HGSFP

NEWSLETTER

Heidelberg Graduate School of Fundamental Physics

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Main Topics:

- Student activities
- The "Axion Haloscope"
- Interfaces in Organic and Hybrid Optoelectronics
- Simulating the complexity of galaxy formation
- The 33rd Heidelberg Physics Graduate Days

Editorial

In this edition of our newsletter, we bring you some exciting physics contributions from different HGSFP groups. We highlight the work of Joerg Jaeckel, searching for dark matter, Yana Vaynzof, developing organic and hybrid interfaces, and Volker Springel's "Illustris Simulation" of galaxy formation. Meet also our student representatives, who warmly encourage all doctoral students to participate in monthly meetings and the football cup.

Sandra Klevansky and Rüdiger Klingeler

Student activities

■ Dear fellow students,
We would like to announce once again the newly fixed date of our HGSFP-*Stammtisch*. We will meet every last Tuesday of the month in the Marstall mensa starting from 20:00. There will always be a reminder on the weekend before each meeting. We cordially invite you all to come to this *Stammtisch*.

In August, there will be the prestigious HGSFP Soccer Cup, so it's probably time to start practising!

Particularly for new students, we would like to point out our HGSFP-Wiki, which has lots of useful information. You will find it at http://wiki.kip.uni-heidelberg.de/hgsfp/.

Please feel free to contact us in case of any organisational problems, questions or new ideas. You can reach us at studentreps@gsfp.uni-heidelberg.de.

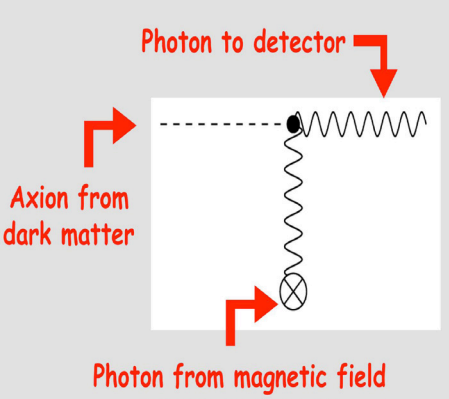
Your representatives
Walter Hahn and Puneet Murthy ◀

The "Axion Haloscope"

■ Currently Joerg Jaeckel (see overpage) is investigating the possibility that very light and very weakly coupled particles could form all or part of dark matter. Such particles are well motivated in extensions of the Standard Model. The prime example of such particle is the axion, motivated by the Peccei-Quinn solution to the question why CP is not violated by the strong interactions. Due to their very different properties from the usual heavy particle paradigm, they require new techniques for their detection.

An example for such a technique is the so-called axion haloscope where Dark Matter axions interact with a magnetic field and are converted into detectable photons (see figure).

A central topic of Joerg Jaeckel's current research is the optimization of such existing search strategies as well as the development of new ones. You can find his office at the Institute for Theoretical Physics, Philosophenweg 16. ◀



Interaction of Dark Matter axions with a magnetic field

Interfaces in Organic and Hybrid Optoelectronics

■ Organic/hybrid optoelectronic devices have drawn the attention of both the academic and industrial research communities due to the potential for a low-cost, large area, solution processible technology alternative to conventional inorganic optoelectronics. The function and performance of these devices is tightly related to their nanostructure and the electronic structure of the surfaces and hetero-interfaces of the device components. Many organic/organic and organic/TiO_2 interfaces have been extensively investigated, and efficient optoelectronic devices - such as polymer: fullerene and Grätzel solar cells - have been successfully demonstrated.

In her academic research, Yana Vaynzof (see overpage) and her research group focus on the study of the vast array of interfaces that are far less investigated. For example, they found that remarkable 50% of photoexcitations result in bound charge pair (BCP) states at the polymer/ZnO interface, never directly observed previously. They also showed that a self-assembled monolayer modification of the interface halves the amount of BCPs, resulting in a three-fold increase in the photovoltaic performance.

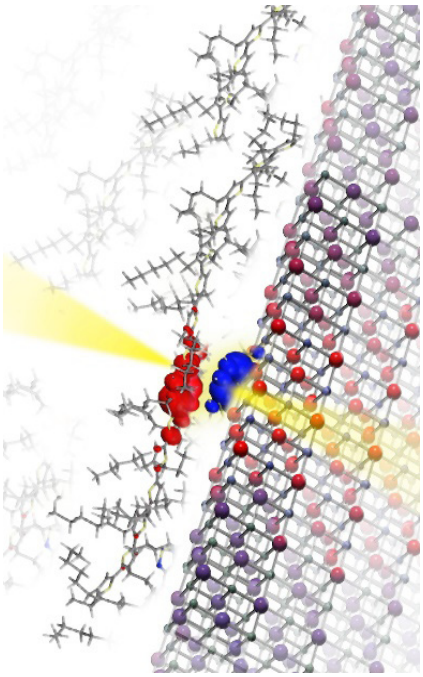


Illustration of exciton charge separation across a hybrid interface in an organic-organic photovoltaic device

Through their work, Yana and her group have demonstrated that once the interfacial structure is resolved and the physio-chemical processes are well understood, it is possible to tame even disordered interfaces to be utilized in a broad range of optoelectronic applications.

You can find Yana Vaynzof at the Kirchhoff Institute for Physics (KIP), INF 227, room 02.312. ◀

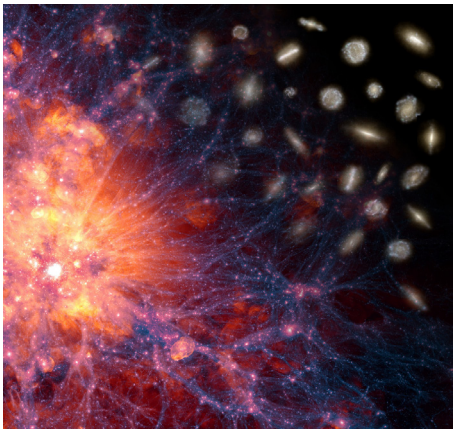
Simulating the complexity of galaxy formation

■ Galaxies are comprised of up to several hundred billion stars and display a variety of shapes and sizes. Their formation involves a complicated blend of astrophysics, including gravitational, hydrodynamical and radiative processes, as well as dynamics in the "dark sector" of the Universe, which is comprised of dark matter and dark energy.

Because the governing equations are too complicated to be solved analytically, numerical simulations have become a primary tool in theoretical studies of cosmic structure formation. The group of Volker Springel at the Heidelberg Institute for Theoretical Studies (HITS) and the Zentrum für Astronomie (ZAH) develops advanced numerical simulation codes for following structure growth far into the non-linear regime. Using large parallel supercomputers, they model representative pieces of the Universe and aim to predict how galaxies formed and how they cluster in space.

An example of this work is the recent "Illustris Simulation", currently the largest and most advanced hydrodynamical simulation of galaxy formation. The calculation used a novel moving-mesh methodology developed by the group, which offers higher accuracy than previous approaches. It also employed a refined treatment of galaxy formation physics. Thanks to these advances, the simulation was for the first time able to reproduce the observed morphological mix of galaxies, consisting of disk-like and spheroidal systems.

Also, observed properties of the neutral hydrogen distribution such as the abundance and metal content of so-called damped Lyman-alpha absorbers could be explained. Ongoing work of the group seeks to add magnetic fields and non-thermal particle components (so-called cosmic rays) to the calculations. Another challenge lies in simulations that self-consistently account for radiative transfer effects such as the driving of galactic winds by radiation pressure. ◀



Visualization of the "Illustris Simulation"

Yana Vaynzof

Joerg Jaeckel

Walter Hahn

Puneet Murthy

Personalia

■ In this edition of our newsletter we profile JProf. Yana Vaynzof and Prof. Joerg Jaeckel and introduce Walter Hahn and Puneet Murthy, who are our student representatives.

Originally from sunny Israel, **Yana Vaynzof** recently joined the Kirchhoff Institute for Physics (KIP) and the Centre for Advanced Materials (CAM) as a junior professor. She received her B.Sc. degree in electrical engineering from the Technion-Israel Institute of Technology, Haifa, Israel, in 2006 and the M.Sc. degree in electrical engineering from Princeton University, Princeton, NJ, in 2008. She pursued a Ph.D. degree in physics under the supervision of Prof. Sir Richard Friend at the Optoelectronics group, Cavendish Laboratory, University of Cambridge, to investigate the photo-physical processes governing the efficiency and stability of hybrid polymer solar cells.

Upon completing her Ph.D. in 2011, she continued her research as a postdoctoral research associate under the supervision of Prof. Henning Sirringhaus, focusing on photoemission spectroscopy studies of organic electronic devices.

Joerg Jaeckel joined Heidelberg University in October 2012. His research focuses on physics beyond the Standard Model and novel approaches to search for it. Prior to joining the Institute for Theoretical Physics he was a staff member at the Institute for Particle Physics Phenomenology in Durham, UK, where he is now also a visiting professor. Before that he was a postdoc at DESY in Hamburg. Joerg Jaeckel obtained his doctorate in 2003 here in Heidelberg.

Walter Hahn is working with Prof. Boris Fine on foundations of quantum statistical physics. In his doctoral project at the Institute for Theoretical Physics, he studies the effect of measurements on the statistical properties of almost completely isolated quantum systems. In particular, he investigates the observability of individual statistical distributions in modern experiments. A better understanding of quantum ensembles emerging under realistic experimental conditions may lead to tests of the conventional postulates of quantum physics.

Puneet Murthy is part of the Ultracold Quantum Gases research group of Prof. Selim Jochim at the *Physikalisches Institut*. Before joining the group more than one year ago, he studied physics in Mysore, India where he developed, among other topics, a strong interest in quantum many-body systems. In Heidelberg, Puneet is part of a team which is creating and probing trapped atomic gases at temperature scales so low that quantum mechanical effects become dominant. The long term goal of this effort is to understand how microscopic quantum interactions between particles influence the macroscopic behavior of a system.

When he is not working on his research, Puneet likes to travel to new places and cultures and pursue gardening at his home. ◀

The 33rd Heidelberg Physics Graduate Days

■ The coming "Graduate Days" will take place this fall from October 6-10, 2014. As usual, one of the highlights is the Hans Jensen Invited Lecture which this time will be held by Alain Aspect. His lecture is entitled *From Einstein's questions to quantum bits: a new quantum revolution.*

Together with sets of lectures on various topics in both experimental and theoretical physics the lecture programme will also contain one soft skills course as well as an industry lecture.

The courses are organised as parallel block lectures, with the morning lectures taking place from 9:30 to 12:30 and the afternoon lectures from 14:00 to 17:00, including coffee breaks. There is also a free lunch each day included in your registration. Note that each course runs every day for five days either in a morning or afternoon slot.

The courses are open for advanced students, in particular those working on their Diploma, Master's and doctoral theses. Our aim is to offer courses that broaden the physics knowledge of our students as well as to teach specialized techniques. ◀

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