NOTE ON D MESONS

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The new experimental results on charm meson decays reported in this edition are predominantly from CLEO II at the e^+e^- storage ring CESR and from fixed-target experiments, especially photoproduction experiment E687 at Fermilab. The first results from the BES experiment, operating at an e^+e^- center-of-mass energy of 4.0 GeV, also appear in this edition. BES has measured the branching fractions for the purely leptonic decay $D_s^+ \to \mu^+\nu_\mu$ and for $D_s^+ \to \phi\pi^+$, albeit with large statistical uncertainties.

Semileptonic decays

For a detailed discussion of experimental measurements and theoretical predictions for leptonic and semileptonic decays of both charm and bottom hadrons, see the recent review by J.D. Richman and P.R. Burchat [1]. Also see the "Note on Semileptonic Decays of D and B Mesons, Part I," by R.J. Morrison and J.D. Richman, in our 1994 edition [2].

In this edition, we have added to the Particle Listings the measurements of the form-factor ratios for $D^+ \to \overline{K}^{*0}\ell^+\nu_\ell$ and $D_s^+ \to \phi\ell^+\nu_\ell$. The form factors $A_1(q^2)$, $A_2(q^2)$, and $V(q^2)$ are defined in the "Note on Semileptonic Decays of B Mesons" in the B-meson Particle Listings. The ratios $A_2(0)/A_1(0)$ and $V(0)/A_1(0)$ have been measured by Fermilab fixed-target experiments E691, E687, and E653 for the mode $D^+ \to \overline{K}^{*0}\ell^+\nu_\ell$, and by E687, E653, and CLEO for the mode $D_s^+ \to \phi\ell^+\nu_\ell$. For each semileptonic mode, the averages of the measured form-factor ratios can be combined with the measured decay rate to extract the values of the form factors themselves [3]. The results are $A_1(0) = 0.55 \pm 0.03$, $A_2(0) = 0.40 \pm 0.08$, and $V(0) = 1.0 \pm 0.2$ for $D^+ \to \overline{K}^{*0}\ell^+\nu_\ell$ and $A_1(0) = 0.62 \pm 0.06$, $A_2(0) = 1.0 \pm 0.3$, and $V(0) = 0.9 \pm 0.3$ for $D_s^+ \to \phi\ell^+\nu_\ell$. The measured decay rate for $D \to \overline{K}\ell^+\nu_\ell$ can be used to extract the single vector form factor $f_+(0)$. The result is $f_+(0) = 0.74 \pm 0.03$. Recent quark-model predictions are in good agreement with the D measurements. Lattice gauge calculations are in good agreement with the vector form factors but predict axial form factors that are somewhat higher than the measured values.

Measurements of the ratio $\Gamma(D \to \overline{K}^{*}\ell^{+}\nu_{\ell})/\Gamma(D \to \overline{K}\ell^{+}\nu_{\ell})$ confirm the initial experimental result that the ratio is only a little over one half, whereas initial theoretical expectations were that it would be about one. By taking into account effects originally ignored, such as relativistic corrections, theorists have managed to accommodate the observed ratio of rates in quark-model calculations. Lattice gauge calculations are also in reasonable agreement with the measured ratio. In contrast to semileptonic B decays, no evidence for higher-mass resonances or nonresonant final states has been observed in semileptonic D decays.

Although the experimental results are statistically limited, the semileptonic decays $D_s^+ \to \phi\ell^+\nu_\ell$ and $D_s^+ \to (\eta \text{ or } \eta')\ell^+\nu_\ell$ appear to follow the pattern of D decays, both in terms of form-factor ratios and of the relative decay rates to vector and pseudoscalar mesons.

Searches for D^0–$\overline{D}^0$ mixing

There have been a number of papers published recently concerning both the sensitivity of $D^0\overline{D}^0$ mixing to new physics and the validity of various assumptions made in existing searches [4]. We have reorganized the mixing limits in the Listings and have added more detailed comments regarding the assumptions made in various searches.

Absolute branching fractions for D_s^+

Two model-independent measurements of the absolute branching fraction for $D_s^+ \to \phi\pi^+$, from BES and CLEO, appear in this edition. All previous measurements depended on theoretical models or on estimates of D_s^+ production cross sections. We no longer use these older results when calculating the average and fit values for $\mathrm{B}(D_s^+ \to \phi\pi^+)$. The BES collaboration (BAI 95C) uses $e^+e^- \to D_s^+D_s^-$ events in which one or both of the $D_s^\pm$ decays are reconstructed to obtain a measurement of the $D_s^+ \to \phi\pi^+$ branching fraction without assumptions on the cross section for $D_s^\pm$ production. However, with only two events in which both $D_s^\pm$ decays are reconstructed, the result, $\mathrm{B}(D_s^+ \to \phi\pi^+) = (3.9^{+5.1}_{-1.9}{}^{+1.8}_{-1.1})\%$, has a very large statistical uncertainty. For their new measurement, the CLEO collaboration (ARTUSO 96) measures the branching ratio $B(D_s^+ \to \phi\pi^+)/B(D^0 \to K^-\pi^+) = 0.92 \pm 0.20 \pm 0.11$ by partially reconstructing the decay $\overline{B}^0 \to D^{*+}D_s^{*-}$. They then use their measured value of $B(D^0 \to K^-\pi^+)$ to determine $B(D_s^+ \to \phi\pi^+) = (3.59 \pm 0.77 \pm 0.48)\%$.

In the past, we of necessity relied heavily on estimates of $B(D_s^+ \to \phi\pi^+)$ based on measurements of $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \to \phi\pi^+)$, combined with theoretical predictions for $F = \Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D^+ \to \overline{K}^{*0}\ell^+\nu_\ell)$ and measurements of $B(D^+ \to \overline{K}^{*0}\ell^+\nu_\ell)$ and the relative D_s^+ and D^+ lifetimes. Although we include the measured values of $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \to \phi\pi^+)$ in the Listings, we no longer use the individual estimates of $B(D_s^+ \to \phi\pi^+)$ since they are each based on different (and sometimes obsolete) estimates of the measured and theoretical correction factors. Here we apply the current best estimates of the correction factors to the current world average, $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \to \phi\pi^+) = 0.54 \pm 0.05$. When we use the world averages $B(D^+ \to \overline{K}^{*0}\ell^+\nu_\ell) = (4.8 \pm 0.4)\%$ and $\tau(D_s^+)/\tau(D^+) = 0.442 \pm 0.017$, we calculate $B(D_s^+ \to \phi\pi^+)$ to be $(3.9 \pm 0.5)\% \cdot F$. Theoretical estimates for F are near 1.0 with a theoretical uncertainty conservatively estimated to be about 25%. Therefore, this estimate for $B(D_s^+ \to \phi\pi^+)$ is in good agreement with the two new model-independent measurements.

D^+ and D_s^+ decay constants

For the leptonic decays $D^+ \to \ell^+\nu_\ell$ and $D_s^+ \to \ell^+\nu_\ell$ only one parameter for each, called the decay constant, is required to describe the nonperturbative physics. (See also the "Note on Pseudoscalar-Meson Decay Constants" in the $\pi^\pm$ Particle Listings.) Decay constants are also used to describe other processes, such as $D^0\overline{D}^0$ and $B^0\overline{B}^0$ mixing, and hence are quite important. Unfortunately, leptonic decays of heavy mesons have small branching fractions and are difficult to reconstruct. However, observations of leptonic D_s^+ decays have now been published by WA75 (AOKI 93), CLEO II (ACOSTA 94), and BES (BAI 95). The systematic and statistical uncertainties on the D_s^+ decay constant are still large. The branching fractions for leptonic B decays are expected to be so small that observation will not be experimentally feasible for some time. Therefore, as the errors on the D_s^+ decay constant decrease with larger data samples, we would benefit from more theoretical work relating the B decay constant to the more easily measured D^+ and D_s^+ decay constants.

References

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4. G. Blaylock, A. Seiden, Y. Nir, Phys. Lett. **B355**, 555 (1995);
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