Symposium Fundamentale Wechselwirkungen und ihre Symmetrien (SYWS)

gemeinsam veranstaltet
vom Arbeitskreis AMOP und
dem Fachverband Physik der Hadronen und Kerne (HK)

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In vielen Gebieten der Physik wurde die Präzision der Experimente in den vergangenen Jahren in fast atemberaubender Weise gesteigert. Grundlegende Größen wie atomare Massen, Teilchenenergien und –impulse, magnetische Moment u.a. können mit erstaunlicher Präzision bestimmt werden. Die höchste Genauigkeit wird erreicht, wenn das betrachtet System, hier kalte und ultrakalte Neutronen, Ionen oder Atome, eine sehr geringe Energie hat. Die erreichte Messgenauigkeit erlaubt es inzwischen, grundlegende Fragen der Physik und Kosmologie ins Blickfeld zu nehmen. Die Vortragsreihe wird einen Überlick und Statusbericht weltweit führender Gruppen auf dem Gebiet der Präzisionsexperimente zur Bestimmung der grundlegenden Kraftkonstanten der Natur und der Tests fundamentaler Symmetrien geben.

Übersicht der Hauptvorträge und Fachsitzungen

(Hörsaal 1A/B/C)

Hauptvorträge

SYWS 1.1	Mi	14:00–14:30	1A/B/C	**Electric dipole moments: theory and experiment** — •E.A. Hinds
SYWS 1.2	Mi	14:30–15:00	1A/B/C	**Improved Tests of Lorentz and CPT Symmetry using Noble-Gas Masers** — •Ronald Walsworth
SYWS 1.3	Mi	15:00–15:30	1A/B/C	**Precision measurements with cold neutrons** — •Torsten Soldner
SYWS 2.1	Mi	16:00–16:30	1A/B/C	**Cold and ultracold molecules - a path for fundamental studies** — •Gerhard Rempe
SYWS 2.2	Mi	16:30–17:00	1A/B/C	**The time Dependence of Fundamental Constants** — •Thomas Udem
SYWS 2.3	Mi	17:00–17:30	1A/B/C	**Highly-charged ions for high-precision Penning trap mass spectrometry** — •Szilard Nagy
SYWS 2.4	Mi	17:30–18:00	1A/B/C	**Determination of the neutrino mass** — •Christian Weinheimer

Fachsitzungen

SYWS 1.1–1.3	Mi	14:00–15:30	1A/B/C	**Fundamental Interactions and their Symmetries I**
SYWS 2.1–2.4	Mi	16:00–18:00	1A/B/C	**Fundamental Interactions and their Symmetries II**

SYWS 1: Fundamental Interactions and their Symmetries I

Zeit: Mittwoch 14:00–15:30 Raum: 1A/B/C

Hauptvortrag SYWS 1.1 Mi 14:00 1A/B/C

Electric dipole moments: theory and experiment — •E.A. Hinds — Centre for Cold Matter, Imperial College London

New elementary particle physics (beyond the standard model) is needed at the 1 TeV energy scale to understand the origin of mass and to explain why we see more matter than antimatter in the universe. This same new physics is expected to give permanent electric dipole moments to elementary particles. Thus the search for electron and neutron EDMs is the search for new particle physics. I will discuss the status and prospects of these searches and their implications for elementary particle theory.

Hauptvortrag SYWS 1.2 Mi 14:30 1A/B/C

Improved Tests of Lorentz and CPT Symmetry using Noble-Gas Masers — •Ronald Walsworth — Harvard University

I will discuss recent improvements of the ^{129}Xe/^{3}He Zeeman maser used to make measurements constraining Lorentz and CPT violation. Experimental investigations of Lorentz and CPT symmetry provide important tests of the framework of the Standard Model of particle physics and theories of gravity. Our previous measurements with the ^{129}Xe/^{3}He Zeeman maser set stringent limits on rotation- and boost-dependent Lorentz and CPT violation involving the neutron, consistent with no effect at the level of 10^{-31} GeV and 10^{-27} GeV, respectively. Recent upgrades to the system should lead to an order-of-magnitude improvement in sensitivity to Lorentz and CPT violation.

Hauptvortrag SYWS 1.3 Mi 15:00 1A/B/C

Precision measurements with cold neutrons — •Torsten Soldner — Insitut Laue Langevin, Grenoble, France

Cold neutrons provide several ways to investigate fundamental symmetries and interactions and to search for "new physics": Right-handed contributions to weak interaction or time reversal violation beyond the Standard Model can be searched for by precision measurements of correlations between neutron decay products. The neutron's electric dipole moment is a very sensitive probe for new sources of time reversal violation. Measurements of asymmetries in reactions of polarised neutrons with light nuclei provide information on the weak contributions to nucleon-nucleon processes. I will present related experiments that have been carried out at the Institut Laue Langevin.

SYWS 2: Fundamental Interactions and their Symmetries II

Zeit: Mittwoch 16:00–18:00 Raum: 1A/B/C

Hauptvortrag SYWS 2.1 Mi 16:00 1A/B/C

Cold and ultracold molecules - a path for fundamental studies — •Gerhard Rempe — Max-Planck Institute for Quantum Optics, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

Remarkable progress has been made in the ability to produce samples of cold and ultracold neutral molecules, homonuclear and heteronuclear, with and without permanent dipole moment, thus opening up new possibilities for precision experiments and fundamental studies. In our laboratory, we have been able to extract the slowest molecules of dipolar gases such as formaldehyde or water with near-unity efficiency from a thermal reservoir, guide the molecules over long distances and trap them, all with electric fields. We have associated ultracold rubidium molecules from ultracold atoms by means of ultranarrow Feshbach resonances, and have produced highly correlated arrays of such molecules in optical lattices. The talk reviews some of these experiments, including the realization of a universal cold molecules source operated at liquid Helium temperature, the measurement of the rotational distribution of the guided molecules, and the investigation of fundamental quantum phenomena which occur when ultracold molecules are restricted to move in zero or one spatial dimension.

Hauptvortrag SYWS 2.2 Mi 16:30 1A/B/C

The time Dependence of Fundamental Constants — •Thomas Udem — Max-Planck Institut für Quantenoptik Garching

Since Webb *et al.* [1] have detected a slightly smaller fine structure constant by quasar absorption spectra about 10 billion years ago an old idea of P.A.M. Dirac [2] from 1937 was revived. Using arguments philosophical in nature he speculated that fundamental constants should vary along with the expanding universe. For a long time the only possibility to search for these minute changes was to exploit the large look-back time of astronomical or geological observations. With the advent of frequency combs the possibility to check for these time variations in the laboratory with optical transitions in atoms, ions and molecules became readily available. Even though the time period covered by these laboratory measurements is typically 10 orders of magnitude shorter than for astronomical observations, they can be 10 orders of magnitude more accurate to provide comparable sensitivity. The question of the time dependence of fundamental constants is of high relevance in the context of modern cosmological models.

[1] J. K. Webb et al. Phys. Rev. Lett. **87**, 091301 (2001).
[2] P.A.M. Dirac Nature, **139**, 323 (1937).

Hauptvortrag SYWS 2.3 Mi 17:00 1A/B/C

Highly-charged ions for high-precision Penning trap mass spectrometry — •Szilard Nagy — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

This contribution will give a detailed insight into the field of high-precision mass spectrometry employing a Penning Trap Mass Spectrometer (PTMS), where the main observable is the cyclotron frequency $\nu_c = qeB/(2\pi m)$ of an ion with charge-to-mass ratio q/m trapped in a homogeneous magnetic field B. The application of ions with multiple charges in high-precision mass spectrometry yields a distinct benefit due to an increased resolution $\nu_c/\Delta\nu_c$.

Recent results will be presented mostly from the Penning trap mass spectrometer SMILETRAP with emphasis on results relevant for fundamental physics questions. Among the highlights are the most precise tritium beta decay Q-value [1], which is of importance in the search for a finite rest mass of the electron anti-neutrino; a newly evaluated ^{76}Ge double beta-decay Q-value [2] relevant in the search for neutrinoless double beta-decay ($0\nu\beta\beta$); the masses of the lithium-like and hydrogen-like ^{40}Ca ions [3], which are indispensable input values when evaluating g-factor measurements of the bound electron in these ions.

Other Penning trap facilities dedicated to highly-charged ions will be discussed such as HITRAP at GSI Darmstadt.

References
[1] Sz. Nagy *et al.*, Europhys. Lett. **74**, 404 (2006)
[2] M. Suhonen *et al.*, JINST **2**, P06003 (2007)
[3] Sz. Nagy *et al.*, Eur. Phys. J. D **39**, 1 (2006)

Hauptvortrag SYWS 2.4 Mi 17:30 1A/B/C

Determination of the neutrino mass — •Christian Weinheimer — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

The recent evidences for neutrino oscillation from atmospheric, solar, reactor and accelerator neutrinos prove, that neutrinos of different flavour are non-trivial mixtures of non-zero neutrino mass eigenstates. Oscillation experiments determine differences between squared neutrino masses, but not the masses, which are very important for particle physics as well as for cosmology and astrophysics.

Information on the absolute neutrino mass scale is obtained from astrophysical observations, from the search for the neutrinoless double beta decay and directly from the investigation of the endpoint region of the tritium or rhenium single beta decay.

The cosmological method and the status of the double beta decay experiments will be discussed. The KATRIN experiment, which is currently being set up by an international collaboration at Forschungszentrum Karlsruhe will be presented. By investigating the tritium beta decay spectrum KATRIN will improve the direct neutrino mass sensitivity by one order of magnitude to 0.2 eV allowing to distinguish between hierarchical and quasi-degenerate neutrino mass scenarios and to check the cosmological relevant neutrino mass range.