RECENT CLEO RESULTS ON CHARM PHYSICS

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ABSTRACT

A summary of recent charm physics results from CLEO 1.5 is presented. Branching fractions for *D°* decays to *K+K~*, *K°K°*, **TT+TT", TTV**, and some other modes involving a *w°* or an r? are given. Using the observation of *Df -+ <j>l+v*, the absolute branching fraction for *Df -> <j>n+* has been derived. A$_c$ results include branching fractions into *pK~x*$^+$, *pK°*, *pR*^{0}*^^*, A?r+, and *Air*$^+$*it~w+*$_f$ and the A$_c$ decay asymmetry parameter.

Introduction

The charm physics results reported in this paper are from **e**$^+$**e~"** annihilation data collected by the CLEO 1.5 detector[1] at the Cornell Electron Storage Ring (CESR) in Ithaca, New York. The data set corresponds to integrated luminosities of 101 pb"[1] below the T(4S) and 212 pb~[1] at the T(4S) taken in 1987 and 116 pb~* taken at the T(5S) in early 1988. About - 1,100,000 hadronic events from the continuum are contained in this data set. Throughout this paper charge conjugate states are implied.

D° decays

While many of the theoretical calculations for rates of two-body, non-leptonic decays of the *D°* are in agreement with experimental measurements, D° -+ *KK* and *D°* -* *ww* present problems. The current world average[3] for the ratio of branching fractions *B{D° -> K+K~)/B(D° -> *+*-)* is 3,9 ± 1.2. This is not easily reconciled with theoretical expectations[3] which range from 1 to 1.4. In lowest order the process D° -> *K°K°* proceeds through two VP-exchange diagrams whose sum cancels in the limit of exact *SU(Z)* flavor symmetry, so *B(D° -> K°K°)* is predicted to be small[4] (~ 10"[4] or less) in a simple quark picture.

Using **J9*$^+$ -* D^{0}TT+** events, selected by requiring |AAf - 145.45 MeV/c^2| < 2.4 MeV/c^2, where AM = M(D*+) - *M(D°)* and *x(D*+)* = *p/pmax* > 0.5, the *K+K~* and ?r$^+$jr~ invariant mass distributions shown in Figs. 1(a) and 1(b) were obtained. The peaks centered at an invariant mass of 1.865 GeV/c^2 are from *D°* -> JfT+iT (249±21 events) and *D°* **-+ TT+T**T (110±15 events), respectively. The other structures are due to reflections from the copious *D°* *K^w*$^+$ and *D°* ->

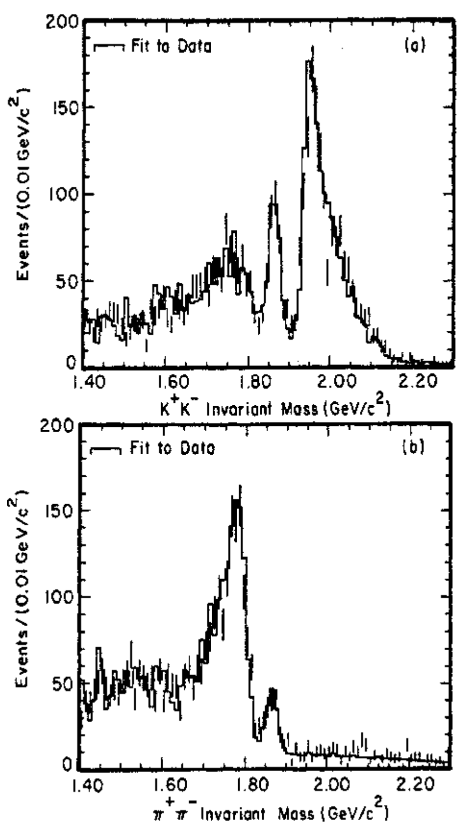

Fig. 1. Invariant mass distributions for (a) *K+K~* and (b) *r$^+$?r. The fit to the data is by the sum of a Monte Carlo simulated background from D° decays, a polynomial background, and a Gaussian signal.

K p' decay modes. Normalizing to the decay channel D° -> K~TÇ+ and correcting for efficiencies, we find B{D° -4 K+K~) = (0.49 ± 0.04 ± 0.03±0.06)% and B{D° -> Tr+Tr") = (0.21±0.03± 0.02 ± 0.03)%, where the third error is due to the uncertainty in B(D° -> K~7r') = (4.2 ± 0.6)%. Thus, the ratio of branching fractions B(D° -+ K+K-)/B{D° -> tt+tT) is 2.35 ± 0.37 ± 0.28, lower than the current world average but higher than theoretical expectations.

D° -> K®K® candidates were selected from D*+ -> D°7T events by requiring that |AM - 145.45 MeV/c²| < 1.2 MeV/c², M{w'it~) to be within 12.5 MeV/c² of M{K°ₛ) and x{D*+) > 0.5. We observe 5 events with masses consistent with D° decay. From Monte Carlo simulations the background is estimated to be 0.3 events. In order to reduce the systematic error in the determination of the D° -> K°ₛKJ branching fraction, we normalized to the decay channel D° K%n'ir~. Using the branching ratio[5] D° -> K°w^n' = (6.4 ± 1.1)%, we find B{D° K°K°) = (0.13^ ±0.02)%, where the systematic error is dominated by the uncertainty in J5(jD° -> This result is consistent with Pham's calculation[4] based on non-perturbative hadronic final state interactions, in which he obtained B(D° ~> K°K°) « \B{D° -> K+K-) « 0.25%. Here we have used our value for B(D° -» K'K") given above.

D° decays involving a tt° or an n

Branching fractions for D° decays involving a 7T° or an 77 are summarized in the Table 1 below. Also shown are theoretical predictions by Bauer, Steck, and Wirbel[6] (BSW) and Blok and Shifman[7] (BS). Our measurements are in good agreement with the BSW predictions, but are somewhat higher than the BS predictions.

Table 1. D° branching fractions for decays involving a é or an rj.

Mode	CLEO	BSW	BS
$K^-\pi^+\pi^0$	$11.5 \pm 0.6 \pm 2.1$		
$\bar{K}^0\pi^0$	$2.3 \pm 0.4 \pm 0.5$	2.5	1.5
$K^-\pi^+\pi^-\pi^+\pi^0$	$5.0 \pm 0.7^{+1.3}_{-1.0}$		
$\bar{K}^0\omega$	$3.4 \pm 0.9 \pm 1.0$	2.7	1.5
$\bar{K}^{*0}\eta$	$2.3^{+0.7}_{-1.1}$	2.5	0.3
$\pi^0\pi^0$	< 0.46 (90% C.L.)		

Df -+ and Df -+ <t>w'.

Through the observation of Df -> ft+v, we have made a determination of the absolute branching fraction for Dj -* 07r'." It is found that the cuts p($+) > 2 GeV/c and p[<f>) > 1 GeV/c isolate D+ -» <j>l'v events. After lepton fake and BE background subtractions there are 37.4 ± 9.0 and 17.0 ±6.4 events. There are 400 ± 27 D+ -> 07r' events. Averaging the and <f>e'v data samples and correcting for efficiencies, we find

B{Df - <t>l'v)/B{D+ -+ <t>ir') = 0.49±010l°;}°.

The value for the i ? ' -> <j>l+v branching fraction is derived from the following relation:

B[Dt -> V+y) = £ f = W - 4*+")*D.
= (0.80 ± 0.08) • B{D+ -> K*°l+v) • TₛJT_{D+}

The factor 0.8 is the average of two predictions,[9] and the error reflects a large range of possible differences in form factor. The measured branching fraction[10] for B{D+ -> K*°l+v) is (4.5 ± 0.7 ± 0.5)% and the ratio of Dₛ and D' lifetimes is 0.42 ± 0.03. The resulting estimate for B(Df -> <f>l+v) is (1.50 ± 0.31)%. Thus, B{D+ -> ^r+) = (3.1±0.61q'6±0.6)%, where the first error is statistical, the second is systematic, and the third is also systematic and arises from the uncertainty on the predicted value of B(Df -» <f>l+v). This value for B(D+ -> <^7r') can be compared with the Mark III upper limit[11] of 4.1% and the E691 lower limit[12] of 3.4%

Λ_c branching fractions and decay asymmetry

Λ_c branching fractions

Absolute branching fractions for several Λ_c decay modes are shown in Table 2 along with the values given by the Particle Data Group[2] (PDG). The CLEO numbers are based on B(K_c -+ pK~n') = (4.3 ± 1.4)%, which is a weighted average[13] of CLEO and ARGUS estimates.

Table 2. Λ_c branching fractions.

Decay mode	CLEO	PDG
$pK^-\pi^+$	4.3 ± 1.4	2.8 ± 0.8
$p\bar{K}^0$	2.1 ± 0.7	1.6 ± 0.6
$p\bar{K}^0\pi^-\pi^+$	1.8 ± 0.8	8.1 ± 3.5
$\Lambda\pi^+$	0.7 ± 0.3	seen
$\Lambda\pi^+\pi^-\pi^+$	2.8 ± 1.0	1.9 ± 0.7

A_c decay asymmetry parameter and A_c polarization

Violation of parity conservation in the weak decays of charmed baryons is expected. The decay A+ -> A7r+ is analogous to the decay A px~, for which the parity-violating asymmetry decay parameter has been measured[2] to be «**A** = 0.642 ± 0.013. The form of the angular distribution of the proton in the decay A+ -> *An+*, where A *pw~,* is given by *dN/dcos 61* = |(1 + **CKAO^COSÔI**), where *6%* is the angle between the A direction in the A_c rest frame and the decay proton's line of flight in the A rest frame. The fit to the CLEO data is shown in Fig. 2 and gives *a^c* = -1.O1^**Q,** constraining **OA**_c to physical values, indicating that parity conservation is violated in the weak decay A+ —• A7r+ as is expected.

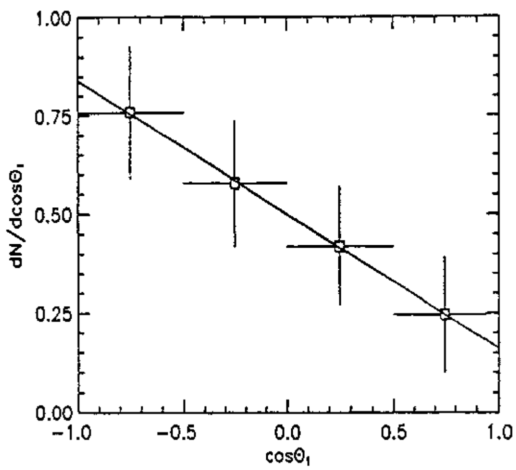

Fig. 2. Angular distribution of the decay proton in the A rest frame. The slope of the distribution is *^a^a^*. **The fit line has a slope of -0.34 ± 0.14.**

Parity conservation in electromagnetic annihilation requires A_c polarization, if it exists, to be normal to the production plane. In addition, the polarization must be the same for particle and antiparticle states since *C* is a conserved quantum number for A_c production. We define the normal to the production plane as n = *p^c* x e+, the cross product of the A_c momentum vector and the direction of the positron beam. In the A+ rest frame the angular distribution of the A relative to n has the form *dN/dcos 62* = |(1 + **POJA**_c cos **#2),** where *P* is the polarization and *62* is the angle between n and the A direction in the A_c rest frame. Since *a^c* = -a^c, subtracting the *l_c* distribution from the A_c distribution yields *dN/d cos $2* = **+PaA**_c cos **02-** The fit to this distribution, shown in Fig. 3, gives *P* = -0.2 ± 0.2, assuming that a**A**_n = -1.0. Thus, we see no evidence for the production of polarized A_c.

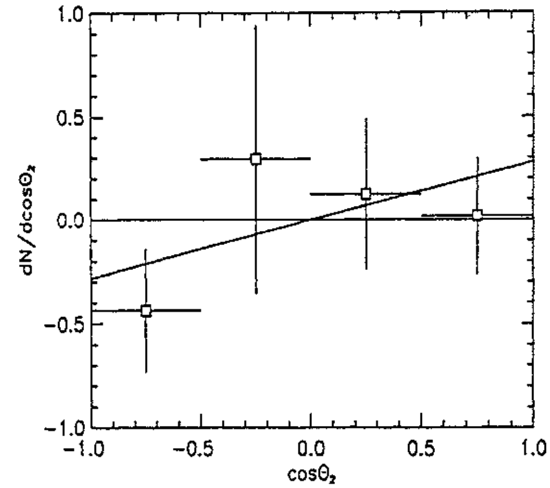

Fig. 3. The angular distribution of the À relative to n. The slope of the distribution is +Pe*A_c. The fit line has a slope of+0.24 ±0.24.

Acknowledgements

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Q. A. N. Kamalff/niv. *Alberta)* : I am a little surprised that you said that the theoretical expectation for the ratio *B(D°* *K+K-)/B(D°* **-* TT+TT'**) is 1 to 1.4. In fact, it is easy to get a value of 2, and if one is prepared to play with QCD coefficients *a* and *ai* of Bauer, Stech and Wirbel, one can get up to 3 for this ratio, putting in final state interactions.

A. E. Shibata: That is good news. It shows that final state interactions are important.