Awards Symposium (SYAW)

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Overview of Prize Talks and Sessions

(Lecture hall Audimax 1)

Prize Talks

SYAW 1.1	Wed	13:30–14:00	Audimax 1	**Organic semiconductors - materials for today and tomorrow** — •Anna Köhler
SYAW 1.2	Wed	14:00–14:30	Audimax 1	**PbTe/CdTe nanocomposite as an attractive candidate for room-temperature infrared detectors** — •Grzegorz Karczewski
SYAW 1.3	Wed	14:40–15:10	Audimax 1	**Fingerprints of correlation in electronic spectra of materials** — •Lucia Reining
SYAW 1.4	Wed	15:10–15:40	Audimax 1	**Artificial Spin Ice: From Correlations to Computation** — •Naëmi Leo
SYAW 1.5	Wed	15:40–16:10	Audimax 1	**From microwave optomechanics to quantum transport – carbon nanotubes as highly versatile hybrid devices** — •Andreas K. Hüttel
SYAW 1.6	Wed	16:20–16:50	Audimax 1	**Quantum spin dynamics of a spin-1/2 antiferromagnetic Heisenberg-Ising chain** — •Zhe Wang
SYAW 1.7	Wed	16:50–17:20	Audimax 1	**Imaging the effect of electron transfer at the atomic scale** — •Laerte Patera

Sessions

SYAW 1.1–1.7	Wed	13:30–17:20	Audimax 1	**Prize Talks**

SYAW 1: Prize Talks

Time: Wednesday 13:30–17:20 Location: Audimax 1

Prize Talk SYAW 1.1 Wed 13:30 Audimax 1
Organic semiconductors - materials for today and tomorrow — •Anna Köhler — Universität Bayreuth, 95448 Bayreuth — Laureate of the Max-Born-Prize 2020

Even though organic semiconductors are a firm part of our daily life, e.g. as displays in mobile phones and as photoconductors in every photocopier, many aspects of their semiconducting nature are still scientifically challenging. To allow for future, advanced applications, such as flexible solar cells, bioelectronic sensors or coated electrotextiles, we need a deeper appreciation of their optoelectronic properties. In this talk I want to introduce what makes up the optical and electronic properties of this class of semiconductors, what determines how they work, and how do they differ from inorganic semiconductors. I will focus on particular how quantum size effects impact on (i) the binding energy of excitons and how this can be overcome for solar cell applications, and (ii) the magnitude of the exchange energy between singlet and triplet states and illustrate approaches to employ this for display applications.

Prize Talk SYAW 1.2 Wed 14:00 Audimax 1
PbTe/CdTe nanocomposite as an attractive candidate for room-temperature infrared detectors — •Grzegorz Karczewski — Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warszawa, Poland — Laureate of the Smoluchowski-Warburg-Prize 2021

The presentation will be devoted to describe the morphological, optical and transport properties of a PbTe/CdTe nanocomposite. Such a nanocomposite is fabricated by depositing alternating multiple PbTe and CdTe thin films by molecular beam epitaxy (MBE). PbTe and CdTe are immiscible. The immiscibility is due to the different crystal structures in which the two materials crystallize (PbTe in the rock salt and CdTe in the zinc blende structure). The observed topological transitions leading to material separation in the PbTe/CdTe system can be treated as an analogue of the spinodal decomposition of an immiscible solution in the solid state and thus can be qualitatively described by the Cahn-Hillard model.

Resistors made of the PbTe/CdTe nanocomposite exhibit pronounced sensitivity to infrared radiation at room temperature. Possible mechanisms causing the relatively high performance of PbTe/CdTe detectors are the decrease in electron concentration in the conductive PbTe layers due to the capture of mobile electrons by the dangling bonds present at the PbTe/CdTe interfaces and the effective suppression of Auger recombination in nanostructures made of narrow and wide band gap semiconductors.

10-Minute Break

Prize Talk SYAW 1.3 Wed 14:40 Audimax 1
Fingerprints of correlation in electronic spectra of materials — •Lucia Reining — LSI, CNRS/CEA/Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau,France — European Theoretical Spectroscopy Facility — Laureate of the Gentner-Kastler-Prize 2020

Many properties of materials are determined by electronic excitations, which can be observed in spectroscopic experiments, such as absorption or photoemission. However, electronic spectra of a real many-body system are often very different from what an independent-particle picture would suggest. How can theory understand, and how can calculations predict, the wealth of unexpected phenomena that may take place ? Density functional theory and many-body perturbation theory based on Green's functions are powerful approaches to face this problem, and indeed, ab initio calculations often yield reliable band structures. However, electronic excitation spectra contain much more: they may exhibit lifetime broadening, an incoherent background or distinct satellite structures. These features are pure correlation effects that cannot be captured by any independent-particle picture, and they are at the forefront of the capabilities of current first principles approaches. In this talk we will present recent progress in the theoretical description and analysis of correlation effects such as satellites in photoemission and inelastic x-ray scattering spectra, using density functionals [1], Green's functions [2], and close collaboration with experiment, and we will discuss new challenges. [1] e.g., M. Panholzer, M. Gatti, and L. Reining, Phys. Rev. Lett. 120, 166402 (2018). [2] e.g., J.S. Zhou, et al., J. Chem. Phys. 143, 184109 (2015); PNAS 117, 28596 (2020).

Prize Talk SYAW 1.4 Wed 15:10 Audimax 1
Artificial Spin Ice: From Correlations to Computation — •Naëmi Leo — CIC nanoGUNE BRTA, Donostia - San Sebastián, Spain — Laureate of the Hertha-Sponer-Prize 2021

Collective ordering phenomena in magnetic materials can lead to the emergence of surprising material properties, especially when spin-spin interactions are competing. Artificial spin ices, which are arrays of magnetostatically-coupled single-domain nanomagnets, have become a testbed to study emergent correlations and phase transitions in tailored two-dimensional lattices. In recent years, further functionalities of such magnetic metamaterials have been explored, based on their field-driven reconfigurability and thermally-driven relaxation behaviour. These could open up the potential for novel low-powered computation schemes.

In this talk, I will give a brief introduction into the field of artificial spin ices. Then I will discuss observation of ordering phenomena in extended lattices as well as recent developments to manipulate the relaxation kinetics via light-controlled plasmonic heating in small-scale circuits for nanomagnetic computation.

Prize Talk SYAW 1.5 Wed 15:40 Audimax 1
From microwave optomechanics to quantum transport – carbon nanotubes as highly versatile hybrid devices — •Andreas K. Hüttel — Institute for Exp. and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — Laureate of the Walter-Schottky-Prize 2021

Single wall carbon nanotubes are in many respects an outstanding model system. From transport spectroscopy, ferromagnet/superconductor-nanotube hybrid devices, and nano-electromechanics all the way to microwave optomechanics, the work of my group here covers by now a wide range of topics. I intend to present both a brief introduction and a select number of recent highlights, with an outlook towards our future research plans.

10-Minute Break

Prize Talk SYAW 1.6 Wed 16:20 Audimax 1
Quantum spin dynamics of a spin-1/2 antiferromagnetic Heisenberg-Ising chain — •Zhe Wang — Department of Physics, TU Dortmund University, Dortmund, Germany — Laureate of the Walter-Schottky-Prize 2020

One-dimensional (1D) spin chains are text-book examples for illustrating basic concepts, such as phase transition and spin dynamics. Apart from magnon excitations with an integer quantum number, excitations with fractional quantumnumber (e.g. spinons with $S = 1/2$) and complex magnon bound states (i.e. Bethe strings) are usually introduced also in the context of spin-chain models. As being exactly solvable, the 1D models provide understanding of the basic concepts in the exact sense, thus it is also a subject of a constant stream of theoretical studies. However, an experimental study of the exotic magnetic excitations is far from straightforward. This is because a proper material realization of the 1D models is scarce, and the magnetic excitations need to be disentangled from other degrees offreedom and at the same time, detectable by available experimental techniques. Recently, these difficulties are overcome in our experimental studies of the spin-1/2 antiferromagnetic Heisenberg-Ising chain compounds SrCo2V2O8 and BaCo2V2O8. I will present our terahertz spectroscopic investigations of quantum spin dynamics in these compounds as a function of temperature and in high magnetic fields. We have been able to identify the long sought-after many-body string excitations, the excitations of confined spinons, as well as magnons, which are characteristic for the different phases connected by magnetic field-induced quantum phase transitions in the 1D spin-1/2 Heisenberg-Ising antiferromagnet.

Prize Talk SYAW 1.7 Wed 16:50 Audimax 1
Imaging the effect of electron transfer at the atomic scale — •Laerte Patera — Institute of Experimental and Applied Physics, University of Regensburg, 93053 Regensburg, Germany — Laureate of the Gustav-Hertz-Prize 2020

Electron transfer plays a crucial role in many chemical processes, from photosynthesis to combustion and corrosion. However, the way in which redox reactions affect individual molecules and, in particular, their electronic structure, remains largely unclear. Unveiling these fundamental aspects requires the development of experimental tools allowing the observation of electron transfer down to the single molecule level. Here, we demonstrate the capability of performing tunnelling experiments on non-conductive substrates to map the orbital structure of isolated molecules upon electron transfer. By driving a change in the redox state of a molecule synchronized with the oscillating tip of an Atomic Force Microscope, previously inaccessible electronic transitions are resolved in space and energy [1]. Our results unveil the effects of electron transfer and polaron formation on the single-orbital scale, opening the door to the investigation of redox reactions and charging-related phenomena with sub-ångström resolution.

[1] L. L. Patera, F. Queck, P. Scheuerer and J. Repp, Nature 566, 245-248 (2019).