(ACOSTA 94) have published evidence for pure leptonic decays of the D_s^+. BES has also presented evidence in the form of a few events recoiling from tagged D_s^+ mesons in the 4-GeV region in e^+e^-. AOKI 93 claims 8 events in an emulsion experiment and finds a decay constant value of 232 MeV. CLEO-II finds about 39 events above background, corresponding to a decay constant of about 344 MeV. Both experiments have errors of about 75 MeV. The CLEO value is surprisingly large, but the error from the background subtraction and statistics still remains large. For further discussion, see also the "Note on Pseudoscalar-Meson Decay Constants" in the $\pi^\pm$ Full Listings.

See also the "Note on Semileptonic Decays of D and B Mesons" that follows for a review of the many new results in that area.

NOTE ON SEMILEPTONIC DECAYS OF *D* AND *B* MESONS, PART I

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I. Introduction

Weak decays of heavy mesons are classified as hadronic, leptonic, or semileptonic, according to the type of particles present in the final state. The most complicated are hadronic decays, in which strong interactions produce nonperturbative effects that are difficult to calculate. In leptonic decays, the final state contains only a charged lepton and a neutrino; if the decaying meson is a pseudoscalar, the effects of strong interactions in the initial state can be parametrized by a single constant. (See the "Note on Pseudoscalar-Meson Decay Constants" in the $\pi^\pm$ Full Listings.) The rates for leptonic decay, however, are generally small and hard to measure.

Semileptonic decays are more tractable theoretically than hadronic decays, both because the $\ell\nu_\ell$ system produced by the virtual W boson is well understood, and because this system cannot have strong interactions with the hadronic decay products. In addition, semileptonic decay rates are reasonably large and experimentally accessible. As a consequence, semileptonic processes are the primary source of information on the Cabibbo-Kobayashi-Maskawa (CKM) matrix (see "The Cabibbo-Kobayashi-Maskawa Mixing Matrix," in Section 28 of the Reviews, Tables, Figures, and Formulae part of this *Review*).

In this Note, we discuss measurements of semileptonic decays of D and B mesons. These studies have two primary goals: first, to understand the dynamics of semileptonic decays, in particular, the effect of strong interactions on the underlying weak process; and second, to measure the magnitudes of the CKM elements V_{cb} and V_{ub}. These goals are related, because the determination of CKM elements relies on a good understanding of the decay process. Our discussion focuses on the sources of uncertainty in different types of measurements, especially the model dependence in the inclusive B semileptonic branching ratio and in the determination of $|V_{cb}|$ and $|V_{ub}|$.

The effects of strong interactions on the semileptonic decay amplitude can be expressed in terms of one or more Lorentz-invariant functions called form factors, which depend only on q^2, the square of the mass of the virtual W. The number of form factors required to describe a given exclusive decay depends on the quantum numbers of the hadrons in the decay. Information on the form factors is obtained by measuring the distributions of decay angles and q^2, as discussed in the following section.

In the charm sector, the absolute scale of theoretical predictions for decay amplitudes (expressed in terms of form factors) can be tested, because the CKM elements can be determined independently of the D semileptonic decay rate using the assumption of CKM unitarity and the smallness of the CKM elements for B decay. Thus, the study of D-meson semileptonic decays is concerned more with the size and q^2 dependence of the form factors than with the determination of CKM elements. However, studies of form factors in D semileptonic decays should provide theoretical information that will help to improve predictions for $b \to u\ \ell^-\overline{\nu}_\ell$ decays, and hence improve the determination of $|V_{ub}|$.

A development of major importance is the heavy quark effective theory (HQET). In the limit of infinite quark mass, the quark mass and spin decouple from the dynamics of the decay, leading to numerous symmetry relations among form factors. In this limit, the description of a process such as $B \to \overline{D}^*\ell^+\nu_\ell$ is simplified considerably, because both the b and c quarks are heavy. The form factors can then be related to a single universal form factor, the Isgur-Wise function. HQET predictions permit a systematic approach to understanding the dynamics of B-meson semileptonic decays and to determining the magnitudes of CKM elements. HQET predictions for D semileptonic decays are less useful, because symmetry-breaking corrections in this case are expected to be large.

We begin with a brief review of the formalism of form factors for exclusive semileptonic decays and then turn to experimental results on D and B mesons. More detailed information may be found in review articles on semileptonic decays and HQET [1,2,3].

II. Form-factor formalism for exclusive semileptonic decays

The amplitude for an exclusive semileptonic process can be constructed from the available four-vectors in the decay and from form factors, which are Lorentz invariant functions of q^2, the square of the mass of the virtual W. Because these functions describe the effect of strong interactions, nonperturbative techniques such as lattice QCD are needed to calculate them. Form factors are generally largest at the maximum value of q^2, where the daughter meson has the smallest recoil velocity and the overlap between the parent- and daughter-meson wave functions is largest. Studies of form factors in D semileptonic decays have focused on the modes $D \to \overline{K}\ell^+\nu_\ell$ and $D \to \overline{K}^*\ell^+\nu_\ell$, which dominate the inclusive semileptonic rate. In B decays, the analogous modes, $B \to \overline{D}\ell^+\nu_\ell$ and $B \to \overline{D}^*\ell^+\nu_\ell$, account for about two-thirds of the inclusive semileptonic rate. The decay $B \to \overline{D}\ell^+\nu_\ell$ has a large background from