Foreword

This report for the first time covers three years, 2011 through 2013. In a new layout, the present report provides extended overview articles on all activities of the Institute, each with a title page and including the most important references. The chapters of the report address “1 Crossroads of Particle Physics and Astrophysics”, “2 Many-Body Dynamics of Atoms and Molecules”, and “3 Service Units, Facts and Figures”. Lists of publications, theses, invited talks, teaching activities, organized conferences, and institutional collaborations are provided on the accompanying CD.

A selection of scientific highlights characterizing the reporting period comprises:

The first light, inauguration and commissioning of the H.E.S.S. II telescope in 2012 – right to the 10th anniversary of the first H.E.S.S. telescope – marked a big step in very-high-energy gamma-ray astronomy. Already a short observation of the ‘standard candle’, the Crab Nebula, with H.E.S.S. II proved its superior capabilities.

An improved lower limit for the half-life of the neutrinoless double beta decay in ^{76}Ge was determined by the GERDA experiment. It casts serious doubts on the former claim of the Heidelberg-Moscow experiment. The recorded energy spectrum showed no indication of a peak at the expected energy (Q-value); the analysis procedure and all cuts had been fixed before analyzing data.

The XENON100 experiment has pushed the limits for dark matter to new records, which were meanwhile partly checked by another experiment. At the same time construction of XENON1T has started which will improve the sensitivity by another factor of 100 to probe the most interesting region.

The symbiosis of experimental and theoretical expertise has enabled a most stringent test of quantum electrodynamics (QED) in strong fields. Based on this joint work the uncertainty of the electron mass value has been improved by a factor of 13 compared to the presently best value.

A new nuclear magic number at N = 32 has been observed by mass measurements of neutron-rich Ca isotopes. This magic number had been predicted by a new class of ab-initio calculations including also three-body nuclear forces.

Laboratory astrophysics explores cosmic processes in controlled and reproducible ways. A joint experimental and theoretical study of highly charged iron ions has solved a long-standing controversy concerning X-ray spectra of stars. Reactions of H_3^+ – a key species in cosmic chemistry – have been studied in great detail at interstellar temperatures.

MOTReMi, a novel and world-wide unique combination of a cold magneto-optically trapped (MOT) target with a reaction microscope (ReMi) was developed at MPIK. For the first time magnetic dichroism in ion-atom collisions was observed in the dynamics of laser-prepared lithium atoms under highly charged ion bombardment.

Structural changes in acetylene molecules have been traced in a pump-probe experiment at the free-electron laser FLASH in Hamburg. The geometry of the molecule was reconstructed from the measured fragment momenta using a reaction microscope. Isomerization was found to occur within about 50 femtoseconds.

Control of absorption line shapes was experimentally demonstrated in the photoionization of helium by attosecond extreme ultraviolet light pulses. The result can be interpreted in an intuitive analytic way as a phase control in the time domain. This opens the possibility to transform absorption into gain, by inducing a phase shift of π.

A fully relativistic tunneling picture of laser-driven ions has been developed theoretically predicting means of measuring the short times spent in the classically forbidden regime. Coherent superpositions of nuclear quantum states via vacuum coupling have been demonstrated both in theory and in experiment with Mössbauer nuclei and X-ray light.

As regards the in-house scientific infrastructure, the cryogenic storage ring CSR is now close to commissioning and will open a new era in laboratory astrophysics. To provide the resources for its construction and commissioning, and ultimately to free space for new installations, operation of the accelerators and the test storage ring TSR was stopped at the end of 2012. The accelerator control room will be rearranged to control the CSR. Further, preliminary work started for the reconstruction of areas in the accelerator halls after dismantling of the accelerators to gain new laboratories and offices.

In recognition of his achievements at MPIK, Joachim Ullrich was appointed president of the Physikalisch-Technische Bundesanstalt, the German national metrology institute in Braunschweig from the beginning of 2012 on and finally left the MPIK end of that year. Appointment of a successor is underway.

The MPIK provides excellent research environment which makes it very attractive for junior research groups. In the reporting period, two ERC Starting Grant groups led by Alban Kellerbauer (Ultracold Negative Ions by Laser Cooling, UNIC) and Holger Kreckel (Cold Collisions and the Pathways toward Life in Interstellar Space, ASTROLAB), and the Otto-Hahn group of Joachim Kopp (Phenomenology of Colliders, Neutrinos, and Dark Matter, PhenoCOND) joined the Institute. The ERC Starting Grant of Werner Rodejohann was followed up by funding from the MPG to continue his research group. MPG research group leader Thomas Pfeifer won an ERC Consolidator Grant. Melanie Schnell-Küpper moved to the newly founded MPI for the Structure and Dynamics of Matter.

The international recognition and success of the Institute is visible by the numerous distinctions to MPIK members and the appointments of MPIK scientists to Universities, listed in section 3.3.

The Institute is involved in three International Max Planck Research Schools, two of them located at MPIK: for Quantum Dynamics in Physics, Chemistry and Biology (IMPRS-QD) and for Precision Tests of Fundamental Symmetries (IMPRS-PTFS), while the third is located at MPIA: for Astronomy and Cosmic Physics. Based on the excellent evaluation result of the IMPRS-QD as a dynamical and internationally competitive graduate school, the MPG approved a second funding period of 6 years from September 2013 on.

The extensive general refurbishment programme for the technical infrastructure of the buildings ran until end of 2011. Also the visual appearance of MPIK‘s premises was improved now ensuring barrier-free access to all of the buildings. In summer 2013, the reconstruction of the former canteen to a day-care center for children from the age of ½ year ultimately started. Its opening is planned for fall 2014. Additional work has been done in the workshop buildings to improve the technical facilities and working conditions.

Indeed, impressing scientific results have been obtained in the last three years and a number of very promising new projects were initiated. The new appointments will to some degree expand the research fields of the Institute but also continue and strengthen successful projects. It should be emphasized that this success wouldn't be possible without our excellent workshops and the support of the different service groups as well as the administration. In conclusion, I would like to thank all members of the MPIK, in particular also the junior scientists, and as well the partners at universities and outside research institutions for their collaboration, support and enthusiasm.

Klaus Blaum
Managing Director