Public Presentation at the Faculty of Physics Date: 25 February 2020 Place: Josef-Stefan lecture hall, 3rd floor, Boltzmanngasse 5, 1090 Wien			
Time Slot	**Name**	**Topic**	**Supervisor**
9:00-9:10	--	Introduction by Bogdan Sepiol	
9:10-9:25	Rieser Philipp	Time domain interference of biomolecules and quantum assisted spectroscopy	Markus Arndt
9:25-9:40	Troyer Stephan	Levitated optomechanics with aspheric nanoparticles and microcavities	Markus Arndt
9:40-9:55	Lanz Andreas	Physics of a non-neutral plasma within a cusped magnetic field	Eberhard Widmann
9:55-10:10	Nowak Lilian	Deexcitation and cooling techniques for precision measurements with antihydrogen	Eberhard Widmann
10:10-10:40	**Bernd Aichner**	**Tuning the electronic properties of superconductors by Helium-ion-irradiation**	
10:40-11:10	COFFEE BREAK		
11:10-11:25	Tüchler Marlene	Probing the strong interaction with kaonic atom x-ray measurements at low energies	Eberhard Widmann Johann Zmeskal
11:25-11:40	Postl Andreas	Automated manipulation of single atoms using focused electron irradiation	Toma Susi
11:40-11:55	Barzegar Hamed	Cosmological non-vacuum spacetimes	Fajman David
11:55-12:10	Fiore Mosca Dario	Quantum Magnetism in Relativistic Oxides	Cesare Franchini
12:10-12:40	**Uros Delic**	**Cooling of a levitated nanoparticle to the motional quantum ground state**	
12:40-13:40	LUNCH BREAK		
13:40-13:55	Kysela Jaroslav	Entanglement, interference and manipulation of systems in high dimensions	Anton Zeilinger
13:55-14:10	Ecker Sebastian	Entanglement distribution over noisy quantum channels	Anton Zeilinger
14:10-14:25	Rosenberg Margaret	Phase behavior of colloidal magnetic patelets	Sofia Kantorovich
14:25-14:40	Mostarac Deniz	Structural and magnetic properties of supracolloidal, nanoscopic magnetic filaments and filament based soft matter systems	Sofia Kantorovich
14:40-15:10	**Iurii Chubak**	**Active topological glass**	
15:10-15:30	COFFEE BREAK		
15:30-15:45	Sukurma Zoran	Auxiliary field quantum Monte Carlo method in projector augmented-wave method	Georg Kresse
15:45-16:00	Maestre Vazquez Dante	Enhancing Phase Imaging with Local Wavefront Shaping Techniques	Thomas Juffmann
16:00-16:15	Wirtitsch Daniel	Quantum Sensing using the Nitrogen Vacancy Center in Diamond	Philip Walther
16:15-16:30	Silvestri Raffaele	Gravitational induced phase shift on single photons	Philip Walther
16:30-16:45	Trillo Fernandez David	Exploring time in non-relativistic quantum mechanics	Caslav Brukner
16:45-17:00	Chirita Mihaila Marius Constantin	Wavefront shaping of free electrons using light	Thomas Juffmann

Tuning the electronic properties of superconductors by Helium-ion-irradiation

Bernd Aichner[1], Benedikt Müller[2], Kristijan Luka Mletschnig[1], Max Karrer[2], Johannes David Pedarnig[3], Vyacheslav R. Misko[4], Dieter Kölle[2], and Wolfgang Lang[1]

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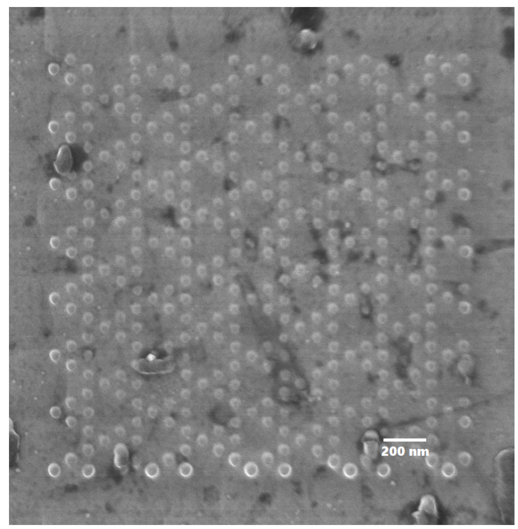
[4] *University of Antwerpen*

Superconductors exhibit intriguing electronic properties when they are cooled below their critical temperature T_c, but their application is by now limited because of the high demand on cooling power. One way out could be the use of high-T_c-superconductors as for example $YBa_2Cu_3O_{7-\delta}$ (YBCO) which has a critical temperature above the boiling point of liquid nitrogen and allows thus for relatively cheap operation. One drawback in the fabrication of electronic devices from this material is its sensitivity to surface damage, which limits the use of conventional etching techniques. A promising method to realize nano-structures in such materials is the local irradiation with light ions, which makes the material non-superconducting instead of removing it.



This can be done, for example, by exposing the superconducting film to the collinear beam of an ion implanter and shading the parts which are intended to remain superconducting by a mask. Indeed, many experiments have been succesfully conducted with this method and it was shown that it is suitable to produce structures with a size of a few hundreds of nanometers [1]. However, we needed to find an other way to produce smaller structures and found it in the use of a helium-ion microscope. These machines have been developed only recently (For further information, see for example ref. [2]) and allow for surface-sensitive imaging with a resolution of 0.5 nm. By intentionally defocusing the beam, they are also suitable to produce nano-structures in thin films of high-temperature superconductors. We use this technique to create artificial defect columns in YBCO films, and investigate the resulting electronic properties by electronic transport measurements at temperatures between 4.2 K and 300 K and in magnetic fields up to 1 T. Since magnetic fields penetrate into a type-II superconductor like YBCO in the form of single flux quanta, the motion of these flux quanta can be used as a method to investigate the influence of the artificially created defect columns. The flux quanta are preferentially anchored in defects and since their motion causes dissipation, stable arrangements that impede motion lead to high critical currents and low resistance.

The aim of this talk is to introduce the concept of manipulating flux quanta and tuning thus the electronic transport properties of YBCO films by the introduction of artificial defect columns. The design of a helium-ion microscope is briefly described and it's applicability to produce defects in superconductors is discussed. The results of electronic transport measurements are presented, which show the practicability of this method [3] and the possibility to switch between two stable states of flux quanta arrangements in a superconducting structure realized by this technique [4].

References

[1] V. Moshchalkov, R. Wördenweber, and W. Lang, *Nanoscience and Engineering in Superconductivity.* Springer Berlin Heidelberg, 2010.

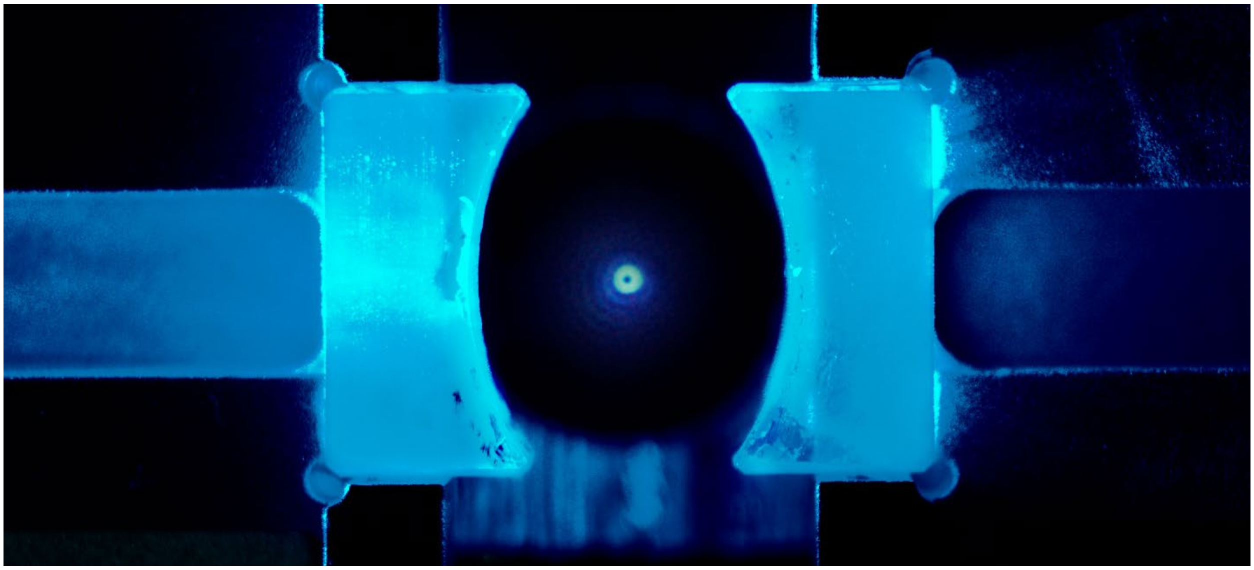
[2] G. Hlawacek and A. Gölzhäuser, *Helium Ion Microscopy.* Springer International Publishing: Switzerland, 2016.

[3] B. Aichner, B. Müller, M. Karrer, V. R. Misko, F. Limberger, K. L. Mletschnig, M. Dosmailov, J. D. Pedarnig, F. Nori, R. Kleiner, D. Koelle, and W. Lang, "Ultradense Tailored Vortex Pinning Arrays in Superconducting $YBa_2Cu_3O_{7-\delta}$ Thin Films Created by Focused He Ion Beam Irradiation for Fluxonics Applications," *ACS Applied Nano Materials*, vol. 2, pp. 5108–5115, Jul 2019.

[4] B. Aichner, K. L. Mletschnig, B. Müller, M. Karrer, M. Dosmailov, J. D. Pedarnig, R. Kleiner, D. Koelle, and W. Lang, "Angular magnetic-field dependence of vortex matching in pinning lattices fabricated by focused or masked helium ion beam irradiation of superconducting $YBa_2Cu_3O_{7-\delta}$ thin films," *Low Temperature Physics/Fizika Nizkikh Temperatur*, vol. 46, no. 4, 2020. in press (to appear on February 28, 2020).

Cooling of a levitated nanoparticle to the motional quantum ground state

Uroš Delić



Owing to its excellent isolation from the thermal environment, an optically levitated silica nanoparticle in ultra-high vacuum has been proposed as a promising candidate to achieve quantum behavior of massive objects at room temperature, with applications ranging from sensing to testing fundamental physics. As a first step towards quantum state preparation of the nanoparticle motion, both cavity and feedback cooling methods have been used to attempt cooling to its motional ground state, albeit with many technical difficulties. We have recently developed a new experimental interface, which combines stable (and arbitrary) trapping potentials of optical tweezers with the cooling performance of optical cavities, and demonstrated operation at desired experimental conditions [1]. Even in such a reliable system ground state cooling has so far been elusive, mostly due to high laser phase noise at low motional frequencies and co-trapping by the cavity associated with high intracavity photon number. These problems have been resolved by implementing a new cooling method – cavity cooling by coherent scattering – which we employ to finally demonstrate ground state cooling of the nanoparticle motion [2, 3]. In this talk I will describe cavity cooling by coherent scattering and present our most recent results on the ground state cooling.

[1] Delić, Grass et al., arXiv:1902.06605 (2019)
[2] Delić et al., Phys. Rev. Lett. 122, 123602 (2019)
[3] Delić et al., Science 30 Jan 2020 (arXiv: 1911.04406)

Active topological glass

Iurii Chubak

The glass transition in soft matter systems is generally triggered by an increase in packing fraction or a decrease in temperature. It has been conjectured that the internal topology of the constituent particles, such as polymers, can cause glassiness too.

However, the conjecture relies on immobilizing a fraction of the particles and is therefore difficult to fulfill experimentally. Here we show that in dense solutions of circular polymers containing (active) segments of increased mobility, the interplay of the activity and the topology of the polymers generates an unprecedented glassy state of matter. The active isotropic driving enhances mutual ring threading to the extent that the rings can relax only in a cooperative way, which dramatically increases relaxation times.