A 1: Atomic Systems in External Fields I

Time: Monday 11:00–13:00 Location: KlHS Mathe

Invited Talk A 1.1 Mon 11:00 KlHS Mathe

Spatially dependent polarization spectroscopy with structured light modes — •Riaan Philipp Schmidt[1,2], Richard Aguiar Maduro[3], Anton Peshkov[1,2], Sonja Franke-Arnold[3], and Andrey Surzhykov[1,2,4] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, Germany — [3]School of Physics and Astronomy, University of Glasgow, United Kingdom — [4]Laboratory for Emerging Nanometrology Braunschweig, Germany

During recent years, a number of studies have been performed to investigate the interaction of matter with structured light modes. These studies paved the way for the application of such modes in optical traps and tweezers, classical and quantum communication, as well as atomic magnetometers [1]. In the course of the latter work, it was observed that the transmission of structured-light polarization components through the atomic sample is very sensitive to the frequency of the incident radiation. To provide the theoretical background for polarization spectroscopy with structured beams, we perform calculations in the framework of the density matrix approach and the Liouville-von Neumann equation. For illustration purposes, we apply our general theory to the $5s\,^2S_{1/2}\,(F=3) - 5p\,^2P_{3/2}\,(F=4)$ transition in Rb^{85}. Based on the results of our calculations, we find that the spatially dependent transmission pattern allows for the analysis of laser frequency. This opens up new opportunities for the application of structured light in laser frequency locking schemes.

[1] F. Castellucci et al., PRL 127, 233202 (2021)

Invited Talk A 1.2 Mon 11:30 KlHS Mathe

Circular dichroism in multiphoton ionization of resonantly excited helium ions near channel closing — •Niclas Wieland[1], Rene Wagner[1], Markus Ilchen[1], Nicolas Douguet[2], Philipp Schmidt[3], Klaus Bartschat[4], and Michael Meyer[3] — [1]Department of Physics, Universität Hamburg — [2]Department of Physics, University of Central Florida — [3]European X-Ray Free-Electron Laser Facility — [4]Department of Physics and Astronomy, Drake University

Circulardichroism (CD) in photoionization experiments offers a unique window into the dynamics of light-matter interaction, enabling the study of symmetry, resonances, and transient states of matter. In this talk, I will present our investigation of the CD of photoelectrons generated by near-infrared (NIR) laser pulses through multiphoton ionization of excited He^+ ions in the 3p (m = +1) state, prepared by circularly polarized extreme ultraviolet (XUV) pulses. By comparing co- and counter-rotating NIR pulse configurations relative to the XUV polarization, we observe a complex dependence of CD on the laser intensity and polarization. These effects are linked to Freeman resonances, selectively influenced by dichroic AC-Stark shifts, which alter the photoionization pathways.

Through experimental results and numerical simulations based on the time-dependent Schrödinger equation, we identify the mechanisms driving this variation in CD. Our findings emphasize the role of intermediate resonances in steering photoionization dynamics and highlight He^+ as a benchmark system for exploring fundamental dichroic effects.

A 1.3 Mon 12:00 KlHS Mathe

Can Atoms Learn How to Read? — •Maurice Beringuier[1,2] and Thomas Pfeifer[1,2] — [1]Max Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Universität Heidelberg, Grabengasse 1, 69117 Heidelberg

Motivated by the potential speed gains of using physical systems for computations we investigate the ability of atomic systems to perform machine-learning tasks.

As in the previous work of Pfeifer et al. (2024, New J. Phys. 26 093018), data and tunable weights are introduced to a simulated atom via the spectral phases of time-dependent electric fields. We compare gradient-free optimization methods and the use of differentiable simulators in their effectiveness to train atoms on the textbook task of recognizing handwritten digits.

We analyze the influence of physical parameters such as the amplitude of the electric field and the level structure of the atoms on its performance on the task.

We identify different phases in the parameter landscape, characterized by the (in-)ability of the atom to learn and correlate these phases with measures that quantify vulnerability to overfitting.

A 1.4 Mon 12:15 KlHS Mathe

Fluctuation-induced Bistability of Fermionic Atoms Coupled to a Dissipative Cavity — •Luisa Tolle[1], Ameneh Sheikhan[1], Thierry Giamarchi[2], Corinna Kollath[1], and Catalin-Mihai Halati[2] — [1]Physikalisches Institut, University of Bonn, Germany — [2]DQMP, University of Geneva, Switzerland

We investigate the steady state phase diagram of fermionic atoms subjected to an optical lattice and coupled to a high finesse optical cavity with photon losses. The coupling between the atoms and the cavity field is induced by a transverse pump beam. Taking fluctuations around the mean-field solutions into account, we find that a transition to a self-organized phase takes place at a critical value of the pump strength.

In the self-organized phase the cavity field takes a finite expectation value and the atoms show a modulation in the density.

Surprisingly, at even larger pump strengths two self-organized stable solutions of the cavity field and the atoms occur, signaling the presence of a bistability. We show that the bistable behavior is induced by the atoms-cavity fluctuations and is not captured by the the mean-field approach.

A 1.5 Mon 12:30 KlHS Mathe

Novel Hilbert-space approach to mixed classical-quantum systems — •Sebastian Ulbricht[1,2], Marcel Reginatto[2], and Andrés Darío Bermúdez Manjarres[3] — [1]Institut für Mathematische Physik, Technische Universit* at Braunschweig, Mendelssohnstraße 3, 38106 Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt PTB, Bundesallee 100, 38116 Braunschweig, Germany — [3]Universidad Distrital Francisco José de Caldas, Cra. 7 No. 40B-53, Bogotá, Colombia

In a mixed classical-quantum system, one part of a physical system is described by quantum theory, while the other part is treated classically. Such hybrid theories are effective to approximate large quantum systems, for instance in the field of quantum many-body calculations or in quantum chemistry. In addition, they can be utilized to investigate whether quantum systems interacting via classical fields, such as classical gravity, can be realized in nature. In this talk, a Hilbert-space formalism for classical particles and its consistent extension to hybrid systems is presented. In our recent publication [1], we show that this novel approach is not equivalent to other approaches to mixed classical-quantum systems, especially regarding quantum systems interacting via a classical mediator. This finding has important implications for the applicability of no-go theorems addressing the issue of whether gravity must be quantized.

[1] A.D. Bermúdez Manjarres, M. Reginatto, and S. Ulbricht, Eur. Phys. J. Plus 139, 780 (2024)

A 1.6 Mon 12:45 KlHS Mathe

Comment on the Sommerfeld Fine Structure Constant tension — •Manfred Geilhaupt — University of Applied Sciences HS Niederrhein

In todays physics, the fine-structure constant (alpha) is a fundamental physical constant which quantifies the strength of the electromagnetic interaction between elementary charged particles. The constant alpha was introduced in 1916 by Arnold Sommerfeld. However, alpha still is an unsolved theoretical and even experimental physical problem up to now! Alpha from atomic interferometric experiments shows a large difference compared to their high accuracy:

1. 2018 Parker et al. 1/137.035999046(27), atomic interferometer experiment Science* 13 Apr 2018:Vol. 360, Issue 6385, pp. 191-195

2. 2020 Morel et al. 1/137.035999206(11), atomic interferometer experiment Nature 588, 61*65 (2020)

3. 2018 Codata 1/137.035999084(15), quantum hall experiment. The 2011 last experimental von Klitzing constant RK=25812.807442(30)Ohm accuracy can be increased by an order of magnitude today. https://doi.org/10.1098/rsta.2011.0198

4. 2019 form Codata given alphaC= 1/137.035999177(21) 2019 from Codata given alphaRKC=1/137.035999127 based on RKC= 25812.807450(00)Ohm (exact defined) does not match. The presenta-

tion contains two answers to the question about tension. (A. Einstein: Ein Problem kann man nicht mit der Denkweise lösen, durch das es entstanden ist.)