A 2: Atomic systems in external fields I

Time: Monday 10:30–12:15 Location: V57.05

A 2.1 Mon 10:30 V57.05

Parity Violation in Hydrogen — •Martin-Isbjörn Trappe, Thomas Gasenzer, and Otto Nachtmann — Institute for Theoretical Physics, University of Heidelberg

We discuss the propagation of hydrogen atoms in static electric and magnetic fields in a longitudinal atomic beam spin echo (lABSE) Interferometer. The atoms acquire geometric (Berry) phases that exhibit a manifestation of parity-(P-)violation effects arising from electroweak Z-boson exchange between electron and nucleus. We provide analytical as well as numerical calculations of the behaviour of the metastable n=2 states of hydrogen. We are able to systematically search for Berry phases with tailored properties. Besides maximizing P-violating geometric phases emerging for the respective states we also find the possibility to modify their decay rates, nearly at the order of a percent, solely through P-conserving geometric phases.

A 2.2 Mon 10:45 V57.05

Ionisation Dynamics and Ion Heating Processes of low-Z Ions in EBIS/T — •Erik Ritter and Günter Zschornack — Institute of Solid State Physics, Technische Universität Dresden, Germany

In the past 40 years, EBIS/T were primarily used in basic research to produce highly charged heavy ions. Hence the production of low-Z ions in EBIS/T has not been well investigated. It is well known, that there exist some difficulties in the physics of low-Z ion production, which have to be covered for the optimal operation conditions of EBIS/T systems. The interest in producing low-Z ions in EBIS/T permanently increase because, EBIS/T are expected to be an alternative approach for the ion production in medical particle therapy facilities.

This work presents investigations on the ionisation dynamics of H^+ and H_2^+ ions but can also be applied for other low-Z ions. The ion losses from the ion trap are dominated by energy transfer processes of the produced low-Z ions from residual gas ions or heating by the electron beam. In order to examine these processes measurements of the ionisation dynamics and the energy spread of the extracted ions were done for different ionisation times/trap times (time resolved ion extraction). Thereby the dependence of fundamental ion source parameters such as gas pressure, electron beam current and electron energies were investigated. The results from a room temperature EBIS (B = 600 mT) and a super conductive EBIS (B = 6 T) are compared for proofing the effects on the electron beam current density.

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A 2.3 Mon 11:00 V57.05

Numerical time-dependent quantum dynamics at relativistic laser intensities — •Heiko Bauke, Matthias Ruf, Frederick Blumenthal, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The quantum dynamics of high intensity laser-matter interactions necessitate a relativistic treatment. The derivation of analytical solutions of the Dirac equation or the Klein-Gordon equation, however, is possible for very few highly symmetric systems only. Many setups of ultrashort laser matter interactions at relativistic intensities require numerical approaches. In this contribution, we survey the challenges of numerical time-dependent relativistic quantum dynamics and present approaches to master these challenges by smart numerical algorithms [1, 2], high-performance implementations on parallel architectures [1, 3] and casting a quantum system's mathematical description by physical insights into a form that is beneficial for numerical methods [4]. Some applications of numerical relativistic time-dependent quantum dynamics will be highlighted.

[1] Matthias Ruf, Heiko Bauke and Christoph H. Keitel, Journal of Computational Physics, **228**, pp. 9092–9106 (2009)
[2] Frederick Blumenthal and Heiko Bauke, Journal of Computational Physics, **231**, pp. 454–464 (2012)
[3] Heiko Bauke and Christoph H. Keitel, Computer Physics Communications, **182**, pp. 2454–2463 (2011)
[4] Heiko Bauke and Christoph H. Keitel, Physical Review E, **80**, article 016706 (2009)

A 2.4 Mon 11:15 V57.05

The time-dependent two-centre Dirac equation: Beyond the monopole approximation — •Sean McConnell[1,2], Anton Artemyev[1,2], Manuel Mai[1,2], and Andrey Surzhykov[1,2] — [1]Universität Heidelberg — [2]GSI, Darmstadt

The realisation of the extreme fields generated by heavy quasi-molecules has been of great interest since at least the early 1970's. As such, solutions to the two-centre time-dependent Dirac equation is of utmost importance. A number of approaches have already been made, particularly by the group of Greiner, using the coupled channel equation, to generate solutions to this challenging theoretical problem. In spite of the progress made in the spherically symmetric coordinate system, solutions to the time-*independent* equation using the coupled channel approach have only been performed for the monopole approximation to the two centre potential. Although the monopole approximation indeed provides very good results for small internuclear distances, its applicability at larger internuclear distances is questionable. Therefore, we present in this contribution, an extension of the work already performed toward the use of higher multipoles in the potential expansion. We have calculated, using the B-Spline method in a dual kinetically balanced basis, cross sections for the collision of two U^{+91} U^{92} atoms. To prove the value of our approach we have also determined cross sections of ionisation using this method with those procured using perturbation theory as implemented elsewhere [1]. Applications to laser assisted collisions will also be discussed.

[1] S R McConnell, J. Phys. B: At., Mol., Phys. **44** (2011) 145204

A 2.5 Mon 11:30 V57.05

Decay of hollow states in time-dependent density functional theory — •Varun Kapoor and Dieter Bauer — Institut für Physik, Wismarsche Str. 43-45, Universität Rostock, Rostock-18051, Germany

Hollow or multiply excited states are inaccessible in time dependent density functional theory (TDDFT) using adiabatic Kohn-Sham potentials. We determine the exact Kohn Sham (KS) potential for doubly excited states in an exactly solvable model Helium atom . The exact single-particle density corresponds to the energetically lowest quasi-stationary state in the exact KS potential. We describe how this exact potential controls the decay by a barrier whose origin is traced back to phase of the exact KS orbital. The potential controls the barrier height and width in order for the density to tunnel out and decay with the same rate as the doubly excited state in the ab initio time-dependent Schrödinger calculation. Instead, adiabatic KS potentials only show direct photoionization but no autoionization. A frequency-dependent linear response kernel would be necessary in order to capture the decay of autoionizing states.

A 2.6 Mon 11:45 V57.05

Observation of local temporal correlations in trapped quantum gases — •Vera Guarrera, Ralf Labouvie, Andreas Vogler, Peter Wurtz, Giovanni Barontini, and Herwig Ott — Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We measure the temporal pair correlation function of a 3-dimensional trapped gas of bosons above and below the critical temperature for Bose-Einstein condensation. The measurement is performed in situ using a local, time-resolved single-atom sensitive probing technique, based on scanning electron microscopy. Third and fourth order correlation functions are also extracted from the same data. We further extend this diagnostics to samples of few 1-dimensional tubes of ultracold bosons in the quasi-condensate and strongly interacting regimes, obtaining, in the second case, clear antibunching signal as a consequence of interaction induced "fermionization". Our results promote temporal correlations as new observables to study the dynamical evolution of ultracold quantum gases.

A 2.7 Mon 12:00 V57.05

^{3}He magnetometer for ultra-sensitive measurements of high magnetic fields — •Anna Nikiel[1,2], Peter Blümler[1], Werner Heil[1], Sergei Karpuk[1], Ernst Otten[1], Andrea Amar[3], Kerstin Münnemann[3], and Maxim Terekhov[4] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]MPI für Polymerforschung, Mainz — [4]Universitätmedizin Mainz

NMR methods are usually used as on-line monitor to measure magnetic fields > 1 Tesla and to trace possible fluctuations. In cases where a very high sensitivity is required an excellent signal to noise ratio (SNR) as well as a long transverse relaxation time T_2^* of the free induction decay (FID) following an NMR excitation is demanded. For example, in Penning trap mass spectroscopy the envisaged resolution of 1 part in 10^{11} or better, requires keeping the magnetic field and its time dependence under control at the same level.

Our approach for an ultra-sensitive measurement of high magnetic fields is to use a gaseous, nuclear spin-polarized ^{3}He spin sample which can reach transverse relaxation times of several seconds, that is far beyond the typical millisecond FID time of a thermally polarized water sample.

We will report on first results obtained in the 1.5 Tesla field of a commercial medical NMR scanner. The ^{3}He gas is spin-polarized in-situ using a new, non-standard variant of Metastability Exchange Optical Pumping (MEOP).