Posters

Soft Plasmonic Composites for Nanomachines - Sean Cormier, NanoPhotonics

Reversible expanding and contracting soft plasmonic composites can be used for optically controlled nanomechanical actuators. These actuators are capable of controlled programmable work and act as a new tool to manipulate objects at extremely small scales. They can help change how we interact with nanoscale objects which play key roles in biological processes.

In this work, plasmonic nanoparticles are coated with thermoresponsive polymers that exhibit fast mechanical actuation from the synergistic combination of plasmonic heating and the temperature-dependent coil-to-globule phase transition of particular polymers. Various light-induced behaviours of these particles are studied, including reversible aggregation and disaggregation in solution, single nanoparticle fast oscillations, dynamic films for object manipulation, and DNA origami flexing nanomachines.

Material Removal Mechanisms during the Solid Particle Erosion of PCD - Arthur Henderson, SMF

Polycrystalline diamond (PCD) was first commercially produced in the 1970s for use in tooling [1]. Combining the hardness of diamond with the toughness of a polycrystalline microstructure it was employed in applications where extreme wear resistance was desired. Finding uses in oil well drilling, coal mining and in large diamond tipped saws [2], it was a suitable replacement for tungsten carbide and other hard materials. As novel applications are explored, it is important to fully understand the wear mechanisms present and the conditions under which each of them occur.

Here, three different grades of PCD are subjected to solid particle erosion (SPE) with sub-millimetre silicon carbide particles at velocities of up to 200 m/s. SPE is a useful wear test as the damage from a large number of impacts (of order 10^5) is measured together to give a precise erosion rate without the need for testing a large number of samples, typical for a brittle material. SEM images of the surface taken between erosion intervals reveal the changes in surface topology due to a small number of impacts.

[1] Wentorf, R. H. et al, “Diamond Tools for Machining”, US Patent 3,745,623, 27-12-1971

[2] Bellin, F et al, Varel International, The current state of PDC bit technology, in World Oil. Oct 2010. p. 53-58.

Ultracold atoms in quasicrystalline optical lattices - Jr-Chiun Yu, Atomic, Mesoscopic and Optical Physics

Quasicrystals are long-range ordered and yet non-periodic. This interplay results in a wealth of intriguing physical phenomena, such as the inheritance of topological properties from higher dimensions, and the presence of non-trivial structure on all scales. Here we report on thefirst experimental demonstration of an eightfold symmetric optical lattice, realising a two-dimensional quasicrystalline potential for ultracold atoms. Using matter-wave diffraction, we observe the striking self-similarity of the quasicrystalline structure, in close analogy to Shechtman's veryfirst discovery of quasicrystals using electron diffraction. The diffraction dynamics on short timescales constitutes a continuous-time quantum walk on a homogeneous four-dimensional tight-binding lattice. These measurements pave the way for quantum simulation in higher dimensions.

Quality control for ATLAS ITk strip sensor production - Christoph Klein, High Energy Physics

With the upgrade of the LHC to the High-Luminosity LHC (HL-LHC), scheduled to commence in 2024, the Inner Detector will be replaced with the new all-silicon ATLAS Inner Tracker (ITk) to maintain tracking performance in this high-occupancy environment and to cope with the increase of approximately a factor of ten in the integrated radiation dose. The outer four layers in the barrel and six disks in the endcap region will consist of strip modules, built with single-sided strip sensors and glued-on hybrids carrying the front-end electronics necessary for readout.

The strip sensors are manufactured as n-in-p strip sensors from high-resistivity silicon, which would allow operation even after fluences expected towards the end of the proposed lifetime of the HL-LHC. Prototypes of different sensor designs have been extensively tested electrically as well as in testbeam setups, yielding mixed results especially in terms of long-term stability. Since pre-production is scheduled to start at the end of 2019, it has become increasingly necessary to have a quality control (QC) procedure for strip sensors which can identify emerging problems with manufacturing results for single sensors or whole batches, ranging from generic electric properties to reliability of long-term operation, as well as understanding the underlying processes. An overview over the QC procedure and its results will be given as well as details about the ongoing challenges.

Ultracold Atoms in an Optical Kagome Lattice - Max Melchner, Atomic, Mesoscopic and Optical Physics

We are currently building a cold-atom experiment to study ultracold atoms in an optical kagome lattice. In the tight-binding approximation, the three lowest motional bands of the kagome lattice are separated from higher-lying bands by a large energy gap. The third lowest energy band is analytically flat. We aim to populate the flat band with ultracold atoms, which should allow us to study effects that arise in strongly correlated many-body systems (e.g. the spin liquid state).

One of the major experimental challenges will be to stabilize the atomic cloud in the flat band of the kagome lattice. Since the flat band is not the lowest band, it will not be occupied by an ultracold atomic gas. There are two basic ways of occupying the flat band: Either one changes the sign of hopping, thereby inverting the band structure such that the flat band is the lowest, or one creates a stable population inversion. In the experiment we are building, we want to do the latter. By using attractive interactions in potassium, we intend to set an upper bound on energy, which will naturally lead to a negative temperature state. An atomic cloud in this negative temperature state will predominantly occupy the highest energy levels, which in our case are in the flat band.

With our experiment we will be able to study transport in a flat motional band. With the addition of interactions and the ability of switching between fermionic and bosonic atoms, we believe this to be an extremely versatile platform for research into single- and many-body localization as well as frustration effects and macroscopic degeneracy of bands.

Homogeneous Bose gas with tuneable interactions - Lena Bartha, Atomic, Mesoscopic and Optical Physics

We explore out of equilibrium quantum many-body physics with an ultra cold gas of 39-K in an "optical box trap". With the help of laser light and magnetic fields, ensembles of 100.000 atoms are cooled to temperatures of tens of nanokelvin, where the quantum mechanical properties dominate their behaviour and a phase transition to a Bose-Einstein condensate occurs. In contrast to the more common harmonic confinement potentials our trapping geometry enables experiments with a homogeneous density and minimal influence of the confinement potentials on the microscopic behaviour. A magnetic Feshbach resonance allows us to arbitrarily tune the interatomic interaction strength over a large continuous range up to a regime where theoretical descriptions are difficult. First, we present how three-body recombination, which so far has mainly been known as a source of unwanted losses and heating, leads to a cooling effect and can even reduce entropy due to bosonic bunching in the three-body correlation function.

In a second project we study a turbulent cascade, which is a steady state under continuous drive. It is characterised by a power law momentum distribution and arises from energy and particle flow between different length scales due to non-linear couplings. The cascade state is universal with respect to the microscopic details of the drive. We are currently investigating the interaction dependence of turbulence in the Bose gas and its implications in the larger context of universal scalings far from equilibrium.

A Two-dimensional Box Trap for Ultracold 39K Atoms with Tunable Interactions - Maciej Galka, Atomic, Mesoscopic and Optical Physics

Ultracold atoms constitute a powerful platform to study strongly-correlated many-body physics due to the high level of control of their confinement, interactions and dimensionality. It has long been known that dimensionality profoundly modifies the physics in the quantum degenerate regime. While three-dimensional Bose gases exhibit Bose-Einstein condensation and superfluidity below a finite critical temperature, thermal fluctuations suppress the emergence of true long-range order associated with Bose-Einstein condensation in a two-dimensional (2D) homogeneous gas. For sufficiently high phase-space densities, however, the 2D Bose gas exhibits an infinite-order topological phase transition to a superfluid, known as Berezinskii-Kosterlitz-Thouless (BKT) transition, which crucially depends on the strength of the interparticle interactions. In the harmonic traps used in previous experimental work, the inhomogeneous atomic density has complicated quantitative studies of the thermodynamics, spatial correlations and out-of-equilibrium dynamics. By exploiting novel light shaping methods we created a 2D uniform trap for bosonic 39K atoms. Taking advantage of the homogeneity of our system we will investigate outstanding problems including the universal jump of the superfluid density which is predicted to occur at BKT phase transition and critical dynamics of lower-dimensional systems.

Prototyping Fourier: A Science Beam Combiner for the MROI, a Next Generation Optical Interferometer - Daniel Mortimer, Astrophysics

The Magdalena Ridge Observatory Interferometer (MROI) is currently under construction in New Mexico at an altitude of 3.2 km. When completed it will consist of ten 1.4 m telescopes and will operate at wavelengths from 0.6 to 2.4 μm. Here we present the preliminary design of the Free-space Optical multi-apertUre combineR for IntERferometry (FOURIER), the first generation near infrared science beam combiner at the MROI which is currently under development. The combiner will operate in the J, H and K bands and combine three beams from the currently funded subset of three telescopes. The primary aim of the combiner is to reach faint limiting magnitudes, leading to its unique design.

The drive towards faint limiting magnitudes is motivated by the science cases of the MROI. A top-level science case is the study of Active Galactic Nuclei (AGN). Optical interferometry offers a unique view as it is possible to spatially resolve the dust torus, broad line, and narrow line regions of AGN, breaking many of the degeneracies present in unresolved observations. Current generation interferometers however have been limited to a dozen or so targets due to sensitivity limits however the MROI aims to observe of order 200 AGN, which will allow for a statistical comparison of the spatially resolved morphology of AGN at optical wavelengths for the first time.

Two-loop five-point massless QCD amplitudes using Integration-By-Parts identities - Herschel Chawdhry, High Energy Physics

Scattering amplitudes are the backbone of theoretical predictions for observables at particle colliders such as the LHC. High-precision predictions for these observables can be compared to experimental measurements in order to test the Standard Model and possibly reveal hints of physics beyond the standard model.

To precisely calculate scattering amplitudes in gauge theories such as Quantum Chromodynamics (QCD), multi-loop integrals need to be evaluated. Multi-loop integrals are the bottleneck in many high-precision QCD calculations and are often evaluated with the help of Integration-By-Parts (IBP) identities.

We present a new strategy for solving IBP identities and apply this towards the calculation of 2-loop massless QCD amplitudes with 5 external particles.