O 85: Vacuum Science & Technology: Theory and Applications II

Time: Thursday 15:00–17:00 Location: HSZ/0401

Invited Talk O 85.1 Thu 15:00 HSZ/0401

From light to pressure: Laser-based quantum technologies for the realization of high-precision pressure and vaccum standards — •Tom Rubin — Physikalisch-Technische Bundesanstalt (PTB), Berlin

The new realization of the pascal in the range between 1 Pa and 100 kPa is achieved by means of photonic pressure measurement. This not only enables significantly lower measurement uncertainties, but also more robust and faster-operating systems that can cover the entire pressure range continuously and for different gases. Gas-density-based methods open up new perspectives: from precise calibrations at the highest metrological level to non-invasive applications in vacuum technology and the development of innovative pressure sensors for the mass market.

This presentation is about key findings and highlights from the EU projects *QuantumPascal* and *MQB-Pascal*. These include overcoming major challenges, such as the need for sub-mK-level gas temperature knowledge, the advantages of the GAMOR (Gas Modulation Refractometry) method, and the latest results from validation and comparison measurements.

O 85.2 Thu 15:30 HSZ/0401

Near Ambient Pressure ARPES for Operando Surface Studies at Synchrotron SOLEIL — •L. Dudy[1], E. Auffray[1,2], J.-J. Gallet[1,3], F. Bournel[1,3], M. Bouaziz[3], B. S. Mun[4], S. Jang[4], Y. Tsujikawa[5], H. Kondoh[5], S. Moser[6], V. Jovic[10], V. Mischke[7], P. Kessler[8], and S. Maehl[9] — [1]Synchrotron SOLEIL, France — [2]U Paris-Saclay, France — [3]Sorbonne U, France — [4]GIST, South Korea — [5]Keio U, Japan — [6]U Bochum, Germany — [7]TU Dortmund, Germany — [8]U Würzburg, Germany — [9]SPECS, Germany — [10]GNS Science, New Zealand

We present a near-ambient pressure angle-resolved photoemission spectroscopy (NAP-ARPES) setup for operando studies of electronic structure under gas exposure at Synchrotron SOLEIL. This development bridges the gap between conventional UHV ARPES and realistic surface environments, enabling momentum-resolved measurements during catalytic and energy-related processes at pressures up to several millibars. The approach is demonstrated using model systems, showing that band structure evolution can be tracked in real-time during adsorption and reaction. These results highlight the potential of NAP-ARPES for investigating dynamic surface phenomena. By extending ARPES into near-ambient conditions, this method opens new opportunities for studying functional materials under realistic environments for operando electronic structure analysis in surface science.

O 85.3 Thu 15:45 HSZ/0401

A new framework for analysing transport ARPES applied to the current induced insulator to metal transition in Ca_2RuO_4. — •Anders Sandermann Mortensen, Hippolyte Raymond Bourel, Katarina Ogliara Praest, Davide Curcio, and Philip Hofmann — Institute of Physics and Astronomy, Aarhus University

The advent of μm-resolution spatially resolved ARPES-measurements allows for in-operando measurements of modifications to the electronic band structure of electrical devices (transport-ARPES). However, this technique poses a new set of challenges, as local biasing of the samples results in systematic shifts of the measured energy, hindering direct comparison of ARPES spectra.

Here, we propose a novel solution to this problem: Realigning the spectra by minimizing the L1-norm between them. Combined with k-means clustering, this provides an effective framework for real-time analysis and characterisation of transport-ARPES measurements.

As a proof of concept, we apply our analysis scheme to transport-ARPES measurements of the current-induced insulator to metal transition in Ca_2RuO_4, and thus provide new, high statistics measurements of the changes to the electronic band structure during the current-induced insulator to metal transition.

O 85.4 Thu 16:00 HSZ/0401

Cross-correlation measurements of a Two-Color Infrared Free-Electron Laser — •Akash Chandra Behera, América Yareth Torres Boy, Sandy Gewinner, Marco De Pas, Gert von Helden, Martin Wolf, Wieland Schöllkopf, Gerard Meijer, and Alexander Paarmann — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Infrared-Free Electron Lasers (IR-FEL) uniquely provide high-power narrowband radiation for spectroscopic measurements, that is continuously tunable from the mid-IR to the terahertz spectral range.

The IR-FEL at the Fritz Haber Institute recently commissioned a two-color upgrade, enabling simultaneous lasing at two independently tunable wavelengths. This is realized by employing a high-frequency kicker cavity to feed alternating electron bunches into the two separate undulators. Within this scheme, a high intrinsic temporal synchronization between both FEL outputs is expected.

In our contribution, we present two-color optical cross correlation measurements proving this synchronization. By leveraging the independently tunable pulse durations in each FEL, we further explore the achievable time-resolution that can be expected when the two-color FEL is employed for future IR-IR pump-probe experiments

O 85.5 Thu 16:15 HSZ/0401

K-Means Clustering of Time-Resolved Diffraction: Dynamics of Laser-Excited Si(111)-(7x7) — •Jonas D. Fortmann[1,2], Alexander Neuhaus[1], Pascal Dreher[1,3], Birk Finke[1], Christian Brand[1], and Michael Horn-von Hoegen[1] — [1]Uni Duisburg-Essen, Duisburg, Germany — [2]MAX IV, Lund, Sweden — [3]Uni Würzburg, Würzburg, Germany

We present an unsupervised analysis workflow that leverages k-means clustering to extract characteristic dynamics from time-resolved diffraction data, using ultrafast reflective high energy electron diffraction (URHEED) measurements of laser-excited Si(111)-(7x7) as a case study. Delay-dependent intensity profiles of diffraction features are clustered by trajectory shape to reveal characteristic dynamics without prior model assumptions. When combined with a simple population model, relative integral-intensity changes of clusters yield lifetimes of coupled phonon systems and trace the excitation pathway to surface electronic states. The method is robust to practical limitations (e.g., camera light sensitivity), scales to large datasets, and is directly transferable to other diffraction modalities (ULEED, UTEM, and pump-probe X-ray diffraction), where clustering of intensity evolutions can provide an objective map of structural dynamics.

O 85.6 Thu 16:30 HSZ/0401

ESEM Automation - Agent-Oriented Autonomous Microscopy — •Maurits Vuijk[1], Johannes Zeininger[2], Karsten Reuter[1], Thomas Lunkenbein[3], and Christoph Scheurer[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]TU Wien — [3]Universität Bayreuth

Are the datasets captured in usual Environmental Scanning Electron Microscopy (ESEM) experiments truly representative? While focusing on a single view or feature, critical events may occur elsewhere on the accessible surface. In addition, effects such as beam damage and inhomogeneous gas concentration introduce further need for more representative surface sampling. Starting from an automation interface to the ESEM, we have built an agent-oriented framework that enables fully autonomous ESEM experiments. To achieve this, the actions normally carried out by the human operator are instead performed by various agents. To this end, a set of agents keep up image quality by controlling brightness and contrast, focus and astigmatism without interrupting the imaging flow. A set of computer vision agents analyze captured images on the fly for interesting features and activity. Using a dynamic priority queue system, high-resolution frames are automatically taken of identified active zones. Each overview image is processed and scored based on activity, feature presence, or other desired qualities. The queue system then assigns an acquisition frequency based on the score, giving priority to more active zones. This gives a full set of overview images and multiple smaller image sets of dynamically identified active areas.

O 85.7 Thu 16:45 HSZ/0401

Image Stacking: A Simple Method to Enhance SNOM Measurements — •Florian Mangold[1], Farid Aghashirinov[1], Enrico Baù[2], Julian Schwab[1], Bettina Frank[1], Andreas Tittl[2], and Harald Giessen[1] — [1]4th Physics Institute, Research Center

SCoPE, and Integrated Quantum Science and Technology Center, University of Stuttgart, Germany — [2]Nano-Institute Munich, Department of Physics, Ludwig-Maximilians Universität München, Germany

Scanning near-field optical microscopy (SNOM) enables optical characterization with spatial resolution far beyond the diffraction limit, making it a powerful tool for studying nanoscale optical and material properties. However, achieving a high signal-to-noise ratio (SNR) in SNOM can be challenging and, depending on the experimental conditions, sometimes not feasible. We present a simple and equipment-free method to enhance SNOM performance by aligning and stacking multiple sequential measurements. This procedure effectively increases the SNR while avoiding drift-induced errors and system alterations. In addition, the stacking process suppresses outliers and isolated noise contributions, further improving data quality. We demonstrate that stacked SNOM measurements can surpass the quality of single measurements under comparable conditions. This straightforward method can be broadly applied to strengthen existing SNOM experiments and opens possibilities for measurements in challenging regimes, including low-signal materials, extended wavelength ranges, and higher-order demodulation schemes where conventional single-shot SNR would be insufficient.