. Jackson, J. Phys. B 41, 203002 (2008).
[2] Y. Castin and R. Dum, Phys. Rev. A 57, 3008 (1998); A. Sinatra, C. Lobo and Y. Castin, J. Phys. B 35, 3599 (2002).
[3] H.T.C. Stoof, J. Low Temp. Phys. 114, 11 (1999).
[4] C.W. Gardiner and M.J. Davis, J. Phys. B 36, 4731 (2003).
[5] N.P. Proukakis, J. Schmiedmayer and H.T.C. Stoof, Phys. Rev. A 73, 053603 (2006).

Q 17.5 Di 11:30 VMP 6 HS-A

BEC's in disordered potentials: from weak to strong localization — •Felix Eckert, Thomas Wellens, Viola Droujinina, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3a, 79104 Freiburg

Recent numerical studies of BEC's scattered from 2-D disordered potentials reveal a reduction (or even inversion) of the coherent back scattering (CBS) cone induced by the atomic mean-field interactions [1]. Since, at least in the linear case, enhanced backscattering corresponds to a reduction of the diffusion coefficient (weak localization), we now investigate whether this correspondence still holds in presence of atomic interactions. Employing a generalization of the self consistent approach of Vollhardt and Wölfle [2] in connection with the non-linear diagrammatic theory developed in [3], we calculate the diffusion coefficient for a BEC in a random finite medium, and study the transition from the weakly to the Anderson localized regime for different coupling constants of the interacting atoms in the BEC.

[1] M. Hartung *et al.*, Phys. Rev. Lett. **101**, 020603 (2008)
[2] D. Vollhardt and P. Wölfle, Phys. Rev. B **22**, 4666 (1980)
[3] T. Wellens and B. Grémaud, Phys. Rev. Lett. **100**, 033902 (2008)

Q 17.6 Di 11:45 VMP 6 HS-A

Transport and depletion of Bose-Einstein condensates in the presence of disorder — Thomas Ernst[1], •Tobias Paul[2], and Peter Schlagheck[3,4] — [1]Center for Theoretical Chemistry and Physics, Massey University Auckland, New Zealand — [2]Institut für Theoretische Physik, Universität Heidelberg — [3]Institut für Theoretische Physik, Universität Regensburg — [4]Division of Mathematical Physics, Lund Institute of Technology, Sweden

We explore transport processes of ultracold Bose-condensed atomic vapors within guided atom lasers beyond the Gross-Pitaevskii Mean-Field approach. For this purpose we generalize the microscopic quantum dynamics approach introduced by Köhler and Burnett to compute the time evolution of the condensate wavefunction as well as the amount of quantum excitations and depletion. Applying this method to flows of ultracold bosonic atoms through quasi 1D waveguides with disorder, we find that the onset of permanently time-dependent scattering of the condensate on the Gross-Pitaevskii level [2,3] corresponds to the appearance of strong depletion of the condensate on the microscopic level.

[1] T. Köhler and K. Burnett, Phys. Rev. A 65, 033601 (2002)
[2] Tobias Paul et al, Phys. Rev. A 72, 063621 (2005)
[3] T. Paul, P. Schlagheck, P. Leboeuf, and N. Pavloff, Phys. Rev. Lett. 98, 210602 (2007)

Q 17.7 Di 12:00 VMP 6 HS-A

Critical velocity of a Bose-Einstein condensate in presence of disorder — •Tobias Paul[1] and Mathias Albert[2] — [1]Institut für Theoretische Physik, Universität Heidelberg — [2]Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris Sud, Orsay

We investigate the breakdown and the critical velocity of the superfluid motion of a quasi-one-dimensional Bose-Einstein condensate in presence of disordered potentials. We present an analytical approach that relates the critical velocity beyond which the superflow breaks down with the statistical properties of the disorder potential. In particular, we study a) smoothly varying disordered potentials like the experimentally relevant case of an optical speckle potential, b) disordered potentials which consists of a series of individual scatterers. We compare our analytical results to full numerical computations which simulate the flow of the condensate through the disordered region.

Q 17.8 Di 12:15 VMP 6 HS-A

Speed of Sound in Interacting Disordered Bose-Einstein Condensates — •Nina Renner, Christopher Gaul, and Cord A. Müller — Physikalisches Institut, Universität Bayreuth, Germany

Elementary excitations of interacting Bose-Einstein condensates are sound-wave like at low energies. The dispersion relation of these excitations is changed by an external disorder potential, for which we consider spatially correlated Gaussian and speckle potentials. To begin with we treat the many-particle Hamiltonian in the Gross-Pitaevskii mean-field framework. After performing a saddle-point expansion of the energy functional followed by a Bogoliubov transformation we arrive at the Bogoliubov Hamiltonian [1]. Its self energy in the disorder-averaged effective medium describes the correction to the dispersion relation and notably to the speed of sound. In several limiting cases for 1D propagation we find very simple analytical expressions for these corrections. Our analytical results agree with numerical simulations of the propagation of sound waves.

[1] C. Gaul and C. A. Müller, Europhys. Lett. **83**, 10006 (2008)