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HEAVY FLAVOURS

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PREFACE

The discovery of the charm quark in November 1974 opened the road to the world of heavy flavours. Since then two new heavy flavours, the τ lepton and the b quark, have been discovered and it is expected that the top quark will be found soon. The list of heavy elementary particles includes also the electroweak bosons $W^\pm$ and Z^0 , which have been with us since 1983; and probably a neutral Higgs particle, which is the most elusive object of the Standard Model.

The physics of heavy particles is not confined to their spectroscopy, their production and subsequent decays. It also involves their impact on various measurable quantities through virtual loop effects containing these heavy particles. One should recall that Gaillard and Lee were able to predict correctly the charm quark mass prior to its discovery by comparing the K_L - K_S mass difference to its experimental value. Similarly the observed B^0 - $\bar{B}^0$ mixing gave the first indication of a large top quark mass (m_t), and present studies of Standard Model loop effects in e^+e^- , $p\bar{p}$ and deep-inelastic collisions favour $m_t \simeq 140 \pm 40$ GeV. The physics of heavy flavours often plays a crucial role in CP violation too, and may also be a hint on a dynamical breakdown of gauge symmetries.

Eighteen years after the discovery of charm, the physics of heavy flavours has developed into a very broad and mature field. Owing to the large masses and momenta involved and to asymptotic freedom in QCD, many calculations and predictions could be made in the perturbative framework improved through renormalization group methods. An impressive amount of work has been done during these years and many technical tools have been developed. Yet not everything can be studied in perturbation theory and consequently new, non-perturbative methods had to be invented. The best-known examples among these are lattice methods, QCD sum rules of various kinds, $1/N_c$ expansions (N_c is the number of colours), and recently the $1/M$ expansion carrying the name of "heavy quark effective field theory".

This book presents a picture of the heavy flavour world painted by selected professionals of this field. We have put the emphasis on physical questions which emerge from the comparison of theory with existing data and on the outlook, rather than on a detailed review of experiments and the methods used to obtain the data. This allowed us to reduce the overlap with the volume *B-Decays*, edited recently by Sheldon Stone.

The present book begins with an introduction of the standard electroweak model and a review of the electroweak corrections to Standard Model parameters (Hollik). The status of electroweak precision tests and the implications and expectations for the value of m_t are summarized. Next, several other methods for indirect determination of the top mass and of its couplings from quark mixing, CP violation and rare decays in the Standard Model are discussed (Buras and Harlander). The consequences of “new” physics (supersymmetry and the extended Higgs sector) on this field are shown by Bertolini.

The chapter by Isgur and Wise introduces the heavy quark effective field theory (HQEFT) and summarizes its advances. The subsequent article by the Heidelberg group (Neubert, Rieckert, Stech and Xu) presents the exclusive weak decays of B mesons, where HQEFT plays an important role. The D -meson decays are discussed by Stone and tau physics is reviewed by Pich. The important advances in calculating low energy parameters by lattice methods, in particular the weak decay constants F_B and F_D , are presented by Sachrajda.

The subsequent two chapters deal with heavy flavours at high energy colliders. While Kühn and Zerwas cover the physics at e^+e^- machines, Nason concentrates on heavy quark production at hadron colliders.

The final three chapters focus on the especially heavy top quark. Bardeen and Hill discuss the status of top condensation models, where $m_t = O(v)$ emerges naturally. Next, the special role of the heavy top quark within and beyond the Standard Model and hints on top condensation models are covered by Lindner. Motivated by the existence of at least one sizable Yukawa coupling in nature, the last chapter deals with the subject of Yukawa models on the lattice (De and Jersák).

In summary: we have covered a wide range of heavy flavour topics, from rather conventional perturbative problems within the Standard Model to non-perturbative questions and/or speculative model extensions. It will be interesting to watch this subject over the years to come when new data arrive.

*A. J. Buras and M. Lindner
Munich, April 1992*