A 3: Atomic systems in external fields I

Time: Monday 11:00–13:00 Location: f303

Invited Talk A 3.1 Mon 11:00 f303

Interaction of atoms and ions with twisted light — •Stephan Fritzsche[1,2], Daniel Seipt[1,2], and Andrey Surzhykov[1] — [1]Helmholtz-Institut Jena, 07743 Jena, Germany — [2]Theoretisch-Physikalisches Institut, Universität Jena, 07743 Jena, Germany

Research on optical vortices, popularly known also as *twisted* light, has attracted much interest during the past two decades. However, while the spin and orbital angular momentum distributions of such light beams have been explored in good detail, little is known so far about their interaction with (clouds of) atoms and how the angular momentum of the light affects the subsequent fluorescence or photoelectron emission. Here, we summarize recent results on the photoexcitation and photoionization of (multi-electron) atoms as obtained within the framework of the density matrix theory. It is shown that the population of the excited atoms, their photon emission as well as the angular distribution of the photoelectrons become sensitive to the transverse momentum and the (projection of the) total angular momentum of the incident radiation, especially if the atoms are localized with regard to the beam (axis).

[1] M. Scholz-Marggraf *et al.*, Phys. Rev. A**90** 013425.
[2] A. Surzhykov *et al.*, Phys. Rev. A**91** 013403.

A 3.2 Mon 11:30 f303

Ab initio 2D computations for quantum reflection from metallic surfaces — •Emanuele Galiffi[1,3], Maarten DeKieviet[2], and Sandro Wimberger[1,4,5] — [1]Institut für Theoretische Physik, Philosophenweg 16, D-69120, Heidelberg, Germany — [2]Physikalisches Institut - Im Neuenheimer Feld 226 69120, Heidelberg, Germany — [3]Department of Physics - Imperial College London, South Kensington Campus London SW7 2AZ, UK — [4]Dipartimento di Fisica e Scienze della Terra - Università degli Studi di Parma, Via G. P. Usberti 7/a, 43124, Italy — [5]INFN, Istituto Nazionale di Fisica Nucleare - Sezione di Milano Bicocca, Gruppo Collegato di Parma, Italy

The numerical study of scattering problems finds a wide range of applications in surface science, and in particular quantum reflection (QR). We present a highly optimised, norm-preserving method to compute QR of slow atoms from metallic surfaces by solving numerically the Time-Dependent Schrödinger Equation in 2D. The aim of our study is to provide a proof of principle that QR from 2D uni-axially periodic potential structures can be investigated in a time-dependent fashion. To this end, the numerical procedures used are presented, as well as comparisons with 1D results for QR from static and oscillating 1D potentials and preliminary results for QR from a truly 2D non-separable potential. This enables the first systematic investigation of atom-surface potentials, where Casimir interactions are relevant, as well as numerical tests on quantum diffraction.

A 3.3 Mon 11:45 f303

Excitonic spectra in high external fields — •Frank Schweiner, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, 70550 Stuttgart, Germany

To understand and interpret excitonic absorption spectra of real semiconductors it is indispensable to incorporate the complete valence-band structure into a quantitative theory. Very recently the zero field splitting of states with different angular momentum quantum number has been investigated for cuprous oxide and successfully explained by effects due to the complexity of the valence band structure [1]. Solving the Schrödinger equation in a complete basis and determining the eigenvalues for high principal quantum numbers, we now want to investigate the spectra in external fields quantitatively.

In a recent preprint [2] quantum chaos and GUE statistics were observed for excitons in high magnetic fields. The GUE statistics has been attributed to the interaction of excitons and phonons. Neglecting the effect of the band structure but considering the movement of the center of mass of the exciton, we also want to solve the corresponding hydrogen-like Schrödinger equation and investigate the effect of phonons on the spectra qualitatively to find out whether GUE statistics appears.

[1] J. Thewes et al, Phys. Rev. Lett. 115, 027402, 2015
[2] M. Aßmann et al, Quantum Chaos of Rydberg excitons, to be published

A 3.4 Mon 12:00 f303

Frequency tunable microwave field imaging with sub-100 μm resolution using atomic vapor cells — •Andrew Horsley, Guan-Xiang Du, and Philipp Treutlein — University of Basel, Switzerland

We have developed a technique for imaging microwave magnetic fields using alkali vapor cells, detecting microwaves through Rabi oscillations driven on atomic hyperfine transitions. This could prove transformative in the design, characterisation, and debugging of microwave devices (e.g. atom chips or ion traps), as there are currently no established microwave imaging techniques. Our technique may also find applications in medical imaging. We have built a high resolution imaging system, whose $50 \times 50 \times 140\,\mu m^3$ spatial resolution, $1\,\mu T/Hz^{1/2}$ sensitivity, and $150\,\mu$m approach distance are now sufficient for charactерising a range of real world devices at fixed microwave frequencies [1].

Frequency tunability is essential for wider applications, however we can only detect microwaves that are resonant with an atomic transition. Our solution is to use a large dc magnetic field to Zeeman shift the hyperfine ground state transitions to any desired frequency. In addition to high resolution images of 6.8 GHz microwave fields, we present results from a proof-of-principle setup, where we have used a 0.8 T solenoid to detect microwaves from 2.3 to 26.4 GHz.

[1] A. Horsley, G.-X. Du and P. Treutlein, *Imaging of Electromagnetic Fields in Alkali Vapor Cells with sub-100 μm Resolution,* New Journal of Physics, 17(11), 112002, (2015)

A 3.5 Mon 12:15 f303

Orbital magnetic flux quantization in hydrogen based on non-relativistic quantum theory with and without external magnetic field — •Wolf-Dieter R. Stein — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, D-14109 Berlin, Germany

An investigation of the quantization of magnetic flux through atomic orbits of the hydrogen atom in non-relativstic quantum theory is presented. In contrast to earlier investigations only an l-dependence of the magnetic flux quantization in units of $h/2e$ is found for the Gordon current contribution in case of vanishing external fields. The spin magnetization current for the ground-state and for the excited-states of hydrogen is considered together with the quantization of their corresponding orbital magnetic fluxes. Application of external magnetic field results in an additional current and hence in an additional magnetic flux, which is taken as the origin of an energy shift. Taking these results, the Zeeman effect is discussed closer on the bases of orbital magnetic flux quantization. For strong magnetic fields the obtained correction behaves differently compared to other models.

A 3.6 Mon 12:30 f303

Progress toward a Global Network of Optical Magnetometers for Exotic research (GNOME) — •Hector Masia-Roig, Arne Wickenbrock, and Samer Afach — Johannes Gutenberg-Universität Mainz

GNOME is a novel experimental scheme which enables the investigation of exotic spin couplings between nuclei and exotic fields generated by astrophysical sources by measuring spin precession. It consist of a network of geographically separated (>100 km), time synchronized and ultrasensitive ($\sim fT/\sqrt{Hz}$) optical magnetometers, each placed in a magnetically shielded environment. This network and similar configurations enables the study of exotic global transient effects.

A specific example of such exotic fields are certain models of axion-like particles which form a network of light pseudoscalar fields permeating the universe.

Here we present an estimation of the experimentally accessible parameter space of such pseudoscalar fields that can be detected within GNOME along with first correlated measurements of long-time run signals will be discussed.

A 3.7 Mon 12:45 f303

Absorption of Laguerre-Gaussian light beam by hydrogen atoms — •Anton Peshkov[1], Andrey Surzhykov[1], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, Germany — [2]Theoretisch-Physikalisches Institut, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany

The family of twisted (or vortex) light beams was actively explored in experiment and theory during the last three decades. These beams possess a well-defined projection of the angular momentum onto their propagation direction. Special attention was paid to the paraxial Laguerre-Gaussian (LG) and nonparaxial Bessel beams. An interaction of atoms with such types of light beams, for instance a photoabsorption process, is thought to be of interest. There was the recent study [1] which have concerned an absorption of Bessel beam by hydrogen atoms. In this contribution we discuss the absorption of LG beam by the hydrogen atoms. The analysis is performed within nonrelativistic first-order perturbation theory. It is shown that the well-known selection rules for atomic magnetic quantum numbers are not valid anymore when atoms absorb a high-order LG mode. In addition, we compare a population of atomic magnetic substates for the transition $1s \to 2p$ with results for an incident Bessel beam obtained in the previous work [1].

[1] H. M. Scholz-Marggraf, S. Fritzsche, V. G. Serbo, A. Afanasev, and A. Surzhykov, Phys. Rev. A 90, 013425 (2014).