POSTER DAY

26 OCTOBER 2021

CHALMERS
UNIVERSITY OF TECHNOLOGY

Excellence Initiative
NANO

Program

From **14.30** Start hanging up posters
15.00 SmallTalks [about Nanoscience] in KA lecture hall (Chemistry building)
15.45 coffee with sweets and wraps
16.00 announcements in KA lecture hall (Chemistry building)
16.20 Posters group A (even numbers in Signes (Physics) and odd numbers in the Chemistry entrance)
17.30 Posters group B (even numbers in Signes (Physics) and odd numbers in the Chemistry entrance)
17.30 More food/dinner
19.00 announcement of poster price in KA lecture hall (Chemistry building)
Until **20.00** mingling

Poster price

The best three posters will be awarded a price which includes up to 10kSEK for traveling to a scientific visit or conference. In the committee you will find David Albinsson, Ingrid Strandberg, Giovanna Tancredi, and Michaela Wenzel. Please prepare a 1-minute pitch to present your poster, since the poster price committee will only have limited time to look at all posters. But also, for starting a discussion with all other people who come to see your poster, such a 1-minute pitch can be very helpful!

Food

Beverages and food will be served in both Signes and in the Chemistry entrance. Coffee and water throughout the event and sweets/pastry and wraps as long as they last. The dinner plate will be served from 17.30 together with beer, wine, and non-alcoholic beverages. It is important that you have your name badge and (if you want wine or beer) your drink tickets.

Wraps with:
Pulled soy, sriracha crème, pickled onion, tomato & romaine lettuce (vegetarian)
Smoked bell pepper marinated chicken, carrots, mango sauce & lettuce
Marinated shrimps, dill cream cheese, fennel, romaine lettuce & spinach

Dinner:
Spinach-baked salmon, potato salad, whipped cream cheese and home-made bread.

SmallTalks [about Nanoscience]:
Magnetic nanoparticles: a multipurpose nanomaterial tool in biology and medicine (lecture hall KA, Chemistry building)

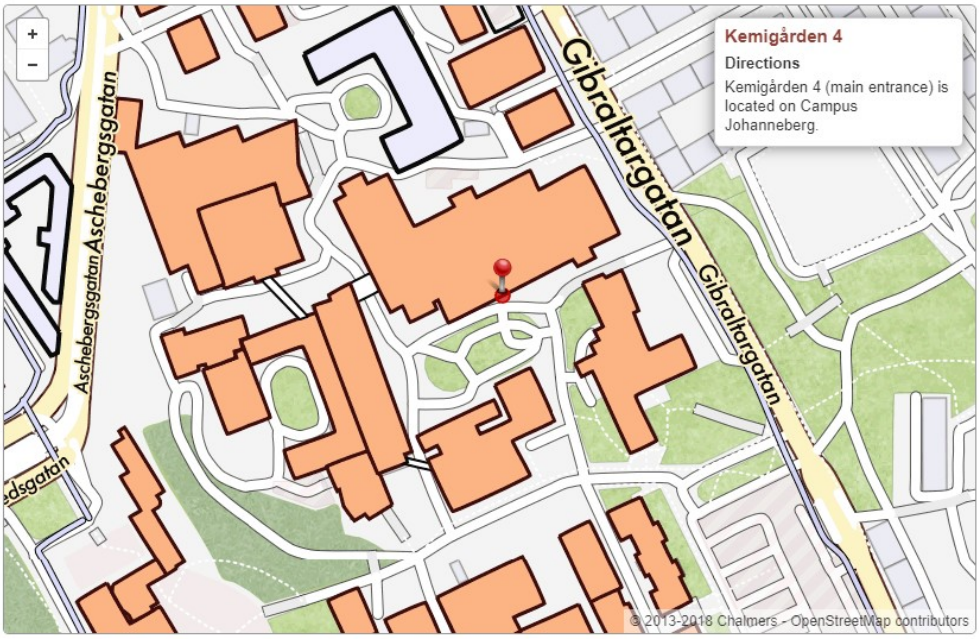
Sobhan Sepehri, sobhan.sepehri@ri.se
Research Institutes of Sweden – RISE AB / Videm AB

Magnetic nanoparticles are widely used in various fields of biology and medicine. By leveraging the magnetic nanoparticles, a range of modern applications within biology and biomedicine has become available. Some application areas are clinically mature, such as diagnostics and imaging while others are interesting pre-clinical research areas such as disease treatment and biomaterial manipulation.

In this talk, I will provide an in-depth introduction on the unique physical and magnetic properties of magnetic nanoparticles. We will see how such properties give particles an edge in biomedical applications. Some recent clinical applications are discussed to highlight these characteristics and the multimodal functioning of the magnetic nanoparticles. Towards the end, we change our focus to the diagnostic applications of magnetic nanoparticles where I describe our own efforts on developing a magnetic nucleic acid assay. Our work has led to a technology-based startup called Videm which seeks to commercialize the assay.

Group A

Even numbers in Signes (Physics) odd numbers in Chemistry entrance.
Presenters will be present 16:20 – 17:20



A.1. Chip-based magnetic levitation of superconducting microparticles for macroscopic quantum experiments

Martí Gutierrez Latorre, PhD student, marti.gutierrez@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

Levitated mechanical resonators have the potential of achieving very low losses, mechanical or otherwise. In addition to very sensitive detection, the low losses would enable long decoherence times when operating in the quantum regime. Thus, magnetic levitation of superconducting microparticles has been proposed as a promising experimental platform in the eld of quantum optomechanics. In this work, the fabrication of chipbased magnetic traps, superconducting microparticles, and chip-based levitation of a superconducting microparticle is demonstrated. The chip-trap consists of a stack of two silicon chips, with one Niobium superconducting coil each. The two coils form an anti Helmholtz-like arrangement, that levitates and traps the particle. Additionally, smaller coils within the trap are used for particle motion detection and manipulation. The detection of the center-of-mass (COM) motion of the levitated particle is to be detected by a SQUID magnetometer connected to the smaller coils. By manipulating the COM motion and coupling it to a qubit, macroscopic quantum states and experimental tests of the principles of quantum mechanics can be achieved. In addition to quantum-enhanced sensing of forces and accelerations.

A.2. Room temperature nonlocal detection of charge-spin interconversion in topological insulator using a heterostructure with graphene spin-valve device

Lars Sjöström, Master student, sjolars@student.chalmers.se
Microtechnology and Nanoscience, Quantum Device Physics

The main goal of spintronics is to utilise the spin degree of freedom for faster and less energy-consuming information technology. Topological insulators are a promising candidate for spin generation and detection in all-electrical spintronics applications, thanks to their strong spin-orbit coupling and non-trivial spin-momentum locking of their topological surface states. Applying a bias current to inducing a net carrier momentum should spontaneously generate a net spin polarization in such a system. The giant charge-spin conversion effects in topological insulators have shown excellent potential for spin-orbit torque switching based ultralow power magnetoresistive random-access memory technology. Although charge-spin interconversion has previously been reported using potentiometric spin measurements, reliable non-local measurements have so far been limited to cryogenic temperatures. Here, we report non-local detection of charge-spin interconversion in the topological insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ at room temperature using a van der Waals heterostructure with graphene in a spin valve device. The observation of both spin-switch and Hanle spin precession signals in the non-local device and detailed bias- and gate-dependent measurements prove the robustness of the charge-spin interconversion effects in topological insulators at room temperature. These findings demonstrate the possibility of using topological insulators to make all-electrical room-temperature spintronics devices for energy-efficient next-generation computing components.

A.3. Molecular Rotational Conformation Controls the Rate of Singlet Fission and Triplet Decay in Pentacene

Rasmus Ringström, PhD student, rasmusr@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

Singlet fission (SF) is a process in which a singlet excited-state molecule interacts with and shares its energy with a ground state molecule, resulting in both molecules ending up as excited triplets. If both triplets could be utilized in a photovoltaic device one incident photon could effectively result in two charge separations and significantly improve the efficiency of such devices.

In this study, three pentacene dimers have been synthesized to investigate the effect of molecular rotation and rotational conformations for SF. In all three pentacene dimers the pentacene units are linked by an ethyne-phenyl-ethyne spacer that provides almost unrestricted rotational freedom between the pentacene- and phenyl-subunits. Substituents on the phenyl spacer adds varying degree of steric hindrance that restricts both the rotation and the equilibrium distribution of different rotational conformers and we have found that the less restricted conformations exhibit faster SF and more rapid subsequent triplet-pair recombination. Further, small shifts in the rotational conformer´s absorption spectrum have been used to selectively excite different conformers and study the subsequent SF. Transient absorption studies at 100 K reveal that the same dimer can have orders of magnitude faster SF in a strongly coupled conformer compared to a more weakly coupled one.

A.4. Novel Toolbox to internally label RNA in vitro and in cellulo

Pauline Pfeiffer, PhD student, paupfe@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

The field of RNA-based therapeutics is evolving very rapidly and requires more native-like and versatile tools to study potential drugs and their action in cells. Fluorescent nucleobase analogues (FBAs) offer unique possibilities to probe nucleic acids while maintaining native interaction patterns when incorporated1. These FBAs have been shown to be excellent substitutes for their corresponding canonical nucleobases when incorporated into short RNA and/or DNA oligos. As nucleoside triphosphates FBAs are accepted as a substrate for enzymatic reactions and hence offer a unique opportunity to act as internal labels of functional nucleic acids. Here we present the unexpectedly efficient and spontaneous cellular uptake of two fluorescent nucleoside triphosphates from the adenine family. The FBAs exhibit significant differences with respect to uptake kinetics, suggesting that divergent internalization mechanisms could be involved. We find that relatively small differences in the molecular structure of the modified nucleobases result in significant differences in the intracellular localization of the FBAs, with one adenine analogue being capable of efficiently entering the nucleus. Following the accumulation in living cells this analogue can be incorporated into RNA in cellulo. Furthermore, we can use the FBA triphosphates to label long native-like RNAs enzymatically in in vitro reactions. Following the successful labeling we aim to formulate and deliver these fluorescent RNAs to human cells and in this way study the uptake process of RNA-based therapeutics. Together, the spontaneous uptake of FBAs with their incorporation into RNA in cellulo, and the in vitro labeling of RNAs offer a novel toolbox to study dynamic aspects of drug delivery and trafficking within living cells.

A.5. Characterizing Membrane Nanodomains in Soil Bacteria and Their Role in Stress Adaptation

Ireny Abdelmesseh Nekhala, PhD student, ireny.nekhala@chalmers.se
Biology and Biological Engineering, Chemical Biology

Bacterial membranes are characterized by distinctly organized domains known as nanodomains, which can be rigid or fluid in nature. Lipid rafts are an example of rigid domains that are thought to play a role in bacterial signal transduction and protein secretion. Recently, regions of increased fluidity (RIFs), a new type of bacterial membrane nanodomain have been identified. We are interested in characterizing RIFs in soil bacteria and evaluating, whether they play a role in stress adaptation. RIFs seem to be involved in the synthesis of the bacterial cell envelope, since disruption of these domains impairs cell wall and lipid synthesis as well as bacterial growth. Moreover, RIFs might be involved in stress adaptation through an association with phage shock proteins, which can contribute to antibiotic resistance. My project aims at characterizing the role of RIFs in cell wall and lipid synthesis, and stress adaptation using relevant microscopy methods and bacterial growth assays. Understanding the role of membrane nanodomains can potentially uncover exciting new applications relevant to ecology, agriculture, and human health.

A.6. The best efficiency of a hot carrier solar cell

Ludovico Tesser, PhD student, tesser@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

When a photon is absorbed by a solar cell it produces an electron-hole pair. By separating these oppositely charged carriers, the solar cell generates power. If the absorbed photon has energy greater than the band gap, one speaks of "hot" carriers. Their excess energy is simply lost, when these hot carriers relax to the lattice temperature. However, this energy could be exploited to improve the performance of solar cells! This is what so-called hot-carrier solar cells aim at, by employing energy filters to extract the hot carriers and harvest their excess energy.

Here, I will present a study on hot carrier solar cells, where the combination of the thermoelectric and the photovoltaic effect plays a central role in the performance of the device.

We find the transmission of the energy filters that maximizes the efficiency of the device for a given power output.

We thereby show that the hot carrier solar cell converts energy into power more efficiently than both the standard Carnot efficiency of a thermoelectric heat engine and the regular solar cell, while keeping the second law of thermodynamics satisfied.

These results are obtained when the carriers are thermally distributed, but we also study the effects of a non-equilibrium carrier distribution, determined by the competition between the generation of hot carriers and the carrier relaxation to the lattice temperature.

A.7. Geometric energy transport in time-dependently driven quantum dots

Juliette Monsel, PostDoc, monsel@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

We study energy pumping in a single-level quantum dot weakly coupled to two electronic reservoirs, when a pair of the setup's parameters are slowly driven. We analyze both a quantum dot with local repulsive, i.e. the usual Coulomb interaction, and as well as with attractive interaction.

We compute analytically the first non-adiabatic correction to the energy current using a geometric approach [1]. We classify the different mechanisms leading to energy pumping and compare them to the case of particle pumping [2].

Interestingly, we find that energy pumping does not require the quantum dot to be in resonance with the Fermi level of one reservoir, in stark contrast to the case of charge pumping. Even more, charge and energy pumping can be complementary, in the sense that for the same pair of driving parameters, they occur in separated areas of the parameter space.

Finally, we identify promising sets of parameters, in which the quantum dot pump can be operated as a heat pump or a refrigerator. Interestingly, attractive interaction seems to be favorable for the operation since it provides a means to suppress leakage currents.

[1] J. Monsel, T. Baquet, J. Schulenborg, M. R. Wegewijs, and J. Splettstoesser, in preparation.
[2] B. A. Placke, T. Pluecker, J. Splettstoesser, M. R. Wegewijs: Phys. Rev. B 98, 085307 (2018)

A.8. Fabrication and Synthesis of Shape-Controlled Metal Nanoparticle Arrays

Jordi Piella, PostDoc, jordi@chalmers.se
Physics, Chemical Physics

Here, we describe a novel methodology in which both nanofabrication and colloidal synthesis methods are synergically combined for achieving the fabrication/synthesis of metal nanoparticle arrays on surfaces compatible with a plasmonic nanospectroscopy platform to apply it in the quest of deriving catalytic structure-function correlations at the single nanoparticle level. Specifically, nanolithography is first used to define arrays of seed particles on a surface and subsequently the positioned seeds are transformed through colloidal chemistry into more sophisticated nanostructures. Demonstrated is an exquisite shape- and size-control of the nanoparticles at the interface comparable to that of colloidal synthesis protocols, and the possibility to produce a variety of accurately positioned structures ranging from highly polycrystalline nanoflowers to single crystal truncated nanocubes. Among the different metals, Pd has been chosen to validate the methodology because it is widely used in plasmonic sensing and catalysis. The applicability of the approach is demonstrated by measuring the H2 adsorption/desorption kinetics of arrayed Pd nanocubes at a single nanoparticle level. At the very least, the approach presented here offer a platform to more systematic studies on individual shape-selected nanoparticles, a field that is hampered by the difficulty of carefully carrying out statistically meaningful measurements.

A.9. Unconventional current phase relation of topological-insulator nanoribbon-superconductor hybrid junctions

Ananthu Surendran, PhD student, ananthu@chalmers.se
Microtechnology and Nanoscience, Quantum Device Physics

Hybrid material systems with a conventional superconductor in proximity to a semiconductor or an unconventional conductor have recently acquired a vast interest due to their potential to hoist exotic phenomena.[1-3] Current studies on superconductor-topological insulator (TI)-superconductor junctions based on exfoliated film and nanoribbons have shown unconventional current phase relations (CPR) that could be associated with Majorana fermions, which may help realize topologically protected quantum computing.[4-8] In a 3D TI-based junction, the Majorana modes should appear in the surface modes as a doublet of gapless Andreev bound states whose energy varies 4π periodically with the phase across the junction alongside the normal 2π periodic Andreev bound states. But in most of the studies on these systems, there is an unavoidable contribution from the bulk, and experiments based on 3D-TI nanoribbons (TINRs) with a reduced number of transport modes are much needed. We make use of Al-Bi2Se3-Al junctions fabricated using TINRs grown by physical vapor deposition. [9-11]To extract the current phase relation of our TI-junction, we utilize an asymmetric dc-SQUID measurement technique. The TI-junction to be studied is connected parallel to a reference junction on the same TINR with a higher critical current, typically 10-15 times more, thus forming a SQUID device. This asymmetry in critical current is achieved by varying the TI-junction width, keeping the distance between the electrodes constant. Now, considering a large ratio between the critical currents and a small SQUID loop inductance (i.e., screening parameter much less than one), the phase across the reference junction stays constant on the application of magnetic flux while the phase across the test junction is changing linearly with the applied magnetic flux. From the modulations of the SQUID critical current, we directly determine the CPR of the small TI-junction. We observe clear deviations from standard sinusoidal CPR of typical tunnel junctions in all our devices. This skewed CPR at low temperatures results from highly transparent modes in our TI junctions. For increasing temperature and one obtains the sinusoidal current phase relation consistent with the thermal population of the Andreev bound states.

Reference:
[1] L. Fu et al., Phys. Rev. Lett. 100, 096407 (2008)
[2] C. Nayak et al., Rev. Mod. Phys. 80, 1083–1159 (2008)
[3] G. Y. Huang et al., Phys. Rev. B: Condens. Matter Mater. Phys. 95, 155420–6 (2017)
[4] J. Wiedenmann et al., Nat. Comm, 7:10303 (2016)
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[7] K. L. Calvez et al., Commun. Phys. 2, 4 (2018)
[8] P. Schüffelgen., Nat. Nanotechnol. 14, 825–831 (2019)
[9] G. Kunakova et al., Nanoscale 10, 19595–19602 (2018)
[10] G. Kunakova et al., Appl. Phys. Lett. 115, 172601 (2019)
[11] G. Kunakova et al., J. Appl. Phys. 128, 194304 (2020)

A.10. Neural Network assisted interpretation of UV-vis spectra of gold nanomaterials

Frida Bilén, PhD student, bilen@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

The structural characterization of nanomaterials, and in particular metal nanoparticles (MNP), in terms of shape, size and polydispersity is often based on electron microscopy or scattering techniques. These analyzes are relevant for batches synthesized by conventional means, but the analysis of nanoparticles prepared in a flow reactor requires methods that can be used inline, e.g. spectroscopic techniques.

For MNPs, a suitable technique is UV-vis spectroscopy as surface plasmon bands correlate with structural properties. However, spectrum interpretation from single UV spectra, with regards to detailed information about e.g. size and polydispersity, remains challenging. Our hypothesis is that a data driven approach using Convolutional Neural Networks (CNNs) can be used to extract details from the UV spectrum by utilizing the ability of this type of neural networks to identify features in complex data [1].

To demonstrate the feasibility of this approach, in-silico generated data for gold nanomaterials have been used to train a machine learning framework based on CNNs. The models take spectroscopic data as input and have been constructed for predicting shape, size and polydispersity of nanoparticles.

We show that the machine learning framework can accurately predict properties from a spectrum for in silico data, and it is now under implementation for use with experimental spectroscopic data generated with a flow reactor system.

[1] LeCun, Y., et al. (2015). "Deep learning." Nature 521(7553): 436-444

A.11. Non-contact measurement of liquid surface tension on a single droplet

Smaragda-Maria Argyri, PhD student, argyri@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

Acoustic levitation allows contact-free manipulation of samples in the micro-liter regime, without the surface-associated shortcoming, such as contaminations or other surface-induced effects. It also gives the possibility to measure surface properties of liquids. Using a levitator based on Langevin horn, Apfel et al. [1] attempted to measure surface tension. Even though the method worked the accuracy of their results was low (±2 mN/m) as compared to traditional methods. One reason was the poor stability of Langevin horns. However, the description of the force field was relatively straightforward, which allows a theoretical description of the deformation of the droplet. Recently, a new generation of more stable levitators has been developed by Marzo et al. [2], based on multisource ultrasonic arrays. Yet, in contrast to Langevin horns, the acoustic field of the new generation of acoustic levitators is more complex and challenging to describe. As a result, the previously established droplet deformation models, based on Langevin horn force field, do not apply. In our study, we have built a highly stable and compact multi-source levitator and monitored the droplet deformation via a high-speed camera under varying acoustic pressure. Taking advantage of the large amount of data that can be generated, we followed a data-driven approach by implementing a neural network to process the droplet contour and predict the surface tension of surfactant solutions. Through this strategy, we have managed to determine the surface tension with an average mean absolute error below 0.7 mN/m and we also have the possibility to determine the critical micelle concentration (CMC) of a surfactant by utilizing continuous measurements on a single surfactant solution droplet.

1. Tian, Yuren, R. Glynn Holt, and Robert E. Apfel. "A new method for measuring liquid surface tension with acoustic levitation." Review of scientific instruments 66.5 (1995): 3349-3354.
2. Marzo, Asier, Adrian Barnes, and Bruce W. Drinkwater. "TinyLev: A multi-emitter single-axis acoustic levitator." Review of Scientific Instruments 88.8 (2017): 085105.

A.12. PdIn intermetallic sites and their role in methanol synthesis over Pd promoted In2O3

Minttu Kauppinen, PostDoc, minttum@chalmers.se
Physics, Chemical Physics

Direct methanol synthesis via hydrogenation of carbon dioxide is a key reaction of interest in the field of green chemistry. The "two birds one stone" approach uses up captured carbon dioxide while producing valuable methanol. As the current commercial Cu/ZnO/Al2O3 type catalysts are optimised to use syngas as the feedstock, novel catalyst search is of vital importance for achieving the production of green methanol. Palladium promoted indium oxide based materials have been recently put forward as promising candidates for selective and stable methanol synthesis catalysts. Our study aims to compare and contrast the PdIn and CuZn alloy phases as the potential active phases of the novel and commercial catalysts, respectively. We employ a density functional theory based mean-field microkinetic modelling approach in order to evaluate the activities and selectivities of the active sites towards the methanol synthesis reaction. Our results will provide a deeper understanding of the reaction mechanism, highlight the similarities and differences between the two materials, and offer clues as to what the role of the PdIn alloy phase is in the catalytic methanol synthesis over the novel indium oxide catalyst.

A.13. Surface steps dominate the water formation on Pd(111) surfaces

Elisabeth M. Dietze, PostDoc, dietze@chalmers.se
Physics, Chemical Physics

Water is formed in many industrially relevant processes and can strongly shift the equilibrium of reactions. Therefore, water formation is one of the most important model reactions studied. Although, the water formation over Pd surfaces is widely studied in literature for a range of conditions, questions on the main reaction path (OH*+H*) or (OH*+OH*) and the active site remain. Using a combined study of first principle density functional theory calculations and kinetic Monte Carlo simulations, we find that the reaction is dominated by surface steps and point defects at all studied conditions. Not only possible reactions towards water formation, but also towards hydrogen-peroxide [1] were included. For low temperatures our kinetic Monte Carlo model was tested against the surface science experiment by Mitsui et al. [2], showing excellent agreement in the light-off behavior and number of formed H2O molecules. At T=1300K, our simulations agree with the partial pressure dependent experiments by Johansson et al. [3].

Thereby, we observed that the dominant water formation pathway at steps is strongly temperature dependent: OH*+OH* for low temperatures (T=300K) and OH*+H* for high temperatures (T=1300K). We also elucidate on the role of steps towards the reaction limiting step OH*-formation. OH* is preferably formed at step sites and for low temperatures, OOH* splitting is an additional active pathway.

References:
[1] L. Chen, J. W. Medlin, H. Grönbeck, ACS Catalysis 2021, 11, 2735−2745.
[2] T. Mitsui, M. K. Rose, E. Fomin, D. F. Ogletree, M. Salmeron, J. Chem. Phys. 2002, 117, 5855−5858.
[3] Å. Johansson, M. Försth, A. Rosén, Surface Science 2003, 529, 247−266.

A.14. Van der Waals Magnet based Spin-Valve Devices at Room Temperature

Roselle Ngaloy, PhD student, ngaloy@chalmers.se
Microtechnology and Nanoscience, Quantum Device Physics

Two-dimensional (2D) materials and their van der Waals (vdW) heterostructures have played a key role in advancing the state-of-the-art in spintronics both in observing exotic physical effects and in demonstrating novel device concepts. With the discovery of layered 2D magnets, several vdW heterostructure-based spin devices have already been implemented but they require low temperature conditions to maintain the magnetic ordering of the material. The recent discovery of the ferromagnet, Fe5GeTe2 reveals magnetic property at room temperature, which prompts exciting applications in an all-2D room temperature spin-based device. Combining Fe5GeTe2 with the excellent spin transport properties of graphene, we demonstrate room temperature spin injection, transport, and detection in lateral spin valve devices with Fe5GeTe2-graphene heterostructure using nonlocal measurements.

A.15. Time-scales of a driven interacting quantum dot with superconducting proximity

Lara Celine Ortmanns, PhD student, ortmanns@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

We analyze the time-evolution of a quantum dot with strong onsite Coulomb interaction in contact with a large-gap superconductor, which is weakly probed by a wide-band normal electrode and driven out of equilibrium by a switch in the applied gate voltage. Whereas basic arguments lead one to expect two time scales that depend nontrivially on the pairing amplitude and Coulomb interaction, we show that only a single time scale associated with quasiparticles is sensitive to the interplay of the proximity effect and electron-electron interaction [1]. Instead, the time scale associated with the change in parity of the quantum dot charge is equal to the overall tunneling constant; it is hence a mere interface property. We map out the full time-dependent decay of the quantum dot controlled by a quench of the gate voltage as reflected by measurable transient charge and heat flows. Here, we make use of a dissipative symmetry for fermionic systems [2], a so-called fermionic duality relation, to identify the amplitudes of transient charge and heat currents. These amplitudes can be conveniently understood in terms of stationary quantities of the real model system and of a corresponding dual system, which is related to the real system by an inversion of energy parameters.

[1] L. C. Ortmanns, M. R. Wegewijs and J. Splettstoesser, "Time-scales of a driven interacting quantum dot with superconducting proximity", in preparation.
[2] J. Schulenborg, R. B. Saptsov, F. Haupt, J. Splettstoesser, and M. R. Wegewijs, "Fermion-parity duality and energy relaxation in interacting open systems," Phys. Rev. B 93, 081411 (2016).

A.16. An all-photonic full color RGB system based on molecular photoswitches

Gaowa Naren, PhD student, gaowa@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

On-command changes in the emission color of functional materials is a sought-after property in many contexts. Of particular interest are systems using light as the external trigger to induce the color changes. Here we report on a tri-component cocktail consisting of a fluorescent donor molecule and two photochromic acceptor molecules encapsulated in polymer micelles and we show that the color of the emitted fluorescence can be continuously changed from blue-to-green and from blue-to-red upon selective light-induced isomerization of the photochromic acceptors to the fluorescent forms. Interestingly, isomerization of both acceptors to different degrees allows for the generation of all emission colors within the red-green- blue (RGB) color system. The function relies on orthogonally controlled FRET reactions between the blue emitting donor and the green and red emitting acceptors, respectively.

A.17. Macromolecular gating with pH mediated polymer interactions

John Andersson, PhD student, anjohn@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

Polymer brushes are widely used to alter the properties of interfaces. In particular, poly (ethylene glycol) (PEG) and similar hydrophilic polymers can make surfaces inert toward biomolecular adsorption at high grafting densities. In published work, we show that by simply introducing a polymeric acid such as poly (methacrylic acid) (PMAA) at low pH, the highly hydrated brush barrier can change its properties entirely, forming a compact, dehydrated and protein adsorbing film. This is caused by multivalent hydrogen bonds in an extremely pH-sensitive process where a pH of 5 is sufficient for complexation to occur at the interface. The changes in brush properties are tunable and become more pronounced when more PMAA is bound. The initial brush state is recovered when releasing PMAA by returning to pH 7. In additional preliminary work, we demonstrate how this process can be controlled with electrochemistry, rapidly switching the polymer brush state using an electrical signal. The described system is currently investigated as a potential macromolecular gating mechanism for nanopore structures functionalised with PEG polymer brushes.

A.18. Macrocavities with AlGaAs heterostructures

Anastasiia Ciers, PostDoc, anastasiia.ciers@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

The field of optomechanics explores the interaction between electromagnetic radiation and nanomechanical motion. The applications for optomechanical systems range from application of highly sensitive detectors to fundamental questions of quantum manipulation of optics and mechanics and generation of non-classical states. III-V materials paves the way towards integrated optomechanics on chip. Grown Al0.92Ga0.08As/GaAs DBR layers create the end cavity mirror and an additional Al0.67Ga0.33As sacrificial layer with GaAs membrane on top of DBR give a precise control over the microcavity gap. This system can be studied as a canonical model of optomechanics, where one mirror of a Fabri-Perot cavity can move, or by assembling the top fixed mirror on the chip we obtain so-called ”membrane-at-the-edge” (MATE) system. The potential advantage of such MATE cavity is generation of pure quadratic dispersive strong coupling, which is important for suppressing linear dissipative back-action (and force noise), hence the possibility of quantum nondemolition readout of the membrane's phonon number states. We investigate the optical and mechanical properties of macrocavities with suspended single photonic crystals slabs of GaAs on DBR.

A.19. Magnetic levitation of micrometer-sized superconducting particles for quantum sensing experiments

Achintya Paradkar, PhD student, achintya@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

Magnetically levitated particles are a promising platform for developing ultra-sensitive force and acceleration sensors, both in the classical and in the quantum regime. In order to reach the quantum regime, we aim to levitate particles at millikelvin temperature inside a dilution refrigerator, with vibration isolation and optical access. We have designed and manufactured the setup for experiments in a dilution refrigerator, including the sample stage, thermal, electrical, and superconducting connections to sample and sensors, and optical read-out. Additionally, the design of a vibration isolation system is in progress to further damp the environment noise that can disturb the quantum state. Later, we aim to couple the particle to an LC resonator via magnetic flux-based coupling for cooling the center-of-mass (COM) mode of the particle motion. Ultimately, this enables the generation of quantum states of the COM motion, such as superposition or squeezed states, which are necessary for quantum sensing of forces such as gravity.

A.20. The Role of H+- and Cu+-Sites for N2O Formation during NH3-SCR over Cu-CHA

Yingxin Feng, PhD student, yingxin@chalmers.se
Physics, Chemical physics

N2O formation during selective catalytic reduction of NOx with NH3 (NH3-SCR) has received increasing attention in recent years as N2O is a potent greenhouse gas. In this work, DFT calculations were used to investigate N2O formation in Cu CHA. We reveal the role of the zeolite by comparing N2O formation via NH4NO3 decomposition in the gas phase with decomposition paths in Al-free CHA and HCHA. Moreover, we propose a path for N2O formation over Cu+-sites, which is solvated by NH3 under low-temperature NH3-SCR conditions.

A.21. Optical nanoparticle characterisation beyond the Stokes-Einstein relation

Erik Olsén, PhD student, olsene@chalmers.se
Physics, Nano and Biophysics

Nanoparticles are often characterised using optical microscopy by relating their diffusivity to hydrodynamical radius via the Stokes-Einstein relation. Such characterisation works well for mono-disperse particles in bulk but less so for non-idealised experimental systems, as for example dynamically changing particles, particles bound to a cellular membrane or particles near interfaces.

My work aims at overcoming several of the limitations by further developing two different optical microscopy techniques. The first technique combines holographic nanoparticle tracking (H-NTA [1]) with deep learning, which is used to quantify particle quantities directly from optical images without relying on the Stokes-Einstein relation. Using this approach, both size and refractive index can accurately be determined over time for the same particle when the particle radius is larger than 150 nm, which was successfully used to resolve fluctuations in the number of 31 nm radius nanoparticles monomers in particle aggregates [2]. The second technique is based on tracking nanoparticles tethered to a supported lipid bilayer under shear induced flow. By relating the velocity to diffusivity, the drag contributions of the particle and tethers was successfully separated in a single measurement. This enabled for the first-time slip length quantification directly for biological nanoparticles, a critical parameter when relating hydrodynamic size to geometrical size as well as for clarifying the mechanistic aspects concerning the mobility of membrane-attached nanoparticles [3].

References
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A.22. Unraveling the role of bacterial membrane nanodomains: Role of phage shock proteins in temperature and antibiotic stress

Luna Baruah, PostDoc, baruah@chalmers.se
Biology and Biological Engineering, Chemical Biology

Bacteria are constantly exposed to a wide range of environmental conditions, such as nutrient limitation fluctuations in temperature, humidity, pH or exposure to antibiotics. They have developed a range of coping mechanisms to sense and survive the fluctuating conditions which are their key to survival. The main sensory interface of the bacterial cell with its environment is the cytoplasmic membrane, which by no means are homogenous in nature. In fact, the bacterial cell membrane is characterized by a distinct nanodomain organization. One important type of bacterial nanodomain is constituted by the so-called 'regions of increased fluidity', in short RIFs. These RIFs are involved in orchestrating the synthesis of the bacterial cell wall. We hypothesized that they are also responsible for sensing environmental stress through an association with phage shock proteins. These stress response proteins are crucial resistance factors for crucial last-resort antibiotics such as daptomycin and are thought to aid cell membrane stabilization.

In this study two distinct phage shock protein homologs: Psp A and LiaH will be studied. These proteins are homologous to their structure but distinct in their function and regulation. PspA is induced by membrane stress while LiaH is induced by inhibition of cell wall synthesis.
However, very little is known about the actual triggers and function of these phage shock proteins. Hence, this study aims to unravel the various triggers of the phage shock proteins and their relation to the bacterial nanodomains.
To this end, we used deletion mutants, fluorescent protein fusions, and specific membrane dyes that report on nanodomains and membrane fluidity and observed how phage shock proteins are involved with RIFs, membrane fluidity, and cell wall synthesis.
So far, we have observed the effects of different temperatures as proxy for different membrane fluidity on deletion mutants of PspA and LiaH and confirmed strong defects of these mutants at low temperature (=low fluidity). We have further observed that at low temperatures the localization of proteins involved in cell envelope synthesis is disturbed in the deletion mutants, suggesting that phage shock proteins play a crucial role in maintaining membrane function under low fluidity conditions. We are currently examining the co-localization of PspA and LiaH with RIFs under high and low fluidity conditions and under antibiotic stress. Interestingly, we could already observe a strong effect of daptomycin on phage shock protein localization, confirming our notion that these proteins are involved in antibiotic resistance.

Bacteria are constantly exposed to a wide range of environmental stress hence they have developed a range of coping mechanisms to sense and survive the fluctuating conditions which is their key to survival. The main sensory interface of the bacterial cell with its environment is the cytoplasmic membrane, which by no means are homogenous in nature.

A.23. Development of biological nanosensors for cell membrane thickness

Margareth Sidarta, PhD student, sidarta@chalmers.se
Biology and Biological Engineering, Chemical Biology

In bacteria, membrane thickness plays an important role in cell physiological processes and the activity of a number of antibiotics. To truly understand these processes in their full complexity, it is paramount to work in an in vivo setting, i.e., in living bacteria. However, to date, there are no cell membrane thickness sensors available that could be applied in vivo. In this project, we aim to develop biological nanosensors for cell membrane thickness that can be used to measure this parameter in living bacterial cells. To this end, we follow two different approaches. In the first approach, we will exploit a bacterial protein that is involved in sensing cold shock. With decreasing temperature, the thickness of the membrane increases, which is recognized by the protein DesK through its transmembrane helices. The DesK minimal sensor domain, derived from these helices, has previously been shown to sense membrane thickness in vitro. Here, we will develop in vivo sensors based on this naturally thickness-sensitive peptide. In the second approach, we will use artificial membrane-spanning transmembrane helices as a molecular ruler for membrane thickness. A similar approach was recently implemented for the yeast endoplasmic reticulum membrane. So far, we have constructed several fluorescence and luciferase fusions of DesK and its minimal sensor domain and are currently characterizing these strains concerning their suitability as membrane thickness sensors. To this end, we are assessing how these fusions behave under conditions that induce membrane thickening and thinning, such as temperature shifts and antibiotic treatment.

A.24. Protocells and Surface-adhered Biomembrane Networks

Ruslan Ryskulov, PhD student, ryskulov@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

Reservoirs of lipid molecules, specifically onion shell vesicles, spread on high energy surfaces, e.g. SiO2, to form a stack of molecular films (double bilayer). Eventually, the spreading lipid exhausts the reservoir, and rising tension ruptures the films. Köksal et al. discovered that this disruptive process generates a network of nanotubes, which redistributes lipid material in order to alleviate local tension (Marangoni flow), and vesicles grow from the tubes. We have shown that local heating accelerate the growth and transformation of containers, and initiates their fusion. Similar processes might have occurred in warm environments on the Early Earth. Our current work aims to utilize this system and control soft matter transformations with IR light to design and construct reconfigurable chemical reaction networks (CRNs) on engineered surfaces.

A.25. Single Crystal X-ray Diffraction coming to Chalmers, what does it mean for EI Nano?

Lars Öhrström, Professor, ohrstrom@chalmers.se
Chemistry and Chemical Engineering, Chemical Engineering
Francoise Noa, Researcher, mystere@chalmers.se
Chemistry and Chemical Engineering, Chemical Engineering

In the end of October 2021 CMAL will receive the new single crystal X-ray diffractometer from Rigaku. It will be the most powerful diffractometer in Sweden and the poster will highlight the new opportunities this will give to EI Nano research.

A.26. Injection Molding for Rapid Fabrication of Passive Devices for Millimeter-Wave and Sub-Millimeter-Wave Applications

Sadia Farjana, PhD student, farjana@chalmers.se
Microtechnology and Nanoscience, Electronics, Materials and Systems

Recently frequency band which covers millimeter-wave, sub-millimeter-wave, and Terahertz frequencies becomes very attractive due to growing commercial applications such as automotive radars, security, imaging, and point-to-point communication links. As soon as we move towards higher frequencies, specially above 100 GHz the dimension of the passive components such as waveguides, antennas, and filters become smaller. Thus, makes the fabrication of these components challenging in terms of dimensional accuracy, time, and cost. Different micromachining techniques have proven themselves very promising to fabricate passive components with high dimensional accuracy, but those techniques are also time-intense, complicated, and costly. We developed an injection molding process where the time-intense and difficult part needs to be manufactured once by using micromachining techniques and later the final chip can be fabricated by using the injection molding process. A slot array antenna based on Gap waveguide technology has been demonstrated by using three different micromachining techniques, SU8 fabrication, PDMS molding, and injection molding of the polymer OSTEMER, together with gold (Au) coating. The fabricated antenna can operate at D-band. The measurement result has good agreement with the simulation result and indicates that injection molding can be a suitable option to fabricate high-frequency passive components.

A.27. Quantum confinement in topological insulator nano-devices

Xavier Palermo, PostDoc, xavierp@chalmers.se
Microtechnology and Nanoscience, Quantum Device Physics

According to theory, a single-electron transistor made with a topological insulator (TI) could be used to define a new standard for defining the Ampere.
One way to do it is to create a quantum dot in a TI nanowire using constrictions as barriers, which is challenging since TIs are delicate materials.
In this work, we present methods to pattern 100 nm-wide constricted nanowires in Bi-doped Sb2Te3 films and as-grown Bi2Se3 nanobelts by electron-beam lithography and argon ion milling.
By using cured PMMA or metallic layers such as Al2O3 as etching mask, we could pattern constrictions down to a few 10 nm in width. Preliminary electrical measurements at 300 mK indicated a switch from ohmic to tunneling behavior for constrictions of approx. 50 nm in width in Bi2Se3 nanowires.
It suggests that further reducing the dimensions may enhance this effect, and possibly lead to the formation of a quantum dot.

A.28. Development of High-Performance Flip-Chip Integrated Superconducting Quantum Processor

Hang-Xi, PhD student, hangxi@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

In order to run a quantum algorithm that outperforms the best classical algorithms for some computational problem, we need a large-scale quantum computer. Current quantum processors based on superconducting circuits, with up to a few dozen qubits, require 3D-integration technologies in order to feed the input and output signals to each qubit. We have developed a flip-chip technology including chip layout redesign and additional device fabrication processes. It is critical that the qubits' coherence and their control and readout fidelities are not degraded in this flip-chip environment. We report the integration of a quantum processor into a flip-chip architecture and demonstrate high-fidelity single-qubit and two-qubit gates. Our qubits' coherence times are about 100 us, and, notably, are not degraded compared to planar, single-chip devices. This result opens the path for us towards building high-fidelity multi-qubit quantum processors.

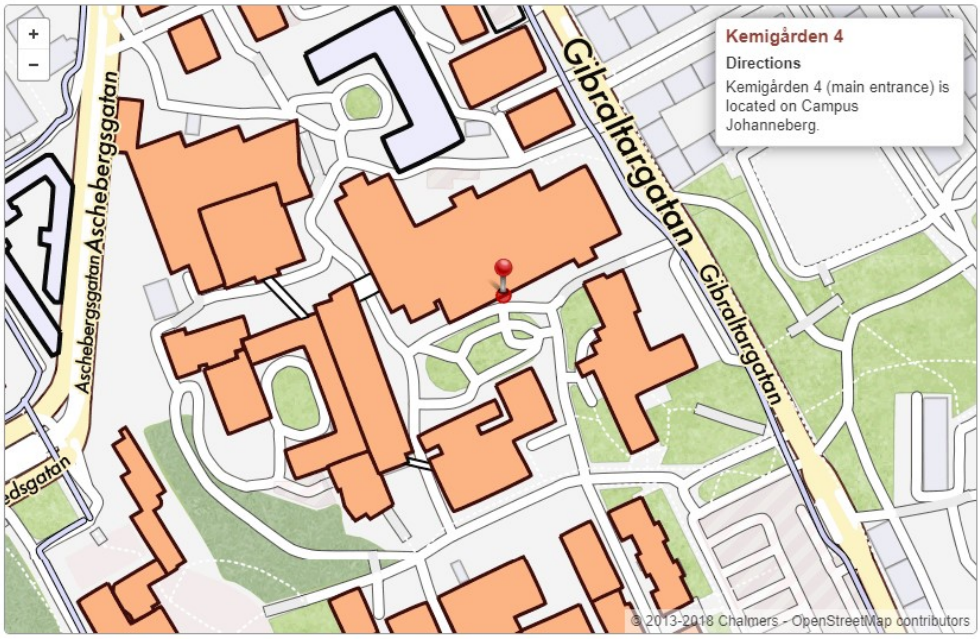
A.29. Nanofluidic Scattering Spectroscopy: Monitoring the Invisible

Björn Altenburger, PhD student, bjorn.altenburger@chalmers.se
Physics, Quantum Technology

Heterogeneous catalysis is focused around (noble) metal particles and their interactions with their environment. The technique of choice for investigating these particles is oftentimes surface plasmon resonance, which works well for particle sizes around 100 nm. However, in industrially applied catalysis, particles below 10 nm size are of interest, which provides a experimental challenge for single particle investigations. In this poster, we introduce a technique that has no need for a visible particle, as the light that is scattered from the particle-containing nanochannel is the indicator here. By monitoring the change of this scattered light before and after the catalyst while reagents are flowing through the channel, it is possible to extract the activity of a single particle without actually looking at it.

Group B

Even numbers in Signes (Physics) odd numbers in Chemistry entrance.
Presenters will be present 17:30 – 18:30



B.1. Fabrication of CMOS compatible micro-supercapacitors for on-chip energy storage application

Agin Vyas, PhD student, agin@chalmers.se
Microtechnology and Nanoscience, Electronics, Materials and Systems

In this work, we describe an efficient CMOS consistent fabrication process scheme for fabricating microsupercapacitors from materials with a high capacity for storage of charge.

B.2. Heat and charge shot noise in the absence of currents

Janine Splettstoesser, Professor, janines@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

Recently, the occurrence of shot noise in the absence of average currents has attracted attention. This phenomenon, initially analyzed for charge transport as the result of a pure temperature bias in an electronic conductor with an energy-independent transmission, is counter-intuitive in so far as shot noise is typically associated to the partitioning of a current.

We have broadly generalized this concept including a study of arbitrary nonequilibrium settings [1]. In particular, we addressed situations relevant for thermoelectric devices: we have on one hand extended the study to conductors with an energy-dependent transmission; in these thermoelectric conductors noise at the thermovoltage, namely at the voltage where transport is suppressed, can play an important role for the performance of the device. On the other hand, we have analyzed the occurrence of heat shot noise in the absence of heat currents. We found that the charge shot noise in the absence of a charge current is in general bounded by the thermal charge noise. In contrast, the heat shot noise can become arbitrarily large. In both cases, an energy-dependent transmission can increase the ratio between shot and thermal noise. We explicitly investigate the experimentally relevant example of a Lorentzian shaped (resonant) transmission, which allows to approach the limit of equal shot and thermal noise in the absence of currents.

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B.3. Cellulose nanocrystals modified with rare earth elements

Panagiotis Spiliopoulos, PostDoc, panspi@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

Cellulose nanocrystals (CNCs) have attracted increased attention in the materials science community throughout the recent years, due to their outstanding properties and peculiar applications. Chelation of CNCs through interaction with inorganic components is an intriguing task, however, the employment of rare earth elements on this purpose still exhibits plenty of space to be explored. Our experimental procedure targets in the fabrication of suphonated CNCs modified with lanthanides. The prepared nanocrystals are expected to demonstrate luminescence, advanced electrical properties, while the attachment of lanthanides on the CNC surface is expected to modify their thermal degradation and water related behavior. Overall, we aim in the preparation of a new generation of advanced CNCs that carry properties not frequently found in the polymeric materials.

B.4.Quantifying Nanobuffering

Bagus Santoso, PostDoc, bagus@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

The “nanobuffering” phenomenon describes the ability of polyelectrolyte polymer brushes to resist the change in pH in their immediate vicinity. The phenomenon exists as polyelectrolyte polymer brushes (e.g. negatively charged poly (methacrylic acid)) could attract H+ ions in the surrounding of the brush as counterions. Thus, the concentration of H+ ions around the polymer brush will be higher than that of the bulk solution (lower pH). This effect can be useful in various biological applications such as antibody purification, improving the throughput of enzyme cascade reactions, and imaging of endocytic organelles.

This effect, however, is not well studied and understood. In this work, we will attempt to quantify this effect. Densely grafted polyelectrolyte polymer brushes will be synthesised on a glass surface and using surface sensitive techniques such as total internal reflection fluorescence (TIRF) microscopy and pH-sensitive dyes, it is possible to measure the pH inside the polymer brushes. This can then be compared to the pH of the bulk solution, and we will come one step closer to understanding this phenomenon.

B.5. Complex Conformational Dynamics of the Heart Failure-Associated Pre-miRNA-377 Hairpin Revealed by Single-Molecule Optical Tweezers

Vinoth Edal Joseph SUNDAR RAJAN, Researcher, edal@chalmers.se
Biology and Biological Engineering, Chemical Biology
Anna Wypijewska del Nogal, Researcher, wypijewska.del.nogal@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

Precursor microRNAs (shortly pre-miRNAs) are hairpin precursors of single-stranded microRNAs (miRNAs), which are a type of cellular non-coding RNAs that play a regulatory role in gene expression (1). Pre-miRNA-377 is a regulatory RNA associated with heart failure (2). Pre-miRNAs have been investigated as a therapeutic target in human disease (3), but the hairpin stability and dynamics have not been fully explored yet, neither for pre-miRNA-377 nor for pre-miRNAs in general. Single-molecule force spectroscopy has emerged as a powerful technique for studying the stability and probing the conformational dynamics of nucleic acids at physiological conditions with a high spatio-temporal resolution (4,5).

Here, for the first time, we use single-molecule optical tweezers to unzip pre-miRNA-377 to study its stability and dynamics, using short dsDNA handles (29 bp). We show that magnesium ions have a strong stabilizing effect, and that sodium ions stabilize the hairpin more than potassium ions. The hairpin unfolds in a single step, regardless of buffer composition. Interestingly, hairpin folding occurs either in a single step (type 1) or through the formation of intermediates, in multiple steps (type 2) or gradually (type 3). Type 3 occurs only in the presence of both sodium and magnesium, while type 1 and 2 take place in all buffers, with type 1 being the most prevalent. By reducing the size of the native hairpin loop from fourteen to four nucleotides, we demonstrate that the folding heterogeneity originates from the large size of the hairpin loop. Further, while efficient pre-miRNA-377 binders are lacking, we demonstrate that the recently developed C2 ligand displays bimodal activity: it enhances the mechanical stability of the pre-miRNA-377 hairpin and perturbs its folding (6). The knowledge regarding pre-miRNA stability and dynamics that we provide is important in understanding its regulatory function and how it can be modulated to achieve a therapeutic effect, for example, in heart failure treatment.

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B.6. Improving the performance of YBCO nanobridges as weak links

Edoardo Trabaldo, PostDoc, trabaldo@chalmers.se
Microtechnology and Nanoscience, Quantum Device Physics

We present a summary of our work to improve the performance of YBCO nanobridges as weak links exploring two main directions: the nanoscale Grooved Dayem Bridge (GDB), and the development of an electromigration (EM) process for tuning the hole doping of nanobridges.
A GDB is a nanobridge with a groove etched across it, which acts as weak link. This is realized during one single lithography step and results in high-quality weak links with ICRN products as high as 350 μV and differential resistances much larger than in bare Dayem bridges at T = 77 K. We have used YBCO GDBs as novel nanoscale building blocks in HTS SQUID magnetometers coupled to an in plane pickup loop, which have been characterized via transport and noise measurements at T=77 K. These devices exhibit large voltage modulations ($\Delta V = 30\text{-}50$ μV), low values of white magnetic flux noise, 6 $\mu\Phi 0$/Hz0.5, and low magnetic field noise, 63 fT/Hz0.5, at T=77 K. GDB based SQUIDs combine the nanofabrication advantages and the device reproducibility, which are typical of Dayem bridges, with the performances, e.g. the magnetic sensitivity, of state-of-the-art SQUIDs based on grain boundary JJs.
At the same time, we developed an electromigration process to tune the superconducting properties of a nanobridge weak link by tuning its oxygen content. AC EM can be used to reduce the doping of a YBCO nanobridge, while DC EM can be conversely used to restore its oxygen content. Indeed, in a single nanowire we were able to change the hole doping in a wide parameter interval, with critical temperatures ranging from 90 K to 45 K. This technique is interesting for technological applications of YBCO weak links, where the tuning of the nanobridge properties, such as critical current and kinetic inductance, is required.

B.7. Growth of III-Nitrides with Plasma-Assisted Molecular Beam Epitaxy for High Electron Mobility Transistors

David Adolph, Researcher, adolph@chalmers.se
Microtechnology and Nanoscience, Microwave Electronics

Metal Organic Chemical Vapor Deposition (MOCVD) has become the standard method of growing epi-layers of III-Nitride semiconductor. However, MBE possesses some interesting characteristics that may complement MOCVD in this context, eg. (1) In-situ monitoring techniques resulting in excellent control of the growth process, (2) Good control of interface abruptness, (4) Ultra-high vacuum and high purity materials leads to lower levels of contaminants, (5) p-GaN does not need a high-temperature activation anneal to become electrically conductive, due to the low hydrogen levels, (6) doping profiles do not suffer from memory effects, (7) lower growth temperatures facilitate high indium content materials.

We are currently growing epitaxial layers in an EPI-930 III-nitride MBE equipped with (In,Ga,Al)(Si,Mg) solid effusion cells and two Nitrogen plasma sources. Up till now we have grown GaN-layers and AlN/GaN heterostructures directly on 4H-SiC(0001). The next step will be to grow MBE-epilayers on MOCVD-grown GaN/AlN/4H-SiC(0001) semi-insulating-templates. This will facilitate determination of electrical properties of the epilayers. The aim of our work is to grow more complex heterostructures suitable for High Electron Mobility Transistors (HEMT:s) operating well beyond 100 GHz. We are aiming at HEMT:s with regrown (GaN:Si) contacts and In-containing channels since this is expected to give a high electron velocity. Pure InN-layers is predicted to have a very high electron velocity (107cm/s). The EPI-930 is located inside MC2 Nanofabrication Laboratory which is a fully equipped cleanroom with state of the art processing equipment which will be used to fabricate the HEMT-structures.

Material characterization is currently being performed with High Resolution X-Ray Diffraction (HRXRD), Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM). We are close to growing layers which will be sent for Secondary Ion Mass Spectroscopy (SIMS) for impurity analysis. Later, Transmission Electron Microscope (TEM) characterization will be used for detailed imaging of interfaces at the atomic level. It is also possible to perform advanced Ellipsometry end Photoluminescence in cooperation with Linköping University. We will also use advanced electrical measurements both at room temperature and cryogenic temperatures with the equipment operational at the Microwave Electronics Laboratory, MC2, Chalmers.

B.8. Nano Enhanced Vapor Chamber for Electronics Cooling Applications

Markus Enmark, PhD student, enmark@chalmers.se
Microtechnology and Nanoscience, Electronics Materials and Systems

The increasing need for high thermal dissipation in electronics put tough requirements on effective cooling designs. One of the most effective passive cooling devices used in electronics today is vapor chambers. A vapor chamber is a phase change cooling device consisting of 3 main parts: a working fluid, a wick for liquid transport and an envelope. Today the state-of-the-art vapor chambers are often made from high thermal conductivity metals such as copper or aluminum. To further increase thermal performance and at the same time make the device lighter, much of recent research is focused on nanomaterials. In this project a demonstrator is manufactured to show the potential of nano enhanced vapor chambers. Graphene based film is used to produce an envelope with low density and exceptional thermal conductivity. A literature study was done to point out the most promising path for future research in the field of nano wick structures. This knowledge is used to determine which nano enhanced wick to incorporate into the device. The demonstrator will be fabricated and characterized in terms of thermal dissipation rate, total thermal resistance and wall superheat temperature to compare it with conventional vapor chambers.

B.9. All-dielectric metalenses: A review

Vasilii Mylnikov, PostDoc, vasilii.mylnikov@chalmers.se
Physics, Nano and Biophysics

Over the last decade, fully dielectric metasurface-based lenses (metalenses) have been extensively studied in the photonic society. Such an increase of attention is due to small metalens' footprint, subwavelength thickness, and exceptional light control compared to traditional lenses. Besides, all-dielectric metalenses offer lower Ohmic losses and compatibility with the CMOS fabrication process, as compared to prior art based on metals [1]. That makes fully dielectric metalenses perfect candidates for components in the next-generation high-performance optical appliances. A typical metalens consists of a two-dimensional array of high-refractive-index nanoparticles on top of a low-refractive-index substrate. The nanoantenna size, shape, location, and orientation in each unit cell are designed to achieve the desired wavefront [2]. That corresponds to the high-efficient metalens with the same phase difference between the desired focal point and the coordinate of every unit cell, which is necessary for constructive interference to form a focal spot. Here, operation principles of dielectric metalenses of different types and functionalities are presented, such as geometric phase-based metalenses, polarization-independent metalenses, achromatic metalenses, etc. Potential applications are also discussed in the review.

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B.10. Strongly coupled ultra quantum matter

Eric Nilsson, PhD student, nieric@chalmers.se
Physics, Subatomic, High Energy and Plasma Physics

Strongly coupled systems pose a great challenge for most conventional methods in condensed matter physics. An example of such a system is the strange metal phase, which as the name suggests, possess some very strange, unexplained features. This phase sits above the transition temperature in high-Tc superconductors, as well as in certain types of graphene - both of which are of interest for the fabrication of nanodevices.

However, through a mathematical method from high-energy physics - the holographic principle - we are able to access the strongly coupled physics, by mapping the problem to a gravitational one living in one dimension higher.

As a new PhD student, this poster contains preliminary results and an outlook on my future work, where I will study the strange metal phase and create holographic models which hopefully can explain the "strange" behavior. Currently, I am investigating the Surface Plasmon Polariton signature in a holographic strange metal, in order to interpret coming results from the next generations' highly resolved experiments.

B.11. Approaching the spin-statistical limit in visible-to-UV photon upconversion

Axel Olesund, PhD student, axel.olesund@chalmers.se
Chemistry and Chemical Engineering, Physical Chemistry

Unconventional strategies for expanding the use of solar energy have attracted significant attention in recent years. Using photon upconversion based on triplet-triplet annihilation (TTA-UC), a process in which low-energy photons are combined to form high-energy light, it is expected that the conventional upper limits in photovoltaics can be shifted upwards. Typically, spin-statistics state that the singlet yield upon triplet pair recombination is 2/5, capping possible TTA-UC quantum yields at 20% (out of a 50% maximum) for most systems. The highest reported visible-to-UV TTA-UC quantum yield to date is however only 10%, even though there is no fundamental reason as to why much higher quantum yields couldn't be reached. Improving the efficiency of this process is of great interest for application in especially photochemical processes.

In this study, we aim to shine light on the fundamental aspects currently limiting visible-to-UV TTA-UC. We do so by thoroughly and systematically investigating both known, relatively efficient, annihilator species as well as two compounds that has not been used in this context previously. The six annihilators used here are paired with a high triplet energy thermally activated delayed fluorescence-type (TADF) sensitizer, allowing for efficient population of also highly energetic annihilator triplet states. We show that also vis-to-UV TTA-UC systems may approach the spin-statistical limit of 2/5 commonly encountered in many annihilator species. Specifically, employing PPO as the annihilator species yields a record-setting TTA-UC quantum yield of 15.9%, a value that is limited only by non-unity fluorescence quantum yield and intersystem crossing (ISC) efficiency. High quantum yields are also obtained for 2,5-diphenylfuran (PPF, 12,5%), a compound never used for vis-to-UV UC before, and for p-terphenyl (TP, 10.9%), a compound which emits much deeper in the UV. The performances of the remaining systems are also evaluated and the intrinsic properties governing the TTA-UC process are obtained and analyzed. Further, we discuss what implications these findings have and what obstacles still need to be overcome in order to make these systems feasible for application in photochemical settings.

B.12. Thermo-responsive polymer brush nanostructures for biomolecule gating

Justas Svirelis, PhD student, justas.svirelis@gmail.com
Chemistry and Chemical Engineering, Applied Chemistry

Controlling molecule translocation through nanosized gaps is of great interest in novel systems for single molecule analysis and biomolecular membranes. The molecular gating property of thermo-responsive end-grafted poly(N-isopropylacrylamide) (PNIPAM) polymer brushes on well-shaped gold-silica nanostructures is investigated via extinction spectroscopy and fluorescence microscopy methods below and above PNIPAM lower critical solution temperature (LCST; 32 °C in water). Polymer brushes are prepared via Activators Regenerated by Electron Transfer Atom Transfer Radical Polymerization (ARGET ATRP; 1:1 v/v methanol/water) by employing HS-(CH2)m-OC(O)-IzoButyrate-Br as an initiator for the reaction. Variation of PNIPAM polymerization time, hence – polymer brush thickness (determined by Fresnel models and Surface Plasmon Resonance (SPR)), and the swollen/collapsed regimes allows controlled gating of bovine serum albumin (BSA) proteins through the polymer brush interface in and out of the fabricated nanowell (aperture up to 120 nm) according to the plasmonic activity as a possible method proposed previously. In addition, molecular gating of fluorescently tagged BSA was investigated by complimentary fluorescence microscopy measurements, which focus either on single or several nanowells.

B.13. Operando catalysis—bridging the gap between single nanoparticle probing and catalyst-bed-averaging

David Albinsson, PostDoc, aldavid@chalmers.se
Physics, Chemical Physics

When used as catalysts, nanoparticles introduce surfaces that enable chemical transformations that would otherwise be kinetically hindered. To understand the relation between specific particles and their catalytic performance, methods studying catalysts at realistic conditions have proven instrumental. Typically, these methods probe the catalyst bed with low spatial resolution resulting in an average response from several single particles. Alternatively, methods exist that probe an extremely small fraction only, e.g. a single nanoparticle, thereby effectively ignoring most of the catalyst. Here, we bridge the gap between these two extremes and introduce highly multiplexed single particle plasmonic nanoimaging. With this approach, we can perform operando characterization of each individual nanoparticle in model catalyst beds comprising ca. 1000 nanoparticles. The method relies on the use of a nanoreactor platform that enables online mass spectrometry from small catalyst samples. Using the example of CO oxidation over Cu, we reveal large variations in catalyst composition throughout the catalyst bed durgin operation and how individual particles can strongly deviate from the average catalyst bed response.

B.14. Deep Learning in Nanofluidic Scattering Microscopy for Label-free Weight and Size Screening of Single Biomolecules

Henrik Klein Moberg, PhD student, henrik.kleinmoberg@chalmers.se
Physics, Chemical Physics

We have introduced NSM to image and quantitatively analyze single biomolecules without the need for labeling or surface attachment, as they freely diffuse inside a nanofluidic channel. Molecular weight and effective hydrodynamic radius of each molecule can be inferred from the optical contrast (iOC) and diffusivity (D) of each corresponding trajectory within the nanochannels, but standard techniques are slow, inaccurate at low iOC and tend to introduce some biases. To solve this, we have implemented deep learning techniques to directly infer iOC and D of each trajectory from raw data. Results correspond well with standard techniques at high iOC and have higher accuracy at low iOC. Results on simulated data also show that a factor 6 times improvement in limit of detection should be possible to achieve.

B.15. Photonic crystal membrane array in AlGaAs heterostructures for integrated cavity optomechanics

Sushanth Kini, PhD student, sushanth.kini@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

We present a mechanically-compliant photonic crystal membrane array in AlGaAs heterostructures for use in cavity optomechanical experiments. The membranes have mechanical frequencies in the range of several hundred kilohertz and demonstrate reflectance of close to unity at telecom wavelengths [1]. An optomechanical system consisting of a mechanical resonator array in an optical cavity has been proposed as a method to reach the elusive single-photon strong coupling regime in optomechanics [2]. A critical requirement of such a system is to have highly reflective and uniform mechanical resonators of well-defined spacing. We demonstrate single- and double-layer devices fabricated in a AlGaAs heterostructure consisting of sub-μm spaced, near-identical mechanical resonators on top of a distributed Bragg reflector. We pattern these resonators with photonic crystal structures for engineering their out-of-plane reflectivity. We characterize the mechanical and optical properties of the membranes individually and as a complete system. The presented devices can be combined with micro-mirrors on an external chip and a spacer chip forming a fully integrated chip-based realization of a multi-element optomechanical system. Additonally, two photonic crystal slabs with sub-μm gap can exhibit so-called photonic bound states in the continuum (BICs). Such photonic BICs can be exploited for surpassing the performance of conventional Fabry-Perot-based optomechanical microcavities [3].

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B.16. Single photon emitters and moire excitons in two-dimensional materials

Hanlin Fang, PostDoc, hanlin.fang@chalmers.se
Microtechnology and Nanoscience, Quantum Technology

Solid-state based single photon emitters (SPEs) are a central building block for a diverse set of quantum technologies, ranging from quantum metrology over quantum communication to photonic quantum computation. Two-dimensional materials offer new opportunities in developing such SPEs on a chip and are compatible with silicon photonics. In our work, we focus on exploring SPEs in transition metal dichalcogenides (TMDs), in particular, WSe2 monolayers and WSe2-MoSe2 heterobilayers. Moiré excitons can be formed in 2D materials by simple stacking of two monolayers of 2D materials with a twist angle and/or lattice mismatch. Moiré excitons are expected to form an array of quantum emitters. We show first results for the optical properties of SPEs in WSe2 monolayers and characterization of moire excitons in WSe2-MoSe2 heterobilayers. Further, we aim at exploring the physical origin of SPEs and moire excitons in TMD-based materials by engineering their optical properties through strain tuning.

B.17. Colorful e-paper based on inorganic nanostructures

Marika Gugole, PhD student**,** gugole@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

In the field of reflective displays, also known as electronic paper, the possibility to control structural colors actively has been of great interest. Despite this possibility exists, it remains a challenge to achieve good color quality. The reasons for this are, among others, the necessity for these structural colors to be used in a sub-pixel configuration and this configuration requiring counter electrodes on top of it. Although the counter electrodes can be chosen to be semi-transparent, they still lower the total reflectivity enough for the color quality to suffer from it. We present a new design of structural colors, based on a Fabry-Perot cavity consisting of a gold thin layer, tungsten trioxide middle layer and a platinum mirror. The new design makes it possible to place the counter electrode behind the colors themselves and in this manner not restricting the choice to semi-transparent materials. Our structures show great reflectivity and chromaticity and can be actively modulated by ion insertion and extraction in the middle tungsten oxide layer.

B.18. Active and passive electrochromic displays with plasmonic structural colors

Oliver Olsson, PhD student, ooliver@chalmers.se
Chemistry and Chemical Engineering, Applied Chemistry

The common emissive screen which creates a picture by producing light and send it to your eyes. A reflective screen is utilizing the environmental light to reflect an image to your eyes, jut like a paper. It is therefore also called electronic paper. Using plasmonic metasurfaces highly reflective colors can be produced in the primary colors red, green, and blue.
Electrochromic materials can switch between an opaque and a transmissive state with an applied voltage and are used to modulate the reflection of metasurfaces.
By arranging numerous of pixels in a matrix with different configurations, each pixel can be modulated individually and a reflective display in color will be produced.
Two configurations of matrix addressing are used. Active addressing, utilizing a commercial thin-film-transistor array and turn them on and off when selecting your pixels. Passive matrix, using stripes of working electrodes and perpendicular stripes of counter electrodes. The intersection creates pixels which can individually be addressed by choosing materials which gives a non-linear voltage-response.

B.19. Observation of ballistic upstream modes at fractional quantum Hall edges of graphene

Christian Spånslätt Rugarn, PostDoc, christian.spanslatt@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

The structure of edge modes at the boundary of quantum Hall (QH) phases forms the basis for understanding low energy transport properties. In particular, the presence of ``upstream'' modes, moving against the direction of charge current flow, is critical for the emergence of renormalized modes with exotic quantum statistics. Detection of excess noise at the edge is a smoking gun for the presence of upstream modes. Here we report on noise measurements at the edges of fractional QH (FQH) phases realized in dual graphite-gated bilayer graphene devices. A noiseless dc current is injected at one of the edge contacts, and the noise generated at contacts at L=4 μ m or 10 μ m away along the upstream direction is studied. For integer and particle-like FQH states, no detectable noise is measured. By contrast, for ``hole-conjugate'' FQH states, we detect a strong noise proportional to the injected current, unambiguously proving the existence of upstream modes. The noise magnitude remaining independent of length together with a remarkable agreement with our theoretical analysis demonstrates the ballistic nature of upstream energy transport, quite distinct from the diffusive propagation reported earlier in GaAs-based systems. Our investigation opens the door to the study of upstream transport in more complex geometries and in edges of non-Abelian phases in graphene.

B.20. Readout of quantum screening effects using a time-dependent probe

Matteo Acciai, PostDoc, acciai@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

In voltage- and temperature-biased coherent conductors quantum screening effects occur if the conductor's transmission is energy-dependent. Here, we show that an additional ac-driven terminal can act as a probe for a direct readout of such effects. We find that screening of charges induced by the static biases impacts already their standard linear thermoelectric response coefficients due to nonlinear effects when accounting for the frequency of the time-dependent driving. Those effects should be observable under realistic experimental conditions and can literally be switched on and off with the ac-driving.

B.21. Phonon-assisted exciton dissociation in transition metaldichalcogenides

Raul Perea-Causin, PhD student, causin@chalmers.se
Physics, Condensed Matter and Materials Theory

The performance of optoelectronic devices based on transition metal dichalcogenides (TMDs) is often limited by the dissociation of tightly-bound excitons. While previously the tunneling at large electric fields has been studied, here we focus on phonon-assisted exciton dissociation, which is expected to dominate at more realistic lower electric fields. Using a fully microscopic model, we track the pathway of excitons from optical excitation to dissociation, identifying the main transitions and dissociation channels. Our work provides microscopic insights in fundamental mechanisms and intrinsic limitations behind exciton dissociation, suggesting routes for optimization of TMD-based optoelectronic devices.

B.22. Hybrid photocatalytic systems consisting of only earth-abundant elements for CO2 reduction

Liam Mistry, PostDoc, mistry@chalmers.se
Chemistry and Chemical Engineering, Physical Chemistry

Visible light-driven conversion of CO2 to more value-added products is a promising technology not only for the reduction of atmospheric CO2 but also for solar energy storage in the form of chemical energy. However, photocatalytic materials that can efficiently and selectively reduce CO2 into CO in a fully aqueous solution are extremely rare, and most of them still involve precious metals that are not suitable for mass production. We report on a novel water-soluble photocatalytic assembly consisting of polymeric carbon nitride dots (PCNDs) as the visible light absorber and a Fe-porphyrin complex substituted at four para positions by trimethylammonium groups (Fe-p-TMA) as the catalyst for the CO2-to-CO conversion. The combination of sensitiser and catalyst were carefully designed to allow for excellent solubility in water as well as improved electronic communications through electrostatic and π - π interactions. These interactions allow for multi-electron transfer from the conduction band of the sensitiser to the catalyst driving the system. This PCNDs/Fe-p-TMA assembly, at the optimised molar ratio, can produce CO with a turnover number (TON) exceeding 105 (selectivity $>$ 96 %) after 10 hours in the presence of a sacrificial electron donor.

B.23. Single molecule experiments highlight the role of NBS1 and Xrs2 in DNA tethering by MRN and MRX in DSB repair

Carl Möller, PhD student, mocarl@chalmers.se
Biology and Biological Engineering, Chemical Biology

To ensure genome stability and hinder introduction of disease-causing changes, DNA double-strand breaks (DSB) need to be repaired. Homologous recombination (HR) is a key DSB repair pathway. At the start of HR, the MRE11-RAD50-NBS1 (MRN) complex finds the broken ends and upon stimulation of its nuclease activity by CtIP performs the DSB processing for repair. The repair process involves DNA tethering, which is poorly understood. In this study, we use single-molecule analysis to investigate how MRN interacts with long DNA. The method is based on confining long DNA molecules in nanochannels. In contrast to tethering one or both ends to a substrate, as in most common single DNA molecule methods, the DNA is completely free in the nano channels, meaning that reaction on the DNA ends can be studied.

Single molecule experiments with MRN and DNA in nanochannels show direct evidence of a strong DNA interaction and tethering of distant DNA fragments by MRN. When comparing MRN and the yeast homologue Mre11-Rad50-Xrs2 (MRX), we observed key similarities. In both systems, the absence of NBS1/Xrs2, lowers the concatemer and circle formation dramatically. Data from single molecule experiments and EMSA show that NBS1 and Xrs2 alone have a strong DNA interaction. These findings strengthen the theory of Nbs1/Xrs2 playing a role in the localization of the MRN/X complex to DNA ends and mediate DNA annealing.

Finally, the addition of the MRN/X co-factor CtIP and Sae2, respectively, shows little to no effect on the bridging by MRN/X, although both CtIP and Sae2 exhibit strong DNA bridging on their own. Thus, the interaction between MRN/X and the co-factor that is crucial for the nuclease activity is potentially not important for DNA bridging.

B.24.Synovial Fluid Profile Dictates Nanoparticle Uptake Into Cartilage-Implications Of The Protein Corona For Novel Arthritis Treatments

Ula von Mentzer, PhD student, peiciute@chalmers.se
Biology and Biological Engineering, Chemical Biology

A major obstacle for joint drug delivery is to penetrate the dense, negatively charged cartilage matrix. Previous studies have extensively investigated particle approaches to cartilage tissue uptake but have neglected to address potential interactions between the particles and the synovial fluid. Here, a NP panel with different PEGylation was incubated with synovial fluid from either rheumatoid or osteoarthritic patients, or FCS. Compared to non-protein covered NPs, we observed a prominent impact of the protein coronas on NP uptake into cartilage, chondrocytes, and monocytes. Utilizing a quantitative proteomics approach, we identified abundant proteins on all panel members irrespective of the NP modifications. Nonetheless, NP and protein condition-specific differences were also observed between the groups. Our study, therefore, suggests that the protein abundance dictates NP efficacy, emphasizing the importance of considering the biological milieu for translating drug delivery designs to the clinic.

B.25. Photon Upconversion by Intra-Molecular Triplet-Triplet Annihilation in Anthracene Polymer Particles

Fredrik Edhborg, PhD student, edhborg@chalmers.se
Chemistry and Chemical Engineering, Chemistry and Biochemistry

The technique of photon upconversion (PUC) by triplet-triplet annihilation (TTA) has potential to increase the energy harvesting efficiency of for example solar cells. The photophysical process of TTA-PUC involves a series of excitation energy transfer events between molecules, which is typically governed by diffusional collision in liquid solutions. However, solid-state upconversion materials are required for practical applications. One way to achieve solid state photon upconversion is to design molecular systems which can do the excitation energy transfer events within a molecular construct. Such a system would hence replace slow diffusion limited inter-molecular TTA by fast intra-molecular TTA. Here we present a study of photon upconversion in a molecular system where the TTA event occurs within an anthracene polymer particle. We show that the upconversion process is significantly faster and more efficient compared to a corresponding diffusion controlled monomeric system. The presented results show that intra-molecular photon upconversion is a versatile concept for achieving efficient solid-state photon upconversion materials.

B.26. Plasma-Induced Heating Effects on Platinum Nanoparticle Size During Sputter Deposition Synthesis in Polymer and Ionic Liquid Substrates

Björn Lönn, PostDoc, bjorn.lonn@chalmers.se
Physics, Chemical Physics

Nanoparticle catalyst materials are becoming increasingly important as we set our aim for a more sustainable future. With the advancement of fuel cell technologies, and in particular proton exchange membrane (PEM) fuel cells, known for their sluggish cathode side oxygen reduction reaction (ORR), platinum (Pt) nanoparticles are of particular importance due to their high ORR catalytic activity. Sputter deposition into low vapor pressure liquid substrates, such as ionic liquids, has opened new doors to the fabrication of clean nanoparticles, without the presence of air and other contaminates or the need for precursors. On this poster, we show information and results from a study where Pt nanoparticles are produced by magnetron sputtering into three imidazolium based ionic liquids and PEG 600. Substrate temperatures are measured during sputtering at varying sputtering power and time. We show that whilst substrate heating induced by increased sputtering time and power, influences the Pt nanoparticle size, the effect is not as great as for other materials.

B.27. What are they doing when they are using phase estimation in a cavity?

Yu Zheng, PhD student, zhyu@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

Phase estimation was introduced by Alexei Kitaev. It is used in Shor's algorithm and quantum algorithm for linear equations in discrete quantum systems. What are the applications of this subroutine in continuous-variable systems?

B.28. Single Magnetic Nanoparticle Hall Magnetometry using LAO/STO heterointerface q2DEG

Paul Burger, Master student, pburger@students.uni-mainz.de
Microtechnology and Nanoscience, Quantum Device Physics

The oxide interface between LaAlO3 and SrTiO3 (LAO/STO) hosts a quasi-two-dimensional electron gas (q2DEG) among other exotic properties. A nano Hall bar in such a q2DEG enables high resolution Hall magnetometry of fields that would otherwise be lost in the bulk. Single Fe3O4 magnetic nanoparticles (MNPs) of 50nm diameter were precisely aligned on top of the LAO/STO surface using atomic force microscopy. A hysteretic Hall effect was observed in the 100nm wide Hall bar due to the single MNP's stray field. This procedure may be used for investigations of proximity effects between nanoscale ferromagnetic objects with superconductors, spintronic devices and topological insulators.

B.29. Ising spin-orbit coupling and superconductivity in monolayer NbSe2

Juliane Graf, Master student, julianeg@chalmers.se
Microtechnology and Nanoscience, Applied Quantum Physics

Two-dimensional transition metal dichalcogenides (TMDs) show large atomic Ising spin-orbit coupling (SOC), which quantizes electronic spins perpendicular to the monolayer plane. Since monolayers of NbSe2 are also superconducting, the mechanism giving rise to this has to take account of the spin-orbit coupling. So far, there is no established microscopic model for this. We examine the emergence of Ising SOC based on a tight-binding model for 2d-TMDs [1] as well as its influence on superconductivity assuming a direct electron-electron pairing mechanism [2, 3]. As a foundation, a numerical, parameterized tight-binding model for the band structure of NbSe2 including the analytic expression for atomic spin-orbit coupling is developed. This gives an accurate three-band description around high symmetry points, reproducing well the splitting of the valence band. The superconducting Hamiltonian for a TMD monolayer is derived within mean-field theory. Two coupled gap equations are obtained, where the gaps are related through time-reversal symmetry. This suggests that if SOC is included into the description of the superconducting properties, the direct electron-electron pairing mechanism may result in a behaviour deviating from conventional BCS theory in showing two different gaps.

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