A 17: Atoms in external fields

Time: Monday 16:15–17:45 Location: K 2.019

A 17.1 Mon 16:15 K 2.019

Observation of the motional Stark effect in low magnetic fields — •Manuel Kaiser[1], Jens Grimmel[1], Lara Torralbo-Campo[1], Florian Karlewski[1], Nils Schopohl[2], and József Fortágh[1] — [1]Center for Quantum Science, Physikalisches Institut, Universität Tübingen, Germany — [2]Center for Quantum Science, Institut für Theoretische Physik, Universität Tübingen, Germany

The motional Stark effect (MSE) originates from a Lorentz force acting in opposite directions on the ionic core and the electrons of an atom moving in a magnetic field. This introduces a coupling between the internal dynamics and the center-of-mass motion of the atom which is therefore no longer a constant of motion. Approximately the MSE can be seen as a Stark effect resulting from an electric field in the frame of a moving atom. We measured this motional Stark shift on ^{87}Rb Rydberg atoms moving in low magnetic fields employing a velocity selective spectroscopy method in a vapor cell. For an atom velocity of 400 m/s, a principal quantum number of n = 100, and a magnetic field of 100 G the shifts are on the order of 10 MHz. Our experimental results are supported by numerical calculations based on a diagonalization of the effective Hamiltonian governing the valence electron of ^{87}Rb in the presence of crossed electric and magnetic fields. Furthermore we present our investigations on the velocity associated with the pseudomomentum as a constant of motion, that is supported by our experimental findings.

A 17.2 Mon 16:30 K 2.019

Excitonic Spectra of Giant-Dipole States in Cuprous Oxide — Markus Kurz and •Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23, D-18059 Rostock

Excitons are the quanta of the fundamental optical excitation in semiconductors. Recently, the discovery of highly excited Rydberg excitons in Cuprous Oxide (Cu_2O) and their exposure to external fields have shown a plethora of complex physical phenomena [1]. In atomic physics an exotic species of Rydberg atoms in crossed electric and magnetic fields, so-called giant-dipole atoms, have been predicted for two decades [2]. These exotic objects are characterized by an electron-ionic core separation in the range of several micrometers.

In this work we present the eigenspectra of a novel species of excitons when exposed to crossed electric and magnetic fields. In particular, we present the eigenenergies of giant-dipole excitons in Cu_20 in crossed fields [3]. We calculate the excitonic spectra within several theoretical approaches. We verify that stable bound excitonic giant-dipole states are only possible in the case of strong magnetic fields, as this is the only regime providing sufficiently deep potential wells for their existence. Comparing both analytic as well as numerical calculations we obtain excitonic giant-dipole spectra with level spacings up to 100 μeV.

[1]T. Kazimierczuk *et al.*, Nature (London) **514**, 343 (2014)
[2]O. Dippel, *et al.*, Phys. Rev. A **49**, 4415 (1993)
[3]M. Kurz, *et al.*, Phys. Rev. B **95**, 245205 (2017)

A 17.3 Mon 16:45 K 2.019

Analytic model of a multi-electron atom — •Oleg D Skoromnik[1], Ilya D Feranchuk[2,3,4], Alexander U Leonau[4], and Christoph H Keitel[1] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Atomic Molecular and Optical Physics Research Group, Ton Duc Thang University, 19 Nguyen Huu Tho Str., Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam — [3]Faculty of Applied Sciences, Ton Duc Thang University, 19 Nguyen Huu Tho Str., Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam — [4]Belarusian State University, 4 Nezavisimosty Ave., 220030, Minsk, Belarus

We put forward a fully analytical approximation for the observable characteristics of many-electron atoms, which is obtained via a complete and orthonormal hydrogen-like basis. The basis contains a single-effective charge parameter that is identical for all electrons of a given atom. The completeness of the basis allows us to employ the secondary-quantized representation for the construction of regular perturbation theory, which includes correlation effects and converges fast. The hydrogen-like basis set provides a possibility to perform all summations over intermediate states in closed form, including both the discrete and continuous spectra. We demonstrate that our fully analytical zeroth-order approximation describes the whole spectrum of the system and provides accuracy, which is independent of the number of electrons. Moreover, the second-order perturbation theory results become comparable with those via a multi-configuration Hartree-Fock approach. [1] J. Phys. B 50 245007 (2017) https://doi.org/10.1088/1361-6455/aa92e6

A 17.4 Mon 17:00 K 2.019

Two-electron nondispersive wave packets — •Alejandro Gonzalez Melan and Javier Madroñero Pabon — Physics department, Universidad del Valle, Cali, Colombia

We provide a full characterization of nondispersive two-electron wave packets (NDWP) found in the Floquet spectrum of driven helium. First evidence for the existence of these quantum objects which propagate along periodic trajectories of the classical three-body Coulomb problem without dispersion where provided by large numerical calculations within one- [1] and two-dimensional [2] models. We are able to identify the resonance states that play the fundamental role in the formation of these NDWP which allows us to perform an efficient treatment of the problem in the full three dimensional system.

[1] P. Schlagheck and A. Buchleitner, Eur. Phys. J. D **22**, 401 (2003)
[2] J. Madroñero and A. Buchleitner, Phys. Rev. A **77**, 053402 (2008)

A 17.5 Mon 17:15 K 2.019

Atomic systems in curved spacetime and non-geodesic motion — •Sebastian Ulbricht[1,2], Robert A. Müller[1,2], and Andrey Surzhykov[1,2] — [1]Physikalisch-Technische Bundesanstalt, Germany — [2]Technische Universität Braunschweig, Germany

It is well known, that any kind of external energy density leads to a curvature of spacetime. Due to an increasing number of high precision experiments, the effects of spacetime curvature on quantum systems are widely discussed in modern physics. Spacetime curvature as well as acceleration (non-geodesic motion) are described in the framework of General Relativity. Both of them may influence the properties of extended quantum objects like electron distribution. Treated as a small perturbation these effects lead, for example, to energy level shifts in atomic systems.

In this contribution we discuss the case of an relativistic hydrogen atom placed in the spacetime of homogeneous acceleration g (Rindler spacetime). Up to now, this model has been mostly described using perturbation theory. We present a more general approach for this scenario, going beyond perturbative methods. The energy level shifts for ground state and exited states are investigated. We analyze them for typical values of acceleration, for instance on the surface of the Earth and in the vicinity of a neutron star.

A 17.6 Mon 17:30 K 2.019

Hydrogen Analogs in an anisotropic crystal in magnetic fields — •Javier Madroñero and Victor Loaiza — Physics Department, Universidad del Valle, Cali

An artificial hydrogen atom with an anisotropic effective mass can be realized in some anisotropic crystals, e.g., silicon crystals with low-concentration phosphorus impurities. Here, we use an ab-initio quantum approach for the description of the anisotropic diamagnetic Kepler problem which combines a representation in a Sturmian basis with the method of complex rotation to identify the auto-ionization resonances from which experimental photothermal ionization spectrum can be obtained. We study the fluctuations of the spectrum and explore the possibility of controlling it by the magnetic field.