

Q 17: Quantengase (Bosonische Gitter I)

Zeit: Dienstag 10:30–12:30

Raum: 6J

Q 17.1 Di 10:30 6J

Sweeping from the Superfluid to the Mott Phase in the Bose-Hubbard Model — ●MICHAEL UHLMANN¹, RALF SCHÜTZHOLD¹, YAN XU¹, and UWE FISCHER² — ¹Institut für Theoretische Physik, TU Dresden — ²Institut für Theoretische Physik, Eberhard-Karls-Universität Tübingen

We study the sweep through the quantum phase transition from the superfluid to the Mott state for the Bose-Hubbard model with a time-dependent tunneling rate $J(t)$. In the experimentally relevant case of exponential decay $J(t) \propto e^{-\gamma t}$, an adapted mean-field expansion for large fillings n yields a scaling solution for the fluctuations. This enables us to analytically calculate the evolution of the number and phase variations (on-site) and correlations (off-site) for slow ($\gamma \ll \mu$), intermediate, and fast (non-adiabatic $\gamma \gg \mu$) sweeps, where μ is the chemical potential. Finally, we derive the dynamic decay of the off-diagonal long-range order as well as the temporal shrinkage of the superfluid fraction in a persistent ring-current setup.

Q 17.2 Di 10:45 6J

Phase-dependent Landau-Zener effect in asymmetric optical lattices — ●TOBIAS SALGER^{1,2}, GUNNAR RITT^{1,2}, CARSTEN GECKELER^{1,2}, SEBASTIAN KLING^{1,2}, and MARTIN WEITZ^{1,2} — ¹Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — ²Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

We report experimental results on transport properties of Bose-Einstein condensates in periodic optical potentials of variable asymmetry. By studying the Landau-Zener effect and Bloch oscillations, we have explored the band structure of both ratchet-type asymmetric and symmetric optical potentials. In earlier work, quantum transport in “conventional” sinusoidal lattices has proven to be a powerful technique for characterisation of the band structure. To realize lattice potentials of variable asymmetry, we superimpose the conventional lattice potential of $\lambda/2$ spatial periodicity with a fourth-order optical potential of $\lambda/4$ spatial periodicity. The high periodicity lattice is realized using dispersive properties of multiphoton Raman transitions¹. To study quantum transport in such Fourier-synthesized lattice potentials the periodic potential is accelerated. We find that the Landau-Zener tunneling rate between the first and the second excited Bloch band critically depends on the relative phase between the two spatial lattice harmonics. Our experimental results are in agreement with theoretical calculations.

¹G. Ritt et al., PRA (in press).

Q 17.3 Di 11:00 6J

Semiclassical quantization of an N-particle Bose-Hubbard model — ●EVA-MARIA GRAEFE and HANS-JÜRGEN KORSCH — Fachbereich Physik Technische Universität Kaiserslautern

We study an N -particle two-mode Bose-Hubbard system, modelling a Bose-Einstein condensate in a double-well potential. We investigate the correspondence of a full many particle description and a mean-field-approximation, which is often called ‘classical’. Furthermore we introduce a semiclassical approximation based on the classical mean-field Gross-Pitaevskii equation, which is expected to be valid for large N . By using a WKB-type quantization condition we reconstruct the quantum properties of the N -particle system approximately from the mean-field dynamics. The resulting eigenvalues are found to be in very good agreement with the exact ones, even for small values of N .

Q 17.4 Di 11:15 6J

Kicked Bose-Hubbard systems and kicked tops – destruction and stimulation of tunneling — ●MARTIN P. STRZYS, EVA-MARIA GRAEFE, and HANS-JÜRGEN KORSCH — Fachbereich Physik, Technische Universität Kaiserslautern

In the two-mode approximation Bose-Einstein condensates (BEC) in a double-well potential can be described by a many particle Hamiltonian of Bose-Hubbard type. We focus on such a BEC whose interatomic interaction strength is modulated periodically with δ -kicks. This system in fact represents a model of a kicked top. The mean-field dynamics

provide a rich mixed phase space with regular and chaotic regions. By increasing the kick-strength a bifurcation leads to the appearance of self-trapping states localized in regular islands. This self-trapping is also found for the many particle system, however in general suppressed by tunneling oscillations. We show that the tunneling time can be calculated from the quasi-energy splitting of the corresponding Floquet states. By varying the kick-strength these quasi-energy levels undergo both avoided and even real crossings. Using this fact stimulation or actually complete destruction of tunneling can be achieved for this many particle system.

Q 17.5 Di 11:30 6J

Bloch-Oscillations Instability of a Bose-Einstein Condensate in an Optical Lattice — ANDREY KOLOVSKY^{1,2}, ●MING-CHIANG CHUNG¹, and ANDREAS BUCHLEITNER¹ — ¹Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden — ²Kirensky Institute of Physics, Ru-660036 Krasnoyarsk

We consider ultracold atoms prepared in the superfluid state, loaded into a 3D optical lattice, and exposed to a linear force, e.g., gravitation. If the linear force is large enough, it localizes the condensate in a 2D plane transverse to the gravitational field, what reduces the microscopic 3-D problem to a 1-D mean field problem. We derive the phase diagram for the quantum dynamics under these conditions, which exhibits a transition from stable to unstable Bloch oscillations. In the unstable regime, the Bloch oscillations decay irreversibly, while they persist in the stable regime.

Q 17.6 Di 11:45 6J

Quenching, relaxation, and a central limit theorem for quantum lattice systems — CHRISTOPHER DAWSON^{1,2}, TOBIAS OSBORNE³, JENS EISERT^{1,2}, and ●MARCUS CRAMER⁴ — ¹QOLS, Blackett Laboratory, Imperial College London, Exhibition Road, London, SW7 2BW, UK — ²Institute for Mathematical Sciences, Imperial College London, Exhibition Road, London, SW7 2BW, UK — ³Department of Mathematics, Royal Holloway University of London, Egham, Surrey TW20 0EX, United Kingdom — ⁴Institut für Physik, Universität Potsdam, Am Neuen Palais 10, D-14469 Potsdam, Germany

A folk conjecture in the study of interacting quantum systems says that, independent of initial state, the system will tend to equilibrate. In this work we study a setting where relaxation to a steady state is exact, namely for the Bose-Hubbard model where the system is quenched from a Mott phase to the strong superfluid regime. We find that the evolving state locally relaxes to a steady state with maximum entropy constrained by the initial local energy. Remarkably, this relaxation is true for all large times, and no time average is necessary to obtain relaxation. Our argument makes use of a non-commutative central limit theorem for harmonic systems. Additionally, we show that for large finite blocks the system will also relax, but not to the thermal state of the new Hamiltonian. We outline generalisations to spin systems, sketch implications for the foundations of quantum statistical mechanics, and discuss signatures of relaxation in the experimental context of cold atoms in optical lattices.

Q 17.7 Di 12:00 6J

Cold atom dynamics in a quantum optical lattice potential — ●CHRISTOPH MASCHLER and HELMUT RITSCH — Universität Innsbruck, Institut für theoretische Physik, Technikerstraße 25, 6020 Innsbruck

We study a generalized cold atom Bose Hubbard model, where the periodic optical potential is formed by a cavity field with quantum properties. On the one hand the common coupling of all atoms to the same mode introduces cavity mediated long range atom-atom interactions and on the other hand atomic backaction on the field introduces atom-field entanglement. This modifies the properties of the associated quantum phase transitions and allows for new correlated atom-field states including superposition of different atomic quantum phases. After deriving an approximative Hamiltonian including the new long range interaction terms we exhibit central physical phenomena at generic configurations of few atoms in few wells. We find strong modifications

of population fluctuations and next-nearest neighbor correlations near the phase transition point.

Q 17.8 Di 12:15 6J

Visibility of Atomic Cloud Released from Optical Lattice

— •ALEXANDER HOFFMANN¹, KONSTANTIN KRUTITSKY², and AXEL PELSTER² — ¹Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — ²Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We present an analytical calculation for the interference pattern of an atomic cloud which expands from an optical lattice. To this end we work out a variational approach which considers quantum fluctuations beyond the mean-field level for finite temperatures. The resulting visibility of the interference pattern indicates both short-range and long-range coherence in the Mott insulator and the superfluid regime, respectively. Furthermore, we account for inhomogeneity effects, which arise from an overall harmonic trap.