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Preface

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In recent years, computational physics has been established as an independent field of research. Theoretical particle physics, in particular, has profited from the development of computer-based techniques. In turn, the challenges provided by complex particle physics phenomena have led to new developments in computational physics.

The two central themes of the Collaborative Research Centre / Transregio 9 (CRC/TR) "Computational Particle Physics", the perturbative calculation of high-energy scattering amplitudes using computer algebra and the numerical simulation of quantum field theories on the lattice, are outstanding examples for this fruitful interplay. The CRC/TR was established in 2003 by the German Research Foundation DFG, has been running for 12 years and expired at the end of 2014. It was coordinated by the Karlsruhe Institute of Technology (KIT) and the RWTH Aachen University, and operated jointly with the Humboldt-Universität zu Berlin, the John von Neumann Institute for Computing (NIC) and DESY, Zeuthen. Within the CRC/TR over thousand publications appeared and over one hundred Ph.D. theses were completed, see `http://sfb-tr9.particle.uni-karlsruhe.de` for more detailed information.

The rapid increase in computer resources and substantial algorithmic improvements have considerably extended the research prospects in theoretical particle physics. Including, for example, dynamical fermions in lattice simulations allows to predict observables, like transition matrix elements or particle spectra, with unprecedented precision. On the other hand, computer algebra has offered the opportunity to perform fully automated perturbative calculations at high loop orders, both for inclusive observables like masses and couplings, and for complex scattering processes at high-energy colliders.

The CRC/TR has pursued two main goals: On the one hand, general methods of perturbative quantum field theory and lattice gauge theories have been developed and combined in an efficient way. On the other hand, calculational and mathematical tools have been established and advanced, and have been used to derive a large number of important predictions for low-energy precision physics and for high-energy collider experiments, in particular the LHC.

In combination, these results have contributed, and will continue to contribute, to the determination of fundamental parameters and/or the identification of completely new phenomena with the required accuracy.

It is worthwhile to point out that all this progress would not have been possible without the financial support of the DFG. The funding period of three times four years allowed for ambitious long-term projects that would have been difficult, if not impossible, to address in a different organizational context. Furthermore, many of the projects could not have been pursued so successfully without the fruitful collaboration within the CRC/TR and with many research institutes and colleagues world-wide.

This volume collects review articles on the various scientific results that have been achieved within the CRC/TR. They comprise three main research areas: perturbative methods and lattice simulations in quan-

tum field theory, specific predictions for high-energy reactions, and various aspects of heavy quark and flavour physics. The results have been presented at the final meeting of the CRC/TR from 15 September to 19 September 2014 in Durbach, Germany. The meeting has been attended by close to 100 participants, including a large number of international guests and collaborators. The conference hotel "Vier Jahreszeiten" offered a warm hospitality and excellent meeting facilities. Special thanks go to Ms. Lepold, not only for her help in organizing the meeting, but also for her dedicated and efficient support of the administration of the CRC/TR. The program of the meeting can be found at: `https://indico.desy.de/conferenceDisplay.py?ovw=True&confId=10306`.