Q 43: Quantum Technologies

Time: Wednesday 16:30–18:30 Location: P

Q 43.1 Wed 16:30 P

Quantum Imaging of Living Tissues with Magnetic Nanoparticles — •Andre Pointner and Roland Nagy — LEB, FAU Erlangen-Nuremberg, Erlangen, Germany

The fight against cancer is one of the greatest challenges for clinicians, oncologists and researchers in this century. The main goal of cancer therapy is to prevent the tumor cell dissemination. Unfortunately, detecting the movement of individual cancer cells *in vivo* and in real time over an extended period of time has not been achieved so far. A promising solution to the aforementioned problem is the research field of quantum sensing. Quantum sensors such as the NV-Center in diamond are very well established and ready to be applied in the field of biology. We intend to use the outstanding properties of the NV center in diamond as a quantum magnetic field sensor to characterize the invasion potential of cancer cells and to describe how their interaction with immune cells triggers or inhibits proliferation. Therefore, we will selectively attach superparamagnetic iron oxide nanoparticles (SPIONs) to live cancer cells in tissues (200 μm thickness) contained in a life-sustaining incubator. The vector magnetic field generated by the SPIONs is measured by evaluating the spin hamiltonians along the four crystallographic [111] directions through NV centers. We will use optically detected continuous magnetic resonance (CW-ODMR) to measure the magnetic field with a wide-field microscope. A sequence of these measurements will result in magnetic vector images. The overlap of these images will accurately determine the migration of individual cancer cells in the tissue samples.

Q 43.2 Wed 16:30 P

Robust and miniaturized Zerodur based optical and vacuum systems for quantum technology applications — •Sören Boles[1], Jean Pierre Marburger[1], Moritz Mihm[3], André Wenzlawski[1], Ortwin Hellmig[2], Klaus Sengstock[2], and Patrick Windpassinger[1] — [1]Institut für Physik, JGU, Mainz — [2]Institut für Laserphysik, UHH, Hamburg — [3]Centre for Quantum Technologies, National University of Singapore

In the ongoing quantum revolution of science, many current studies aim to bring quantum systems to market maturity, such as quantum computers and quantum sensors. Ongoing efforts attempt to increase the accessibility of such systems, while minimizing size, mass and power requirements. We previously demonstrated the succesful use of stable optical and laser systems based on Zerodur glass ceramic in space borne atom interferometry experiments, e.g. FOKUS, KALEXUS, MAIUS and BECCAL.
Current developments target the usage of Zerodur glass ceramic as a material of choice for highly compact vacuum systems.
On this poster, we present techniques of Zerodur to metal flanges, enabling the manufacturing of accessible, yet mechanically and thermally stable vacuum systems. Furthermore, we report on the ongoing effort of the construction of a passively pumped Zerodur vacuum chamber for quantum sensoric applications, using optical activation of passive pumps and atom dispensers to demonstrate a MOT. With this technology, we aim to lay the foundation for a miniaturized, fully integrated and highly stable Zerodur based quantum system.

Q 43.3 Wed 16:30 P

Machine learning optimal control pulses in an optical quantum memory — •Elizabeth Robertson[1,2], Luisa Esguerra[1], Guillermo Gallego[2,3], and Janik Wolters[1,2,3] — [1]Deutsches Zentrum für Luft- und Raumfahrt, Institute for Optical Sensor Systems, Rutherfordstraße 2, 12489 Berlin, Germany — [2]Technische Universität Berlin, Str. des 17. Junis 135, 10623 Berlin, Germany — [3]Einstein Center Digital Future Robert-Koch-Forum, Wilhelmstraße 67, 10117 Berlin, Germany

Optical quantum memories are key components for quantum communication systems, and improving their storage and retrieval efficiency is key for the adoption of the technology [1]. We present a method for machine learning the shape of the optical control pulses used in a hot cesium vapor EIT memory, to maximize the efficiency [2]. Using a genetic algorithm [4], with genes encoded as weighted coefficients of Legendre polynomials, we generate a variety of waveforms, which are given as input into the memory experiment simulation [3]. The retrieval efficiency evaluated, which serves as the fitness function, and subsequent populations are chosen by tournament selection. In the memory simulation, the optimal efficiency could be improved to be 0.51, starting with 0.12 for a unoptimized gaussian control pulse. We will give an outline of the experimental implementation of the method.

[1] Gündoğan, M., et al., npj Quantum Inf 7, 128 (2021).
[2] Wolters, J., et al., Phys. Rev. Lett. 119, (2017)
[3] Rakher, M., et al., Phys. Rev. A 88, (2013)
[4] Katoch, S.,et al., Multimed Tools Appl 80, (2021).

Q 43.4 Wed 16:30 P

Investigation of a SiV^--ensemble towards a diamond magnetic sensor — •Anna Fuchs and Christoph Becher — Universität des Saarlandes, Saarbrücken 66123, Germany

Quantum sensing promises new opportunities in applied physics and life sciences due to high sensitivity, precision, and high spatial resolution. A possible implementation of a quantum sensor that became well known in recent years is based on NV centers in diamond. Whereas NV center based quantum sensors are based on microwave manipulation of their spin states, the negatively charged group IV-vacancy centers in diamond offer the option of an all-optical, microwave-free coherent control of their spin states. This allows for applications where the use of microwave fields is detrimental or technically challenging.
We here investigate an ensemble of negatively charged silicon-vacancy (SiV^-) centers for its suitability for quantum sensing. To this end we use an experimental implementation based on coherent population trapping where two spin states are coupled to an excited state via two laser fields. To detect small magnetic changes we fix the laser frequency to the steepest slope of the dark-state resonance and detect the Zeeman shift by a change in the absorption signal. We report first experimental results on characterizing our samples for achievable sensitivities.

Q 43.5 Wed 16:30 P

Fabrication of micro 4H-SiC lenses for quantum and photonic applications — •Marina Scharin-Mehlmann[1], Julietta Foerthner[1], Mathias Rommel[1], Christian Gobert[1], Susanne Beuer[1], Patrick Berwian[1], and Roland Nagy[2] — [1]Fraunhofer Institute for Integrated Systems and Device Technology IISB, Schottkystrasse 10, 91058 Erlangen, Germany — [2]Chair of Electron Devices, Friedrich-Alexander-University Erlangen-Nuremberg, Cauerstrasse 6, 91058 Erlangen, Germany

Silicon carbide (4H-SiC) is a very promising material platform for quantum applications and nanophotonics, such as quantum sensing, computation or communication. However, the main drawback of 4H-SiC is its high refractive index, which reduces the collected defect photoluminescence. In our previous work, we showed that lens structures optimized by numerical simulation can have a strong impact on the collection efficiency. Now, in order to increase the total photon collection efficiency, we demonstrate two possible approaches of producing micro lens structures in 4H-SiC. Firstly, we successfully manufacture lens structures by focus ion beam milling. Secondly, we use a scalable method of fabricating 4H-SiC lenses by photolithography and a reflow process in order to create hemispherical droplets, followed by an etching process. We fabricate the optimized simulated lens shape variations for investigating and maximizing collection efficiency.

Q 43.6 Wed 16:30 P

Fabrication of nanostructured van der Waals heterostructures — •Khairi Elyas[1], Hannah C. Nerl[2], Johanna Richter[3], Kirill Bolotin[3], and Katja Höflich[1] — [1]Ferdinand Braun Institut gGmbH, Berlin, Germany — [2]Humboldt Universität zu Berlin, Berlin, Germany — [3]Freie Universität Berlin, Berlin, Germany

Two-dimensional (2D) materials can exhibit a significantly enhanced light-matter interaction making them interesting for highly-confined and low-loss light transport. When combining different 2D materials the corresponding polaritonic modes may hybridize providing the strong localization of plasmonic excitations in combination with the long propagation distances of phonon modes.

Here we report on the fabrication of heterostructures of the (semi)metallic graphene and the wide-bandgap material hexagonal boron (hBN) nitride. The dry-release transfer of graphene and hBN makes use of polydimethylsiloxane(PDMS) and poly(propylene) carbonate (PPC) films. Due to the strong adhesion between PPC and 2D materials at room temperature, we show that single-layer to few-layer graphene as well as few-layer hBN can be produced on a spin coated PPC film/SiO2/Si substrates by mechanical exfoliation. Using He ion beam patterning we further modify the geometry of the heterostructures on the nanoscale with the specific aim to tune hybrid polaritonic modes. The optical properties of the fabricated heterostructures are then mapped using monochromated low-loss scanning transmission electron microscopy (STEM) electron energy-loss spectroscopy (EELS).

Q 43.7 Wed 16:30 P

Argon Trap Trace Analysis: Working principle of the applied Quantum Technology and its dating application in Oman's groundwater — •Florian Meienburg[1,2], Julian Robertz[1], Yannis Arck[2], David Wachs[1,2], Martin Stute[4], AN Paukert Vankeuren[5], Juerg M. Matter[6,4], Markus Oberthaler[1], and Werner Aeschbach[2,3] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute of Environmental Physics, Heidelberg, Germany — [3]Heidelberg Center for the Environment, Heidelberg, Germany — [4]Columbia University, Palisades, USA — [5]California State University Sacramento, Sacramento, USA — [6]University of Southampton, Southampton, UK

Radioisotopes are a widely used and important tool for dating environmental systems. The half-life of 269 years, a constant input function and its chemical inertness render ^{39}Ar a valuable tracer for dating between 50 and 1000 years. This time scale corresponds to processes like ocean circulation, deeper groundwater flow or the flow of alpine glaciers. However, a very small abundance in the range of 10^{-16} requires an ultra-sensitive and highly selective detection method which is achieved by the Quantum Technology Argon Trap Trace Analysis (ArTTA). The slightly different resonance frequencies of the isotopes together with multiple resonant scattering processes allows to detect single ^{39}Ar atoms in a magneto-optical trap (MOT).

In addition to the important features of this spectroscopy technique, the poster will present a groundwater study in the Sultanate of Oman in the context of carbon sequestration as an application of ArTTA.

Q 43.8 Wed 16:30 P

Towards on-chip pump filtering of quantum light sources — •Julian Brockmeier[1], Nina Lange[1], Thomas Hummel[1], Maximilian Protte[1], Viktor Quiring[2], Raimund Ricken[2], Harald Herrmann[2], Christof Eigner[2], Christine Silberhorn[2], and Tim Bartley[1] — [1]Mesoskopische Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Integrierte Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Our goal is the realization of on-chip experiments including spontaneous down-conversion sources (SPDC) and detection by superconducting integrated detectors at cryogenic temperatures. The integration of the source on-chip is realized by using periodically poled lithium niobate waveguides. However, in order to be able to differentiate the created photon pairs from the pump light it is crucial to suppress the latter by at least 100 dB. This must be realized while maintaining low losses for the quantum light. We present approaches towards on-chip pump filtering by utilizing various effects such as wavelength selective routing and reflective coatings. Another key factor is the dispersion of pump and signal due to the different group velocities in the crystal, which can take advantage of with our high-speed response of superconducting integrated detectors.

Q 43.9 Wed 16:30 P

Towards a quantum memory for single photons from semiconductor quantum dots — •Benjamin Maass[1,2,3], Florian Günther[1,2], Luisa Esguerra[1,2], David Becker[1,2], Norman Ewald[1], and Janik Wolters[1,2] — [1]Deutsches Zentrum für Luft- und Raumfahrt, Berlin — [2]Institut für Optik und atomare Physik, Technische Universität Berlin — [3]Optische Systeme, Institut für Physik, Humboldt Universität Berlin

We present our approach to use room temperature cesium vapour as storage medium for single photons from semiconductor quantum dots at the D1 line employing a ladder-type configuration of electromagnetically induced transparency (FLAME[1],ORCA[2]). As first steps towards storage of photons in the collective spin state of the atoms we investigate the initialisation of all atoms in the maximally polarised state $m_f = 4$ of the $F = 4$ hyperfine level of the $6^2S_{1/2}$ groundstate. Two-colour optical pumping with circularly polarised light enables efficient preparation of this individual Zeeman sublevel.

We present our experimental setup and discuss its prospects for storing attenuated laser pulses and even true single photons. We give an outlook on interfacing the memory with a strain tunable semiconductor quantum dot.

[1] R. Finkelstein et.al., Fast, noise-free memory for photon synchronization at room temperature. Sci. Adv. 4,(2018). [2] K. T. Kaczmarek et.al., High-speed noise-free optical quantum memory, Phys. Rev. A 97, 042316 (2018).