Q 29: Quantum Optics and Photonics I

Time: Tuesday 14:00–16:00 Location: K 0.016

Q 29.1 Tue 14:00 K 0.016

From electromagnetically induced transparency to Autler-Townes splitting with x-rays — •Xiangjin Kong[1], Jörg Evers[1], Johann Haber[2], Ralf Röhlsberger[2], and Adriana Pálffy[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Coherent control of light interacting with matter is one of the ultimate goals of optics and quantum physics. The key role is played by resonant interactions, with control often refined within a resonance by the use of a second field coupling to neighboring levels of a multi-level system. This can lead for instance via Fano interference effects to electromagnetically induced transparency (EIT)- the medium is rendered transparent over a narrow spectral window within an absorption line. A different route can be achieved via Autler-Townes splitting (ATS), where a single resonance line is replaced by a doublet structure in the absorption profile by pumping with a strong second field.

Here we investigate the transition between EIT and ATS in the x-ray regime using thin-film x-ray cavities with two layers of resonant nuclei. In such planar cavities, the incidence angle can be used as tunable parameter to observe either of the two processes [1,2]. We use the Akaike Information Criterion [3] to evaluate the experimental data and discern which of the two mechanisms is dominant. Our results confirm the observation of EIT and ATS in thin-film x-ray cavities.

[1] R. Röhlsberger *et al.*, Nature 482, 199 (2012).
[2] J. Haber *et al.*, Nature Photonics 11, 720 (2017).
[3] P. Anisimov *et al.*, Phys. Rev. Lett. 107, 163604 (2011).

Q 29.2 Tue 14:15 K 0.016

Stationary Collective Effects in Polarized Atomic Ensembles induced by off-resonant Probes — •Alexander Roth[1], Kirill Tikhonov[2], and Klemens Hammerer[1] — [1]Institute for Theoretical Physics, Leibniz University Hannover — [2]St. Petersburg State University

We investigate atomic ensembles at room temperature with continuous optical pumping and off-resonant probing, which have previously been used in entanglement generation [1] and quantum back action evasion [2]. We show that the off-resonant probe acting collectively on all atoms induces atom-atom correlations leading to a superradiant behavior in the steady state. These collective effects can be tuned via the angle of linear polarization of the probe and influence relevant parameters such as the polarization and line-width significantly. Our numerical calculations with approximately 10^9 atoms use a new approach to the cumulant expansion allowing us to calculate higher correlation orders, such as the 8-atom cumulant. This new approach applies to a wide class of symmetric master equations and gives access to the reduced density matrix containing multi-atom correlations.

[1] Phys. Rev. Lett. 107, 080503 (2011)
[2] Nature 547, 191-195 (13 July 2017)

Q 29.3 Tue 14:30 K 0.016

Subradiant states in many-body quantum systems for excitation storage — •Jemma Needham[1,2] and Beatriz Olmos[1,2] — [1]Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, University Park, Nottingham, NG7 2RD, UK. — [2]School of Physics and Astronomy, University of Nottingham, University Park, Nottingham, NG7 2RD, UK.

Many-body quantum systems are currently of great interest due to increased developments in quantum computation. We explore the dynamics associated with a 1D chain of atoms excited to low-lying states, limited to a single excitation within the system. The atoms are closely spaced such that the system enters a regime exhibiting collective behaviour. In particular, we are interested in the subradiant state that arises when an atomic chain is initialised with a single excitation at one end and then allowed to evolve. Subradiant states decay very slowly, if at all, and hence this system could find applications as a quantum memory. We derive expressions for long-range coupling between pairs of atoms and collective dissipation that occur due to small atomic spacing. We then develop a protocol to initialise an excited state, and we store the excitation for timescales much longer than those occurring naturally. This protocol allows natural evolution from a relatively simple initial state, into a slowly decaying state which could be utilised in the storage of quantum information. We finally explore the properties of the possible stored states, and gain further understanding on the system's time evolution.

Q 29.4 Tue 14:45 K 0.016

Superlattices by twisted bilayer photonic graphene in photorefractive media — •Matthias Rüschenbaum, Marius Rimmler, Alessandro Zannotti, and Cornelia Denz — Institut für Angewandte Physik and Center for Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

Photonic graphene, characterized by a hexagonal, periodic refractive index modulation, features outstanding light propagation, band structures, and topological effects. From solid state physics it is well-known that two rotationally mismatched graphene monolayers introduce an additional large scale periodicity and thus create graphene superlattices. Such a material leads to the appearance of new physical phenomena that manifests predominantly in its band structure. Especially, the new superlattice potential leads to the formation of Dirac points that are slightly displaced from the Fermi energy. Despite these attractive features, a photonic realization of superlattice graphene is still lacking.

In our contribution, we propose the realization of twisted bilayer photonic graphene superlattices by photo-induced refractive index changes. Our approach is based on reversible two-dimensional photonic lattices created by optical induction, using complex non-diffracting writing beams. The resulting lattices show a transversely modulated refractive index while being invariant in the direction of propagation. Incoherent superposition of two of this lattices enables the realization of superlattice structures providing a platform to optically investigate quantum mechanical and topological effects caused by twisted bilayer graphene.

Q 29.5 Tue 15:00 K 0.016

Solitons and their eigenvalues in the presence of gain and loss. — •Christoph Mahnke, Alexander Hause, and Fedor Mitschke — Universität Rostock, Institut für Physik, Albert-Einstein-Str. 23-24, 18059 Rostock, Germany

Due to the growing demand for data transmission capacity, the concept of fiber-optical solitons as information carriers [1] has regained interest recently [2]. This technique is based on soliton eigenvalues, which are invariants of the Nonlinear Schrödinger equation.

When one considers real-world implementations, power loss is unavoidable and amplification becomes a necessity. Then, the invariance of the soliton eigenvalues is lost. In this case researchers resorted to perturbation techniques [3]. Using the Nonlinear Fourier transform we can characterize solitons in the regime beyond weak gain or loss.

Considering the cases where the initial condition contains zero, one, or two solitons, we can demonstrate that the eigenvalue spectrum, and the soliton number in particular, can change during amplification. We demonstrate how the copropagating linear radiation acts as the energy source for the generation of new solitons. We believe that our results can be helpful for the future design of nonlinear transmission systems.

[1] A. Hasegawa, T. Nyu, J. Lightwave Technol. 11, 395-399 (1993).
[2] S. Turitsyn et al., Optica 4, 307-322 (2017).
[3] A. Hasegawa, Y. Kodama, Opt. Lett. 15, 1443-1445 (1990).

Q 29.6 Tue 15:15 K 0.016

Coherent control and wave mixing in a thin ensemble of silicon vacancy centers in diamond — •Johannes Görlitz[1], Christian Weinzetl[2], Jonas Nils Becker[1,2], Eilon Poem[3], Joshua Nunn[4], and Christoph Becher[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Clarendon Laboratory, University of Oxford, United Kingdom — [3]Weizmann Institute of Science, Rehovot 76100, Israel — [4]University of Bath, Claverton Down, Bath BA2 7AY, United Kingdom

In recent research the silicon vacancy center (SiV) in diamond received significant attention due to its favorable spectral properties such as a narrow zero phonon line (ZPL) and weak phonon side bands. At cryogenic temperatures the SiV reveals its four-line fine structure, related to a level scheme featuring orbital doublets of ground and excited state. These states constitute two optically accessible Lambda-schemes. We recently demonstrated ultrafast all optical coherent control between these orbital states showing the suitability of the SiV for quantum in-

formation processing. Due to its inversion symmetry and the resulting insensitivity to fluctuating environmental fields it is possible to grow dense SiV-ensembles with small inhomogeneous broadening, thus allowing for light matter interactions in the single photon regime. We here present Stimulated Raman adiabatic passage, Raman absorption as well as a stimulated Four Wave Mixing gain process in a dense ensemble of SiV centers. These processes reveal a strong light matter interaction and thereby pave the way for further applications like single photon switches or optically controlled quantum memories.

Q 29.7 Tue 15:30 K 0.016

Bulk-like emission of Silicon Vacancy centers in nanodiamonds after surface treatment — •Andrea Filipovski[1], Lachlan Rogers[2], Ou Wang[1], Valery Davydov[3], Viatcheslav Agafonov[4], Fedor Jelezko[1], and Alexander Kubanek[1] — [1]Institute for Quantum Optics, Ulm University, Ulm, Germany — [2]Macquarie University, Sydney, Austrailia — [3]Russian Academy of Science, Moscow, Russia — [4]Université F. Rabelais, Tours, France

The negatively charged silicon vacancy center in diamond (SiV^-) is a promising candidate for quantum repeaters in solid state, due to its indistinguishable photon emission, high Debye Waller factor and spectral stability[1]. These extraordinary optical properties have only been reported in low-strain bulk diamond[2]. However, SiV^- in NDs which are favorable for integrated quantum systems, suffer from high strain resulting in large spectral instability.

Here we show bulk-like optical behavior of SiV^- in NDs with diameters below 150 nm after H-Plasma treatment. We recover single SiV^- with the typical 4-line fine structure, a high polarisation contrast and an inhomogeneous line width below 150 GHz with long term spectral stability. We developed a strain model consistent with our experimental data infering, for the first time, the zero-field splitting for SiV^- of $47.2^{+0.2}_{-0.3}$ GHz for the ground and 255^{+1}_{-2} GHz excited state. Suprisingly, almost 50% of the investigated SiV^- centers show strain values as low as best values reported for SiV^- in bulk diamond[3].

[1] L. J. Rogers et al, Nat. Comm.5, 2014, [2] A. Dietrich et al, NJP, Vol. 16, 2014, [3] L. J. Rogers et al, in preparation

Q 29.8 Tue 15:45 K 0.016

NV assisted spectroscopy and control of the local paramagnetic spin bath in 15N delta-doped diamond — •Florian Böhm[1], Nikola Sadzak[1], Claudia Widmann[2], Christoph Nebel[2], and Oliver Benson[1] — [1]AG Nanooptik, Humbodt-Universität zu Berlin, Germany — [2]Fraunhofer-Institut für Angewandte Festkörperphysik, Freiburg

The Nitrogen-vacancy (NV) center is amongst the most prominent defects in diamond, i.a. due to it's manipulable electron spin. However, the diamond matrix can also host other 'dark' paramagnetic impurities operating as a local spin bath interacting with the NV centers electron spin, leading to its decoherence [1].

In this work we use single shallow NV centers to investigate the nature and behaviour of the local bath environment in a 15N delta-doped [111] diamond using electron spin resonance (ESR) spectroscopy and probe its dynamics using double spin resonance [2]. By actively controlling the spin bath we can i.a. suppress the dephasing of the NV centers spin and measure the coupling strength between the NV sensor and different Nitrogen symmetry groups.

Our research aims at extending the coherence time of NV centers generated in diamond via implantation or delta-doping of 15N in order to enhance their magnetic field sensitivity.

[1] De Lange, G., et al. (2012). Sci. rep., 2, 382.
[2] Grotz, B., et al. (2011). New Jnl. of Phys., 13(5), 055004.