

Preface

This volume contains the written versions of the lectures delivered at the “40. Internationale Universitätswochen für Theoretische Physik” in Schladming, Austria. The 40th “Schladming Winter School” took place during the period March 3rd–10th, 2001. The topic of the School was “Dense Matter”.

After the establishment of quantum chromodynamics as the fundamental gauge field theory of strong interactions it soon became an intriguing question whether a new form of matter consisting just of the ultimate constituents of hadrons, i.e. quarks and gluons, would be possible. Could nuclear matter undergo a phase transition and transform to quark matter? What would be the necessary conditions for the creation of the so-called quark-gluon plasma? Did such a state exist at the beginning of the universe and could it still be found somewhere in our cosmos? These were only a few of the questions that could be posed on the issue of a deconfined state of quark matter. Theoreticians rapidly came up with a variety of answers. Sometimes the corresponding predictions were rather speculative but gradually they gained a more quantitative nature. Experimental physicists started to think about ways of realizing the new form of matter in the laboratory. Soon the idea of letting heavy nuclear systems collide at high energies was born. Thereby, possibly, conditions could be reached such that the hadron constituents could get deconfined over a reasonably large local domain and one could observe quark matter. The discipline of heavy-ion physics developed rapidly at the interface between nuclear and particle physics. A lot of effort went into the theoretical and experimental investigations of heavy-ion reactions. In particular, experimentalists had a hard time reaching a stage where they could manage head-on collisions of heavy nuclei at energies large enough so that a quark-gluon plasma could be formed. After many years and a long series of experiments, in early 2000 sufficient and convincing enough experimental data were accumulated so that physicists at CERN could announce the observation of quark matter. Evidently, this brought new enthusiasm to the field of heavy-ion physics. Also, one could then expect exciting new evidence of the quark-gluon plasma from RHIC, which started data taking later on in 2000. Through these developments one certainly had enough reason to devote the 2001 Schladming Winter School to the topic of “Dense Matter”.

We are happy that we got some of the most renowned experts in the field to lecture at Schladming. Thus the meeting not only became a respectable jubilee Winter School – the 40th in a continuous series since 1962 – but was also very successful scientifically. Practically all relevant topics relating to heavy-ion physics and the quark-gluon plasma were dealt with in the lectures presented. C. Lourenço summarized the modern experimental evidence on quark matter formation as they were achieved at CERN. M. Gyulassy complemented them with the most recent data from RHIC, along with exposing the theory of ultra-relativistic heavy-ion reactions, and M. Alford reviewed aspects of quark matter in compact stars. The general theory of the quark-gluon plasma was presented by J.-P. Blaizot, while A. Rebhan explained the treatment within thermal gauge field theories. The evidence on the properties of the quark-gluon plasma so far obtained from lattice QCD calculations were reviewed by F. Karsch. Finally E.V. Shuryak and L. McLerran opened exciting views on a variety of new phenomena that can be studied through quark matter, for example, color superconductivity or the formation of a color glass condensate. We should also mention that all of these lectures were accompanied by a number of seminars given on related topics by the participants of the School.

Here we would like to express our sincere gratitude to the lecturers for all their efforts in preparing, presenting, and finally writing up their lectures. Our thanks are also due to the main sponsors of the School, the Austrian Federal Ministry for Education, Science, and Culture and the Government of Styria, for providing generous support. We also appreciate the contributions from the University of Graz and the valuable organizational and technical assistance from the town of Schladming, Ricoh Austria, and Hornig Graz. Furthermore, we thank our secretaries, S. Fuchs and E. Monschein, a number of graduate students from our institute, and, last but not least, our colleagues from the organizing committee for their valuable assistance in preparing and running the school.

Graz,
October 2001

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<http://www.springer.com/978-3-540-43234-0>

Lectures on Quark Matter

Plessas, W.; Mathelitsch, L. (Eds.)

2002, XIV, 338 p., Hardcover

ISBN: 978-3-540-43234-0