CUI: ADVANCED IMAGING OF MATTER

AIM Winter School 2020

24 - 28.02.2020

ABC Tagungszentrum Hüll
Bauernreihe 1
21706 Drochtersen-Hüll

CLUSTER OF EXCELLENCE
CUI: ADVANCED
IMAGING OF MATTER

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Program at a glance

24 - 28.02.2020

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 - 8:30		Breakfast	Breakfast	Breakfast	Breakfast
8:30 - 9:00					
9:00 - 9:30	Transfer to Winter School from ZOB (close to HH main station)	PhD and Postdoc Plenary Talks	Prof. Salvatore Stagira (Lecture Area B)	Dr. Florian Meinert (Lecture Area A)	Prof. Zeger Hens (Lecture Area C)
9:30 - 10:00					
10:00 - 10:30					
10:30 - 11:00		Coffee break	Coffee break	Coffee break	Coffee break
11:00 - 11:30	Check in and moving into rooms	Mentoring session	Prof. Salvatore Stagira (Lecture Area B)	Dr. Florian Meinert (Lecture Area A)	Prof. Zeger Hens (Lecture Area C)
11:30 - 12:00					
12:00 - 12:30					
12:30 - 13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00 - 13:30					
13:30 - 14:00					
14:00 - 14:30	Welcome	Prof. Dirk Notz Extra-Area Lecture	Mentoring Groups	PhD and Postdoc Plenary Talks	Closing remarks and feedback
14:30 - 15:00				Poster slam (5 min. talks)	Transfer back to ZOB (close to HH main station)
15:00 - 15:30					
15:30 - 16:00	Coffee break	Coffee break		Coffee break	
16:00 - 16:30	PhD and Postdoc Plenary Talks	Prof. Dirk Notz Extra-Area Lecture	Coffee break	Individual discussion groups	
16:30 - 17:00			Free		
17:00 - 17:30					
17:30 - 18:00	Poster slam (5 min. talks)	Poster slam (5 min. talks)			
18:00 - 18:30					
18:30 - 19:00	Dinner	Dinner	Dinner	Dinner	
19:00 - 19:30					
19:30 - 20:00	Poster	Poster	Free	Poster	
20:00 - 20:30					

Detailed Program

Monday 24.02.2020

09:00 to 11:00	**Transfer to the Winter School from ZOB (close to Hamburg main train station)**
11:00 to 12:30	**Check-in and moving into the rooms**
12:30 to 14:00	**Lunch**
14:00 to 15:30	**Welcome by the organizers** *Overview of the AIM cluster of excellence and of the winter school. Collection of the topics for the individual discussion groups on Thursday.*
15:30 to 16:00	**Coffee Break**
16:00 to 17:30	**PhD and Postdoc Plenary Talks:**

Chithra Sharma – MoS2 for quantum device applications

MoS_2 is a highly tunable and easily available van der Waals system with robust electrical and mechanical properties. The presence of 2D polymorphic phases with distinct electrical properties makes MoS_2 a potential candidate for all-2D monolithic circuits. The properties of the different polymorphic phases will be briefly discussed in this talk with emphasis on the following. (i) The semiconducting 2H phase can be engineered by electrostatic gating to achieve scalable quantum devices such as quantum point contacts and quantum dots. (ii) The 1T phase is metallic and, shows emergent 2D superconductivity with characteristic Berezinskii-Kosterlitz-Thouless transition (BKT).

Tamme Wollweber – Clement: Improving the efficiency of Correlative Light and Electron cryo-Microscopy (cryo-CLEM)

CLEM combines complementary features of light and electron microscopy and allows the tomographic imaging of specific labeled proteins in their near native structure at a very high resolution. However, image registration of the two different modalities can be challenging and time consuming.
Clement is an open-source Python-based software that has been developed to overcome this bottleneck. The software allows the user to semi-automatically register two-dimensional fluorescence (FM) and electron microscopy (EM) images and thereby facilitates the search for features of interest in EM images, even those which are hard to visualize in the electron microscope. I will discuss the features of the software, show some applications and discuss some planned future enhancements.

Monday 24.02.2020

Matteo Vandelli - Feynman diagrams for strongly correlated materials

The understanding of the properties of strongly correlated materials is very challenging and far from being complete, because common tools as for instance DFT do not capture the effects of strong interactions. High-temperature superconductors and some transition metal dichalcogenides belong to this class of materials. Calculations of the properties of these systems involve the combination of advanced theoretical tools, as Feynman diagrams, and efficient computational methods. In this talk I will briefly explain how diagrammatic approaches work and I will show recent results for model systems obtained with an unbiased method.

17:30 to 18:30 **Poster slam (5 minutes talks):**

Joseph Adelina
Femtosecond Science On-Chip: Direct Probe of Light-Induced Superconductivity

Hauke Biss
Phase Coherence and Superfluidity in Ultracold 2D Fermi Gases

Niels Breckwoldt
Molecular Dynamics in Vicinity of a Conical Intersection

Lukas Freystatzky
Dark state dynamics in the 1D Fermi-Hubbard model

Michael Koof
Shear-induced structure formation in colloidal systems

Torben Sobottke
Towards generation of Squeezed States of Light at the Rb D1 line

Huan Zhao
Femtosecond dynamics of nanoparticles by 2-dimensional Fourier transform spectroscopy

18:30 to 19:30 **Dinner**

19:30 to 20:30 **Poster session**

Same presenters of the poster slam

Tuesday 25.02.2020

08:00 to 09:00 **Breakfast**

09:00 to 10:30 **PhD and Postdoc Plenary Talks:**

Dan Bosworth – Atoms and ions near absolute zero

Since the earliest demonstrations of laser cooling in the 1960s, "cold" atomic physics has developed into a diverse and fertile field of research, whose notable milestones include the production of the first Bose-Einstein Condensate in 1995. One current frontier of this burgeoning discipline is the ongoing bid to marry together two unique species - ions and quantum gases - within a single hybrid system. Merging these distinct phenomena offers us a fresh platform for probing hitherto unseen quantum effects and realising novel technologies. This brief talk aims to summarise several key results and ongoing challenges within this promising subject.

Mario Neundorf – Ultrafast electron cooling in an expanding ultracold plasma

Strong-field ionization of a quantum gas by ultrashort laser pulses allows the instantaneous creation of electrons and ions with tunable excess energy. A single femtosecond laser pulse focused to a micrometer-sized waist can ionize up to several thousand atoms, thus triggering the formation of strongly coupled ultracold plasmas at the densities and temperatures of Bose-Einstein condensates.
We report on the observation of electron cooling in an expanding micro-plasma from initially 5000 K electron temperature to about 1 K within a few hundred nanoseconds. Our experimental setup grants access to the electronic kinetic energy distribution with meV resolution. Furthermore, we have performed numerical simulations of the collective Coulomb driven plasma dynamics which are in excellent agreement with the measurements. The simulations reveal an efficient energy transfer to the ionic system within the first ten picoseconds.

Felix Thiel – Cation Exchange Reactions: From Cu2-xS to CuInS2

Copper indium dichalcogenide, specifically CuInS2 (CIS), presents as a valuable material as a light absorber in quantum dot and thin film photovoltaics, due to its high absorption coefficient, and tunable optical properties from the visible spectrum to the near-infrared. CIS, with a band gap of 1.45 eV, could be a suitable alternative to more toxic, heavy metal based materials, such as CdSe.
Well-established direct synthetic routes exist to produce small spherically shaped CIS NCs. However, achieving different morphologies with high control is still a challenge. Therefore, cation exchange reactions have proven to be an excellent alternative. This synthetic strategy, based on using one nanostructure as a template, generates the final desired composition via exchange of ions. This is usually achieved by partially or fully exchanging lattice cations, while retaining the initial anionic sublattice of the NCs.

Tuesday 25.02.2020

10:30 to 11:00 — **Coffee break**

11:00 to 12:30 — **Mentoring session**
Coordinated by the students' representatives

12:30 to 14:00 — **Lunch**

14:00 to 15:30 — **Extra-Area Lecture**

Prof. Dirk Notz - The big melt (part I)
Bitter cold, frozen oceans, gigantic glaciers: This prevailing image of the polar regions of our planet still captures the true look of these regions quite well. But possibly not for very much into the future: In the Arctic, sea ice on the Arctic Ocean disappears rapidly, temperatures rise two to three times as fast as the global average, and the glaciers slowly disappear.
In this mini-lecture, I combine my own experiences from numerous expeditions into the polar regions with the scientific background of climate change. In doing so, we will explore climate change in the distant past, the rapid changes that we all experience today, and will examine how the future will possibly look like - and how we can still influence its course. And in doing so, we will be able to answer the overarching question of whether we can still stop the big melt...

15:30 to 16:00 — **Coffee Break**

16:00 to 17:30 — **Extra-area lecture**

Prof. Dirk Notz - The Big Melt (part II)

17:30 to 18:30 — **Poster slam (5 minutes talks)**

Mei Bai
X-ray spectroscopy of molecular clusters

Markus Bohlen
Sound propagation and quantum limited damping in a two-dimensional Fermi gas

Jakob Butlewski
Approaching the motional ground state of a cold nanomechanical oscillator in a hybrid atom-optomechanical system

Jannik Lübke
Control of (bio-)nanoparticles in external fields

Ellen Gattowski
Novel CaM-binding motif in its NudT9H domain contributes to temperature sensitivity of TRPM2

Sergei Riabchuk
Modeling the generation of few-femtosecond UV pulses in gas

Lucas Schneider
Bottom-up construction of magnetic nanostructures on superconducting surfaces

Tuesday 25.02.2020

18:30 to 19:30	Dinner
19:30 to 20:30	Poster session
	Same presenters of the poster slam

Wednesday 26.02.2020

08:00 to 09:00	**Breakfast**
09:00 to 10:30	**Lecture Area B**
	Prof. Salvatore Stagira - Visualizing molecular properties through strong-field processes (part I) *When an intense laser pulse interacts with molecules or atoms, the outermost electrons of the target species are ionized and then steered by the laser field. Several phenomena, known as strong-field processes, take place resulting in the release of charged particles and photons. The properties of the ionized molecules/atoms are encoded in the distribution of the emitted particles and can be retrieved by suitable data processing; this concept is at the base of strong-field spectroscopy. In order to introduce the audience to this subject, I will organize the lectures as follows.* *In the first lecture a general introduction to strong-field optical processes will be provided, with particular emphasis on high-order harmonic generation; the topic of molecular manipulation in the gas phase by optical pulses will be also presented, since this is an essential tool in strong-field spectroscopy.*
10:30 to 11:00	**Coffee break**
11:00 to 12:30	**Lecture Area B**
	Prof. Salvatore Stagira - Visualizing molecular properties through strong-field processes (part II) *The second lecture will be devoted to applications of strong-field processes to molecular spectroscopy like molecular orbital tomography and rovibrational spectroscopy based on high harmonic emission. A mention to other applications as well as perspectives on this field will then be given.*
12:30 to 14:00	**Lunch**
14:00 to 16:00	**Mentoring groups** *Coordinated by the student representatives*
16:00 to 16:30	**Coffee Break**
16:00 to 18:30	**Free time**
18:30 to 19:30	**Dinner**
19:30 to 20:30	**Free time**

Thursday 27.02.2020

08:00 to 09:00 Breakfast

09:00 to 10:30 Lecture Area A

Dr. Florian Meinert – Ultracold Rydberg-Atoms (part I)

This lecture will cover recent advances in experimental research with Rydberg atoms prepared at ultralow temperatures. I will start with the fundamental properties of Rydberg states comprising their characteristic mutual interactions and the phenomenon of Rydberg blockade. This will form the basis to discuss recent experimental platforms which allow for controlling individual Rydberg atoms particle-by-particle and for exploiting their unique interaction properties for Rydberg-based quantum simulations.

10:30 to 11:00 Coffee break

11:00 to 12:30 Lecture Area A

Dr. Florian Meinert – Ultracold Rydberg-Atoms (part II)

In the second part of the lecture, I will turn to studies of Rydberg atoms embedded in quantum degenerate gases. In this regime, the giant Rydberg electron orbit can largely increase way beyond the mean particle distance in the gas, leading to situations where few to many ground-state atoms reside within the orbital. I will discuss, how this gives rise to novel molecular bonds, ultracold chemistry, and even new ways to study ions embedded in a quantum gas.

12:30 to 14:00 Lunch

14:00 to 14:30 PhD and Postdoc Plenary Talks:

Georgios Koutentakis - Interplay of Phase Separation and Itinerant Magnetism in the Correlated Dynamics of Few Fermions Confined in a Double-Well

We explore the stability of the phase separation phenomenon in few-fermion spin-1/2 systems confined in a double-well potential. It is shown that within the SU(2) symmetric case, where the total-spin is conserved, the phase separation cannot be stabilized. An interaction regime characterized by metastable phase separation emerges for intermediate interactions which is inherently related with the ferromagnetic spin-spin correlations emanating within each of the wells. The breaking of the SU(2) symmetry crucially affects the stability properties of the system as the phase-separated state can be stabilized even for weak linear gradients of the magnetic potential. Our results imply a more intricate relation between phase separation and ferromagnetism that lies beyond the view of the Stoner instability.

14:30 to 15:30 Poster slam (5 minutes talks)

Alexandra Mozdzen

An experiment to study small Fermi-Hubbard systems

Thursday 27.02.2020

Marty Rogers
Photocaging for Time-Resolved Protein Crystallography

Joss Weise
Imaging molecular structure through strong-field ionisation

Cassian Plorin
Imaging molecular structure through strong-field ionisation

Emanuele Rossi
Stimulated RIXS: introduction and perspectives

Dennis Bonatz
CdSe nanoparticles synthesis and characterization in a free-liquid-jet

15:30 to 16:00 **Coffee break**

16:00 to 18:30 **Individual discussion groups**
Discussion groups on the topics collected during registration and on Monday.

18:30 to 19:30 **Dinner**

19:30 to 20:30 **Poster session**

Same presenters of the poster slam

Friday 28.02.2020

08:00 to 09:00	**Breakfast**
09:00 to 10:30	**Lecture Area C**
	Prof. Zeger Hens – Excitons in Nanocrystals *This lecture will address the fundamental understanding of optical excitations in zero-dimensional (0D) colloidal quantum dots and two-dimensional (2D) colloidal quantum wells. Starting from the electronic structure for both cases, we address basic insights in the band-edge absorption. Contrasting quantum dots and quantum wells, we discuss the difference between electron-hole pairs and excitons and we introduce transient absorption spectroscopy as a method to elucidate fingerprints of both types of optical excitations. Finally, we address the dynamics of cooling of electron-hole pairs after high energy, non-resonant photoexcitation.*
10:30 to 11:00	**Coffee break**
11:00 to 12:30	**Lecture Area C**
	Prof. Zeger Hens – Optical Gain by Nanocrystals *We apply the insight in optical excitations in colloidal semiconductor nanocrystals to address stimulated emission by such materials after photo-excitations. We show how the material gain, an intrinsic characteristic of stimulated emission, can be readily measured experimentally for colloidal nanomaterials by means of femtosecond transient absorption spectroscopy. Using this approach, we compare optical gain by 0D CdSe-based quantum dots, 2D CdSe nanoplatelets and bulk-like perovskite nanocrystals.*
12:30 to 14:00	**Lunch**
14:00 to 14:30	**Closing remarks and feedback**
14:30 to 16:30	**Transfer from the Winter School to ZOB (close to Hamburg main train station)**