A 24: Poster – Interaction with VUV and X-ray light

Time: Wednesday 17:00–19:00 Location: Tent

A 24.1 Wed 17:00 Tent

Nuclear resonant scattering at X-ray free electron lasers — •Luis Yagüe Bosch and Jörg Evers — Max-Planck Institut für Kernphysik, Heidelberg, Germany

Forward scattering experiments on resonant Mössbauer nuclei using X-rays delivered by synchrotron radiation facilities are well established and can be fully described by existing quantum optical models. However, recent experiments at the EuXFEL with high spectral flux densities have revealed unexpected "anomalies" in nuclear resonant scattering (NRS) from samples containing ^{57}Fe Mössbauer nuclei. We explore modifications of the quantum optical models to explain the observed discrepancies. This may pave the way for deeper understanding of, and availability of new tools for Mössbauer spectroscopy.

A 24.2 Wed 17:00 Tent

Collective hyperfine splitting in resonant x-rays scattering — •Fabian Richter[1], Lars Bocklage[2], Ralf Röhlsberger[2], Xiangjin Kong[3], and Adriana Pálffy[1] — [1]Julius-Maximilians-Universität Würzburg — [2]Deutsches Elektronen Synchrotron DESY, Hamburg — [3]Fudan University, Shanghai

In an ensemble of identical atoms, cooperative effects like superradiance may alter the decay rates and shift the transition energies from the single-atom value by the so-called collective Lamb shift. While such effects in ensembles of two-level systems are well understood, realistic multi-level systems are more difficult to handle. Mössbauer nuclei in x-ray thin-film cavities are a clean quantum optical system in which the collective Lamb shift has been observed [1].

Here, we present a quantitative study of systems of ^{57}Fe nuclei under the action of an external magnetic field, where a collective contribution to the Zeeman level splitting appears, leading to measurable deviations from the single-atom magnetic hyperfine structure. We have developed a theoretical formalism to describe single-photon superradiance in multi-level systems and have identified three parameter regimes, two of which exhibit measurable deviations in the radiation spectrum compared to the case of single-nucleus magnetic-field-induced splitting [2]. Based on this theoretical framework, we analyze experimental data that show such deviations, which may be consistent with the predicted parameter regimes.

[1] R. Röhlsberger et al., Science 328, 1248 (2010).
[2] X. Kong and A. Pálffy, Phys. Rev. A 96, 033819 (2017).

A 24.3 Wed 17:00 Tent

Nuclear excitation in ^{229}Th using Laguerre-Gauss beams — •Alexander Franz, •Janek Bergmeier, Tobias Kirschbaum, and Adriana Pálffy — Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Twisted light refers to light carrying orbital angular momentum along its direction of propagation. In combination with its spatially inhomogeneous intensity profile, this form of light has been studied in relation to atom-light interaction. As one application, twisted light can be used in quantum metrology to minimize the unwanted light shift in atomic clock transitions [1]. A promising alternative to atomic clocks is a clock based on the ^{229}Th nucleus and its unique 8.4 eV transition [2]. It is thus intriguing to investigate the interaction of thorium with twisted light.

In a first attempt we have described Bessel beams interacting with ^{229}Th for solid-state and ion targets [3]. Here, we build upon that work by considering more realistic Laguerre-Gauss beams. Two aspects are investigated. First, we address the temporal excitation dynamics of a single ion as a function of impact parameter. Second, we model the propagation dynamics and investigate the case of two-pulse driving in a Λ coupling scheme [4]. Thereby we focus on the effects of a Laguerre-Gauss control beam.

[1] R. Lange *et al.*, Phys. Rev. Lett. **129**, 253901 (2022).
[2] C.Zhang *et al.*, Nature **633**, 63-70 (2024).
[3] T. Kirschbaum *et al.*, arXiv: 2404.13023 (2024).
[4] H. R. Hamedi *et al.*, Opt. Lett. **46**, 17, pp.4204-4207 (2021).

A 24.4 Wed 17:00 Tent

Numerical study of IR-laser dressing signatures in coherent diffractive imaging — •Tom von Scheven, Björn Kruse, and Thomas Fennel — Institute of Physics, University of Rostock, Albert-Einstein-Str. 23-24, D-18059 Rostock, Germany

Single-shot coherent diffractive imaging (CDI) enables the capture of a full diffraction image of a nanostructure using a single flash of XUV or X-ray light. The resulting scattering image encodes both the geometry and the optical properties of the target. So far, this method has mainly been employed for ultrafast structural characterization [1]. However, CDI can also be utilized to resolve ultrafast optical property changes caused by e.g. transient excitation from nonlinear scattering [2], or by illumination with a second ultra-short laser pulse.

Here, we explore the expected signatures for the latter case theoretically, where simultaneous exposure to a strong IR field can induce transient optical properties. To this end, the effective optical properties emerging from the laser dressing must be determined and used to describe the resulting scattering process, which we model using the well-known Mie-solution. We extract the effective optical properties from the dipole response of a local quantum description based on an atom-like solution of the time-dependent Schrödinger equation. The identification of the states and processes responsible for these properties and the corresponding features in the diffraction image is performed by a systematic comparison with results for a few-level system.

[1] I. Barke *et al.*, Nat. Commun. **6**, 6187 (2015)
[2] B. Kruse *et al.*, J. Phys.: Photonics **2**, 024007 (2020)

A 24.5 Wed 17:00 Tent

Electron-Photon Coincidence Measurements at Synchrotron Facility MAX IV during TRIBs operation mode — •Johannes Viehmann[1], Niklas Golchert[1], Yusaku Terao[1], Adrian Krone[1], Arno Ehresmann[1], Antti Kivimäki[2], Noelle Walsh[2], and Andreas Hans[1] — [1]Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]MAX IV Laboratory, Lund University, Fotongatan 8, 224 84 Lund, Sweden

Coincidence measurements are an important experimental tool in atomic or molecular physics. Our group has used electron-photon coincidence measurements to investigate rare gas clusters after synchrotron irradiation. More specifically, electron times-of flight and photon counts (UV-VUV) are recorded between two consecutive synchrotron pulses.

However, to employ these coincidence measurements using electron time-of-flight detection techniques at synchrotron facilities requires so-called single bunch operation mode. This mode offers the needed time spacing in between synchrotron excitation pulses. Nevertheless, the lower synchrotron intensities makes this mode unattractive for many users not reliant on this kind of time resolution.

Transverse Resonance Island Buckets (TRIBs) is an operation mode where a pseudo-single bunch in addition to conventional multi bunch is accessible for users by aligning beamline optics to the respective orbitals of the bunches. Here, we present the first results from coincidence measurements during TRIBs operation mode at MAX IV.

A 24.6 Wed 17:00 Tent

Probing few femtosecond dynamics in thin solids using a table top extreme ultraviolet transient absorption spectroscopy — •Monalisa Mallick[1], Tobias Helk[1], Zichen Xie[1], Rudrakant Sollapur[1], Michael Zürch[1,2], and Christian Spielmann[1] — [1]Institute of Optics and Quantum Electronics, Friedrich Schiller University, 07743 Jena, Germany — [2]Department of Chemistry, University of California, Berkeley, 94720, USA

In 2D materials like transition metal dichalcogenides and thin metallic films, nanoscale dimensions strongly affect the processes like carrier and phonon relaxation and scattering timescale. We are developing an extreme ultraviolet (XUV) spectroscopy system which offers element and site-specific sensitivity and high temporal resolution. It employs a pump-probe scheme, where samples are excited by few-cycle near-infrared (NIR) pulses and probed with broadband XUV pulses. Transient absorption changes near the absorption edges of metals or chalcogens are recorded to reveal the underlying few femtosecond-scale dynamics.To generate few-cycle pulses, 40 fs, 800 nm pulses from a commercial Ti:Sapphire laser are compressed using a neon-filled hollow-core fiber (HCF).The dispersion is compensated using dielectric chirped mirrors, achieving pulse durations as short as ~5 fs. These pulses enable broadband XUV generation via high harmonic generation (HHG) in argon gas, producing radiation spanning 30-100 eV. By

employing a recirculating HHG gas, and active beam pointing stabilization at the fiber entrance, the system demonstrates stability for over 12 hours.