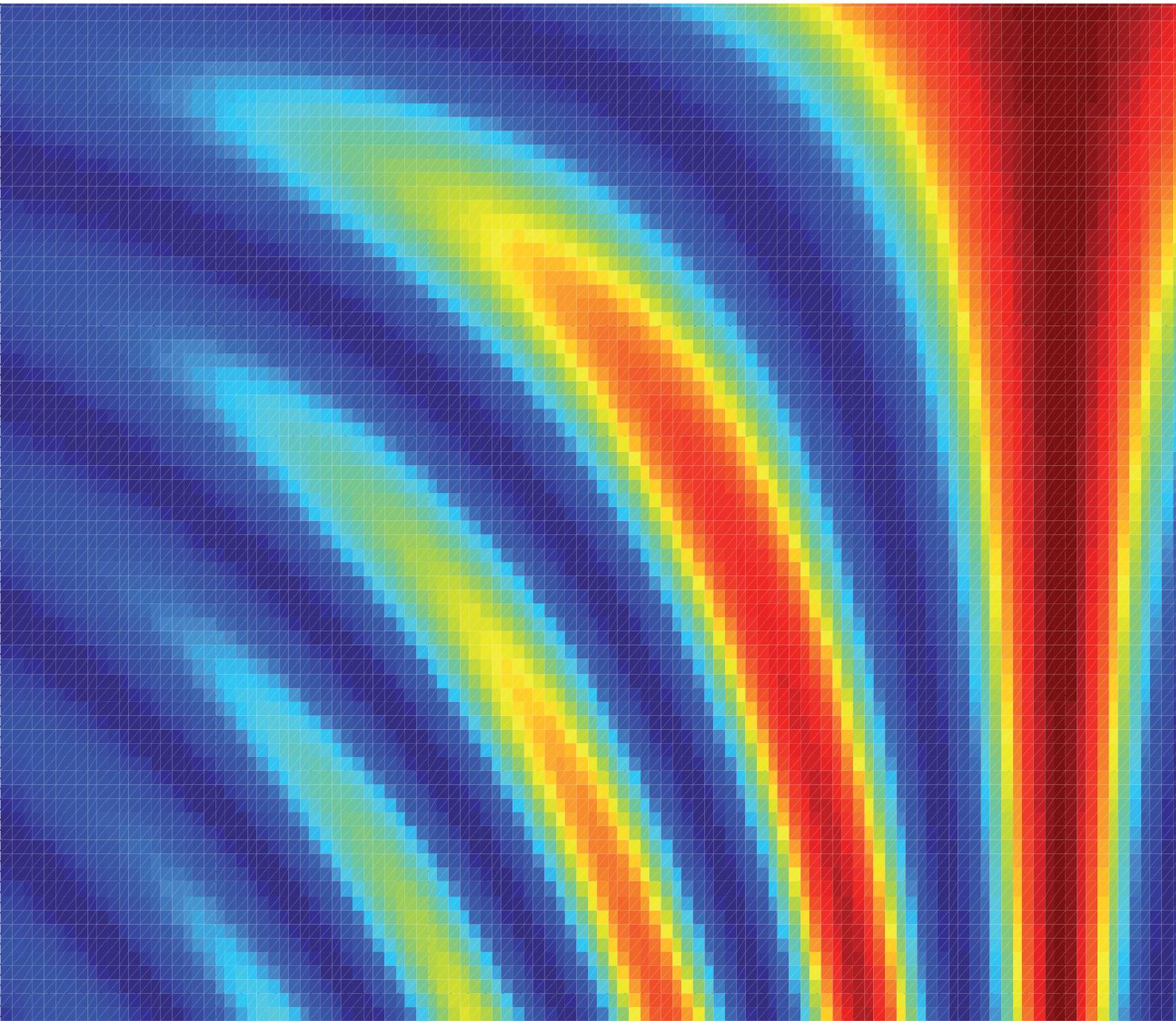




MAX-PLANCK-GESELLSCHAFT

# MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

## PROGRESS REPORT 2009–2010



*Cover: FT-ICR line profiles of stored ions in a Penning trap using a Ramsey excitation pattern.*



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## Foreword

This report covers the scientific work performed at the Max-Planck-Institut für Kernphysik during the years 2009 and 2010. The first two chapters contain the research areas “Crossroads of Particle Physics and Astrophysics” and “Many-Body Dynamics of Atoms and Molecules”. All major subtopics are introduced by a specific introduction followed by detailed reports of that specific field. Information about the on-site experimental facilities, service units and workshops is provided in the third chapter. The Annex contains lists of publications, invited talks, lectures and courses at universities, jointly organized conferences and workshops, habilitations, dissertations, and diploma theses as well as institutional collaborations, the MPIK organizational structure and personnel.

A partial and by no means complete list of scientific highlights characterizing the reporting period, and described in more detail in the corresponding sections of this report, is: First hints on differences between matter and antimatter was seen in the LHCb detector in proton-proton collisions at 7 TeV in the large Hadron Collider LHC of CERN. Clear evidence for antineutrinos with energies corresponding to the decay of U and Th in the Earth’s interior, so-called geoneutrinos, was found by Borexino proving that radioactivity contributes substantially to geothermal heating. The H.E.S.S. telescope system succeeded to observe the starburst galaxy NGC 253, the weakest-ever detected high-energy gamma-ray source as a point-like object and also Centaurus A, a nearby radio galaxy with an active galactic nucleus. The cosmic dust detector on board of the Cassini spacecraft further analyzed the dust particles in the diffuse E ring around Saturn and thereby traced dust plumes of individual ice geysers. The diffraction pattern of a single virus exposed to a single hard X-ray pulse of the LCLS at SLAC was registered with the newly developed CAMP instrument and the 30 nm resolution enabled reconstruction of the compartmentalized interior of the virus. Calculations on the expansion and inner dynamics of a quark-gluon plasma revealed large intermediate anisotropy which opens the possibility to produce yoctosecond double pulses of GeV energy aiming for future pump-probe experiments at nuclear and high-energy processes. Examination of the dissociative recombination of hydronium ions with cold electrons in the TSR showed that the water molecules formed are vibrationally highly excited corresponding to temperatures of several ten thousand Kelvin explaining infrared bands found in spectra of some comets. A process occurring in the neighborhood of Black Holes, the ionization of Fe atoms to about  $\text{Fe}^{14+}$  by X-rays, was reproduced in an EBIT at BESSY II and the high-resolution spectra identified the most accurate theoretical model.

The developments of the institute’s in-house and remote facilities are the seed for future results: The steel structure of H.E.S.S. II is now under construction at the site in Namibia by a new company. The preparatory phase of CTA, a next-generation international facility for gamma-ray astronomy strongly promoted by MPIK scientists, is now supported by the European Commission and coordinated by Werner Hofmann. The commissioning of the GERDA experiment is on-going aiming at improved measurements of neutrinoless double beta decay. The Double Chooz far detector has been completed which will lead to improved neutrino oscillation measurements. XENON1T is a next-generation Dark Matter experiment building on the success of XENON100 and which will cover most of the expected parameter space for WIMP Dark Matter. The construction of the cryogenic storage ring CSR proceeded with the installation and successful leakage tests of the outer vacuum chambers before the assembly of the electrostatic beam optics in the first quadrant started. A high-voltage platform that will house the ion source feeding the CSR has been installed. The new PENTATRAP laboratory in the basement of the accelerator building was deployed for first measurements in fall 2010. The CFEL ASG multi-purpose instrument CAMP has been developed by MPIK researchers for measurements at free-electron-laser facilities like FLASH in Hamburg or LCLS in Stanford. An in-ring reaction microscope has been successfully implemented in the TSR and another one is under design for the CSR.

The institute provides an excellent research environment which makes it very attractive to junior research groups. Since early 2009 two new junior research groups joined, one led by Thomas Pfeifer and the other by Daniel Fischer, supported by MPG and DFG in its Emmy Noether program, respectively. Thomas Pfeifer is working on attosecond spectroscopy, interferometry and quantum control, while Daniel Fischer performs precision studies on ion collisions. The Emmy Noether funding of Alban Kellerbauer ended in August 2009

and his group is now part of the division of Joachim Ullrich. The Emmy Noether group of Elisa Resconi also expired after five years at the end of the reporting period and she left the Institute to join the Exzellenzcluster “Origin and Structure of the Universe” in Munich. In addition, Melanie Schnell-Küpper since October 2010 is head of an independent junior research group in the ASG at CFEL in Hamburg.

A further International Max Planck Research School on “Precision Tests of Fundamental Symmetries in Particle Physics, Nuclear Physics, Atomic Physics and Astroparticle Physics” with Manfred Lindner as spokesperson and Klaus Blaum as deputy spokesperson has been established in 2010 together with the University of Heidelberg. A new IMPRS for “Ultrafast Imaging and Structural Dynamics” at the University of Hamburg was approved in December 2010.

Numerous distinctions to MPIK scientists are proofs of the recognition extended to our Institute: Wolfgang Krätschmer with the European Inventor Award 2010 in the category Lifetime Achievement, external scientific member Volker Soergel with a honorary doctorate of the University of Hamburg, Werner Hofmann with a membership in the Heidelberger Akademie der Wissenschaften, Yuri Litvinov with a visiting professorship for senior international scientists of the Chinese Academy of Science, Felix Aharonian, Werner Hofmann, Heinz Völk and the H.E.S.S. collaboration with the Rossi prize 2010 of the high energy astrophysics division of the American Astronomical Society, German Hermann and Till Kirsten with distinguished fellowships of the McDonnell Center for Space Sciences, Klaus Blaum with the membership award of the GSI Exotic Nuclei Community, Jörg Evers with the Sigrid-und-Viktor-Dulger-Preis and a Kollegiat of the Heidelberger Akademie der Wissenschaften, Erik Viktor Lötstedt, Michael Andreas Schmidt and Joachim Kopp with Otto Hahn Medals of the MPG, Joachim Kopp also with a Otto Hahn junior research group, as well as Andreas Fischer and Christian Hofrichter with the Otto Haxel prize. Manfred Lindner was elected in the Vorstandsrat of the DPG and Jörg Evers was selected Outstanding Referee for the journals of the American Physical Society. Last but not least, Sebastian Hummel and Kevin Zink in 2009 as well as Julia Schlicksupp in 2010 received apprentice’s prizes of the MPG, and also the Institute’s apprentices’ workshops for electronics and for precision mechanics in 2010 received prizes of the MPG.

The success of the institute is further visible in appointments of MPIK scientists: During the reporting period Dieter Bauer got a chair in theoretical physics at Rostock University, Selim Jochim a W3 professorship for experimental physics at Heidelberg University, Stefan Schönert a chair in experimental physics at the Technical University of Munich, and Sascha Kempf accepted an assistant professor position with tenure track at the University of Colorado, Boulder.

During the whole reporting period, construction activities in the framework of the second phase of refurbishment of infrastructure were ongoing in many areas of the institute. In the library building, the Otto-Hahn-Hörsaal and the foyer were reconstructed. Work in the accelerator building was continued to meet the demands of the division of Klaus Blaum. A new computer room with efficient air conditioning was built in the basement of the Bothe laboratory replacing an older one. The guest houses were renovated and some remaining work in the Gentner laboratory and in the electronics building was done. In fall 2010, the reconstruction of the footpaths and stairs on the MPIK premises started. The former canteen is foreseen to become a day-care facility for children. The electronic ID badges of the new access-control system also serve as pay cards for the EMBL canteen.

Impressive scientific results have been obtained during the reporting period and quite a number of new projects are very promising for the future. It is therefore fair to say that the major restructuring of the institute during the last years has been mastered very successfully and that MPIK has a bright future. I would like to thank all members of the institute and all outside partners for their dedication and support.



Manfred Lindner  
Managing Director

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