A 20: Atomic Systems in External Fields II

Zeit: Donnerstag 11:30–13:15 Raum: 6G

Hauptvortrag A 20.1 Do 11:30 6G

Controlling Ultracold Rydberg Atoms in the Quantum Regime — •Igor Lesanovsky — Institut für Quantenoptik und Quanteninformation, Universität Innsbruck, Austria

Controlling the external quantum state of ultracold ground state atoms by means of magnetic fields is nowadays a well-established experimental technique. Even in steep magnetic traps the inhomogeneous field varies on scales much larger than the extension of an atom. Hence, atoms can be regarded as point-particles exposed to a quasi-homogeneous field. For Rydberg atoms whose size can be of the order of micrometers this is no longer the case and consequently the internal atomic structure must be taken into account. Therefore it is difficult to make a priori predictions on whether trapping is possible or not. By solving the Schrödinger equation we demonstrate that bound states of the center of mass motion of Rydberg atoms exist in standard magnetic traps. We illuminate a novel class of states where the extension of the electronic Rydberg wave function becomes equal to or even exceeds the size of the center of mass state and outline a way to generate a low-dimensional ultracold Rydberg gas.

[1] I. Lesanovsky and P. Schmelcher, PRL 95, 053001 (2005)
[2] I. Lesanovsky and P. Schmelcher, PRA 72, 053410 (2005)
[3] B. Hezel, I. Lesanovsky and P. Schmelcher, PRL 97, 223001 (2006)

A 20.2 Do 12:00 6G

Evidence for laser-induced relaxation in metastability exchange (ME) optical pumping (OP) of ^{3}He — •Marion Batz[1], Werner Heil[1], Pierre-Jean Nacher[2], and Geneviève Tastevin[2] — [1]Universität Mainz — [2]Laboratoire Kastler Brossel, Paris

To understand current limitations of ^{3}He MEOP, we perform systematic studies of 2^3S-2^3P$_0$ pumping below 30mT. Experimentally, the time evolution of the nuclear polarisation M is monitored as a function of gas pressure (0.65-2.6 mbar), discharge intensity, power (0-5W) and tuning of the pump laser. An OP model is used to compute the laser-driven 2^3S and 2^3P populations and the evolution of M under combined OP, ME, and relaxation processes. Pump absorption and M growth rates measured at M=0 provide accurate relaxation-independent data to quantitatively validate the model. During M build-up, however, experimental growth rates decrease faster than expected, and systematically lower steady-state Ms are measured. To account for this, relaxation rates must be used in the model that exceed those measured in the plasma (pump off) by up to two orders in magnitude. The required additional relaxation rates are found to be proportional to the absorbed laser powers. We can directly measure the actual relaxation rates for C_8 pumping (2^3S, F=1/2 - 2^3P$_0$), the net loss of angular momentum being simply equal to the difference between the deposited one (absorbed power) and the stored one (M growth) for single-component excitation. Potential contribution of laser-enhanced relaxation processes, such as radiation trapping or collisions with metastable He_2^* molecules (more likely formed from 2^3P states), will be investigated.

A 20.3 Do 12:15 6G

A control of creating narrow wave packet via atom scattering by a chirped standing light wave — •Maxim A. Efremov[1,4], Mikhail V. Fedorov[1], Valeri P. Yakovlev[2], Markus K. Oberthaler[3], and Wolfgang P. Schleich[4] — [1]General Physics Institute, RAS, Moscow, Russia — [2]Moscow Engineering Physics Institute (State University), Moscow, Russia — [3]Kirchhoff-Institut für Physik, Universität Heidelberg, Heidelberg, Germany — [4]Institut für Quantenphysik, Universität Ulm, Ulm, Germany

We investigate the formation of narrow wave packets in the process of atomic scattering at a resonant standing light wave. One way to provide such a narrowing effect was described theoretically in our earlier works [1] and confirmed successfully by Stützle et al. [2]. Here we suggest and describe an alternative approach: we consider a chopped standing light wave and the intra-atomic excitation due to the adiabatic inversion of levels. Because of the intimate connection between the internal and external variables of atomic motion the adiabatic passing results in the formation of narrow atomic wave packets. The method provides an easy control of three important parameters: (i) the position of creation, (ii) the time interval, during which the absorption process plays a crucial role, and (iii) the final size of the wave packet. All of these parameters are determined only by the chirped pulse parameters.

[1] M.A. Efremov et al., Laser Phys. 13, 995 (2003); M.V. Fedorov et al., JETP 97, 522 (2003).
[2] R. Stützle et al., Phys. Rev. Lett. 95, 110405 (2005).

A 20.4 Do 12:30 6G

Noise induced ionization and dissociation of diatomic molecules — •Anatole Kenfack[1], Frank Grossmann[2], and Jan-Michael Rost[1] — [1]Max-Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]Institute for Theoretical Physics, Dresden University of Technology, D-01062 Dresden, Germany

A quantum system can efficiently absorb energy from a noise source. We have demonstrated this effect in the noise induced dissociation of polar diatomic molecules[1]. In a second step we investigate, beyond the Born-Oppenheimer approximation, the competition between ionization and dissociation of the Hydrogen molecular ion (H2+) exposed to the same noise of source. The time dependent Schroedinger equation is solved for a three dimensional H2+ system with two electronic and one vibrational degrees of freedom. We show that by appropriately choosing the noise kicking period, with respect to other time scales of the system, one can selectively ionize or dissociate H2+. This selectivity is difficult to achieve with the use of laser fields [2,3].

[1] A. Kenfack and J.M. Rost, J. Chem. Phys. 123, 204322 (2005)
[2] S. Chelkowski, A. Bandrauk, and P.B. Corkum, Phys. Rev. Lett. 65, 2355 (1990)
[3] J. H. Kim, W. K. Liu, F. R. W. McCourt and J. M. Yuan, J. Chem. Phys. 112, 1757 (2000)

A 20.5 Do 12:45 6G

Time-dependent density functional theory: Causality and other problems — •Michael Ruggenthaler and Dieter Bauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

Time-dependent density functional theory (TDDFT) is a reformulation of the time dependent many-body problem in quantum mechanics which is capable of reducing the computational cost to calculate, e.g., strongly driven many-electron systems enormously. Recent developments were able to overcome fundamental problems associated with ionization processes [1,2]. Still vital issues have to be clarified. Besides the construction of the underlying functionals we investigate the causality problem of TDDFT by general considerations and by studying a exactly solvable system of two correlated electrons in an intense laser-pulse. For the latter system, the two alternative approaches to the construction of the action functional or a constrained functional derivative by van Leeuwen [3] and Gál [4], respectively, are explored.

[1] M. Lein and S. Kümmel, Phys. Rev. Lett. **94**, 143003 (2005).
[2] F. Wilken and D. Bauer, Phys. Rev. Lett. **97**, 203001 (2006).
[3] R. van Leeuwen, J. Mod. Phys. **15**, 1969 (2001).
[4] T. Gál, J. Phys. A: Math. Gen. **35**, 5899 (2002).

A 20.6 Do 13:00 6G

Plasma-Satelliten aufgrund von evaneszenten Wellen und Langmuir-Oszillationen in der Hohlkathode — •Johannes Hildebrandt — GISES GmbH, Gesellschaft für Informationssysteme, Engineering und Service, D-45527 Hattingen

Die Messung von Plasma-Oszillationen über den HF Stark-Effekt wurde bereits 1961 von Baranger und Mozer vorgeschlagen. Hildebrandt und Kunze gelang 1980 der erste Nachweis von Plasma-Satelliten einer verbotenen Komponente im optischen Spektrum der He I Linie bei 447 nm (Phys.Rev.Lett. 45, 183 (1980)). Erst kürzlich konnten die genauen Vorgänge in der verwendeten Hohlkathodenquelle im Detail analysiert werden (J. Hildebrandt, J.Phys.D 39, 3625 (2006)). Die zugehörige 2-Quanten-Theorie ist intensiv diskutiert worden (E. Oks, Plasma Spectroscopy, V. 9 (Springer; Berlin 1995)), und dieser Vortrag stellt eine Antwort auf die dort erhobenen Einwände dar. Beide Ansätze, sowohl die Dirac'sche Störungstheorie mit sich langsam entwickelnden Zustandsvektoren, als auch die Multi-Satellitentheorie von Hicks, Hess und Cooper (Phys. Rev. A 5, 490 (1972)) mit schnell drehenden Entwicklungstermen bei der Feldfrequenz, werden über passende Koeffizienten in der zeitabhängigen Schrödingergleichung miteinander vereint. Damit ist die Analogie zum Matrixprodukt (J. Hildebrandt, Opt.Lett.

10, 541 (1985)) bei niedrigen Feldstärken hergestellt. Als wichtigstes Ergebnis wird eine Schwellwert-Feldstärke vorgestellt, ab der auch longitudinale Felder über ein definiertes dielektrisches Modenvolumen erfasst werden. Es wird ein Bezug zu aktuellen Messungen hergestellt (N. C. Woolsey et al, JQSRT 99, 680 (2006)).