Status of section

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Introduction

layout of section as presented at the KEK meeting (50-60 pages)

Introduction

D-mixing and CP violation

Theory

Brief history

2.5 p. Mixing

(3.5 p) CPV ⟶ in next subsect.

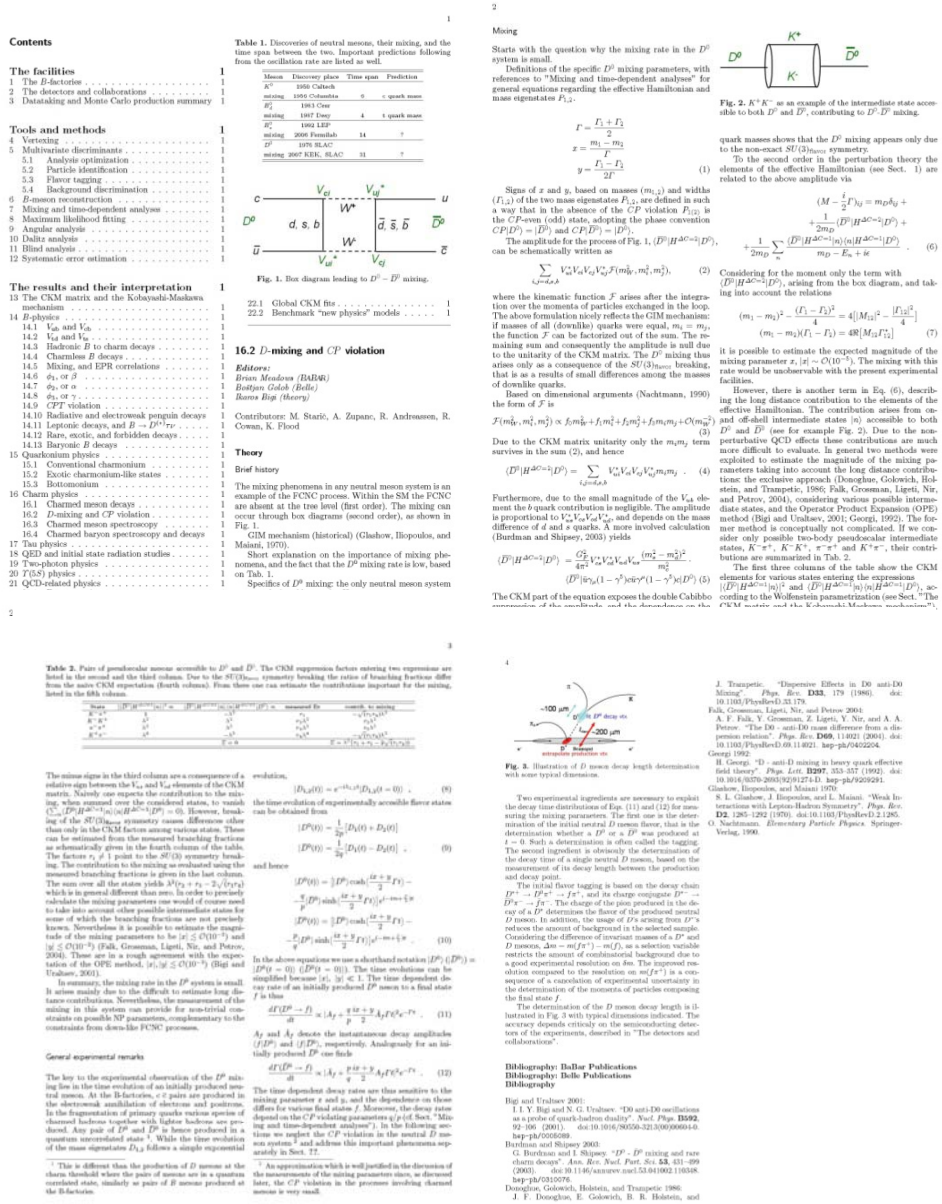
NP ⟶ not yet

General Exp. Remarks

2.5 p. *D** tagging

(3.5 p.) Decay-t resolution

previous estimate (~15 p.) 2x longer

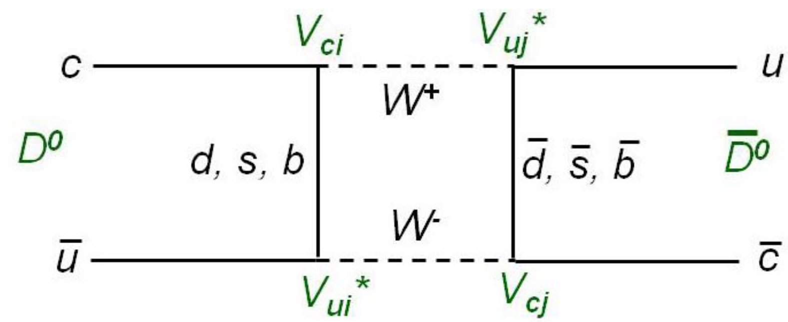


Introduction

Theory

- Brief history
  - Table;
  - short explanation of the importance of the mixing phenomena;
  - GIM mechanism historical intro to be included;
  - shortly on specifics of D^0 system (FCNC of up-like quarks)
- Mixing
  - definitions specific to D^0;
    - → interplay with Sect. "Mixing and time dependent analyses"
  - e.g. Δm not defined +ve, but use H_{eff} from there;

Meson	Discovery place	Time span	Prediction
K^0	1950 Caltech		
mixing	1956 Columbia	6	c quark mass
B_d^0	1983 Cesr		
mixing	1987 Desy	4	t quark mass
B_s^0	1992 LEP		
mixing	2006 Fermilab	14	?
D^0	1976 SLAC		
mixing	2007 KEK, SLAC	31	?



Signs of x and y, based on masses ($m_{1,2}$) and widths ($\Gamma_{1,2}$) of the two mass eigenstates $P_{1,2}$, are defined in such a way that in the absence of the CP violation $P_{1(2)}$ is the CP-even (odd) state, adopting the phase convention $CP|D^0\rangle = |\overline{D}^0\rangle$ and $CP|\overline{D}^0\rangle = |D^0\rangle$.

$$\Gamma = \frac{\Gamma_1 + \Gamma_2}{2}$$

$$x = \frac{m_1 - m_2}{\Gamma}$$

$$y = \frac{\Gamma_1 - \Gamma_2}{2\Gamma}$$

Introduction

Theory

Mixing

why mixing rate is small;

$$\langle \overline{D}^0 | H^{\Delta C=2} | D^0 \rangle = \sum_{i,j=d,s,b} V^*_{ui} V_{ci} V_{cj} V^*_{uj} m_i m_j$$

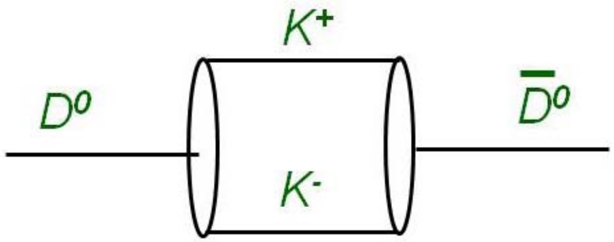
short distance;

$$\langle \overline{D}^0 | H^{\Delta C=2} | D^0 \rangle = \frac{G_F^2}{4\pi^2} V^*_{cs} V^*_{cd} V_{ud} V_{us} \frac{(m_s^2 - m_d^2)^2}{m_c^2} \cdot \langle \overline{D}^0 | \bar{u}\gamma_\mu (1-\gamma^5) c \bar{u} \gamma^\mu (1-\gamma^5) c | D^0 \rangle$$

DCS, SU(3) breaking

$$(M - \frac{i}{2}\Gamma)_{ij} = m_D \delta_{ij} + \\ + \frac{1}{2m_D} \langle \overline{D}^0 | H^{\Delta C=2} | D^0 \rangle + \\ + \frac{1}{2m_D} \sum_n \frac{\langle \overline{D}^0 | H^{\Delta C=1} | n \rangle \langle n | H^{\Delta C=1} | D^0 \rangle}{m_D - E_n + i\epsilon} .$$

long distance;



difficult to estimate

Theory

Mixing

why mixing rate is small;

long distance;

example of PP intermediate states;

$$(M - \frac{i}{2}\Gamma)_{ij} = m_D \delta_{ij} + \\ + \frac{1}{2m_D} \langle \overline{D}^0 | H^{\Delta C=2} | D^0 \rangle + \\ + \frac{1}{2m_D} \sum_n \frac{\langle \overline{D}^0 | H^{\Delta C=1} | n \rangle \langle n | H^{\Delta C=1} | D^0 \rangle}{m_D - E_n + i\epsilon} .$$

State	$\lvert\langle \overline{D}^0 \lvert H^{\Delta C=1} \rvert n \rangle\rvert^2 \propto$	$\langle \overline{D}^0 \lvert H^{\Delta C=1} \rvert n \rangle \langle n \lvert H^{\Delta C=1} \rvert D^0 \rangle \propto$	measured Br	contrib. to mixing
$K^-\pi^+$	1	$-\lambda^2$	r_1	$-\sqrt{(r_1 r_4)}\lambda^2$
K^-K^+	λ^2	λ^2	$r_2\lambda^2$	$r_2\lambda^2$
$\pi^-\pi^+$	λ^2	λ^2	$r_3\lambda^2$	$r_3\lambda^2$
$K^+\pi^-$	λ^4	$-\lambda^2$	$r_4\lambda^4$	$-\sqrt{(r_1 r_4)}\lambda^2$
		$\Sigma = 0$		$\Sigma = \lambda^2(r_2 + r_3 - 2\sqrt{(r_1 r_4)})$

→ interplay with Sect. "Charmed meson decays"?

$|x|, |y| \leq \mathcal{O}(10^{-3} - 10^{-2})$

In summary, the mixing rate in the D^0 system is small. It arises mainly due to the difficult to estimate long distance contributions. Nevertheless, the measurement of the mixing in this system can provide for non-trivial constraints on possible NP parameters, complementary to the constraints from down-like FCNC processes.

General Exp. Remarks

starts with decay time evolution as the exp. tool to access the mixing parameters;
first order approximation (after full formulae);

$$\frac{d\Gamma(D^0 \to f)}{dt} \propto |A_f + \frac{q}{p}\frac{ix+y}{2}\bar{A}_f \Gamma t|^2 e^{-\Gamma t} \quad . \qquad (11)$$

A_f and $\bar{A}_f$ denote the instantaneous decay amplitudes $\langle f|D^0\rangle$ and $\langle f|\overline{D}^0\rangle$, respectively. Analogously for an initially produced $\overline{D}^0$ one finds

$$\frac{d\Gamma(\overline{D}^0 \to f)}{dt} \propto |\bar{A}_f + \frac{p}{q}\frac{ix+y}{2}A_f \Gamma t|^2 e^{-\Gamma t} \quad . \qquad (12)$$

The time dependent decay rates are thus sensitive to the mixing parameter x and y, and the dependence on those differs for various final states f.

CPV is small;

$$2\, arg(V_{cs}V_{us}^*) = 2\, arg(-V_{cd}V_{ud}^* - V_{cb}V_{ub}^*) \approx$$
$$\approx -2A^2\lambda^4\eta = 1.2 \cdot 10^{-3} \quad ,$$

can/should be moved to “Theory” subsect.?

General Exp. Remarks

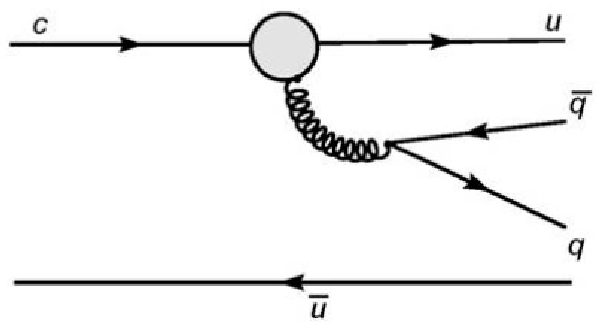
$$|\frac{q}{p}|^2 \equiv 1 + A_M \qquad (15)$$

is often used. Three types of the CP violating effects can be distinguished, as in any other neutral mesons system. First, the CP violation in the mixing occurs if $A_M \neq 0$ (alternatively, $|q/p| \neq 0$). CP violation in decays is present if $|\bar{A}_{\bar{f}}/A_f| \neq 1$. This effect is sometimes parametrized in terms of

$$|\frac{\bar{A}_{\bar{f}}}{A_f}|^2 \equiv 1 + A_D^f \quad . \qquad (16)$$

CPV: parametrization
→ discuss with Brian

→ DCPV: two amplitudes, described before?



can/should be moved to “Theory” subsect.?

$$\lambda_f = -\sqrt{R_D^f}\,\frac{1 + A_M/2}{1 + A_D/2}\,e^{-i(\delta_f - \phi)}$$

General Exp. Remarks

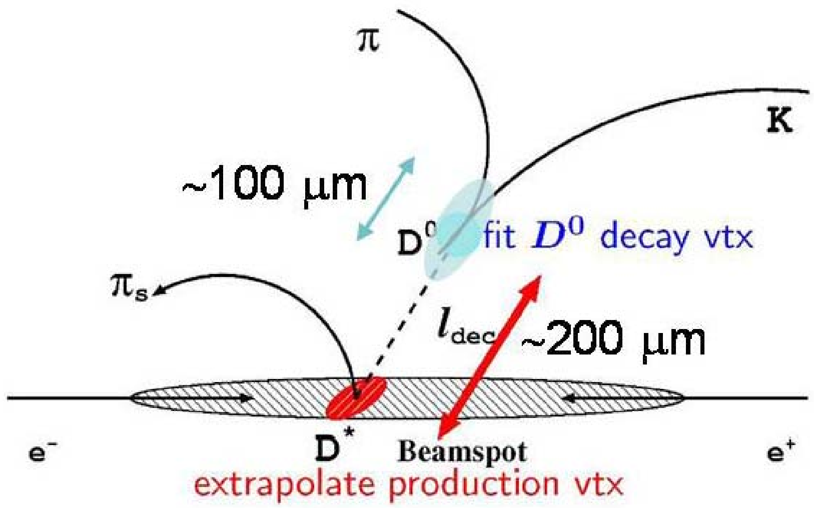
*D** tagging
Δm definition, explanation
on background reduction;

need rule on inv./nominal
mass notation?

$D^{*+} \rightarrow \underline{D}^0\, \pi^+$
$D^{*-} \rightarrow \overline{D}^0\, \pi^-$

$$m(K\pi)$$
$$m_{D^0}$$

Decay-t resolution
illustration with typical
dimensions;
→ interplay with
Sect. "Vertexing"?
(IP profile)

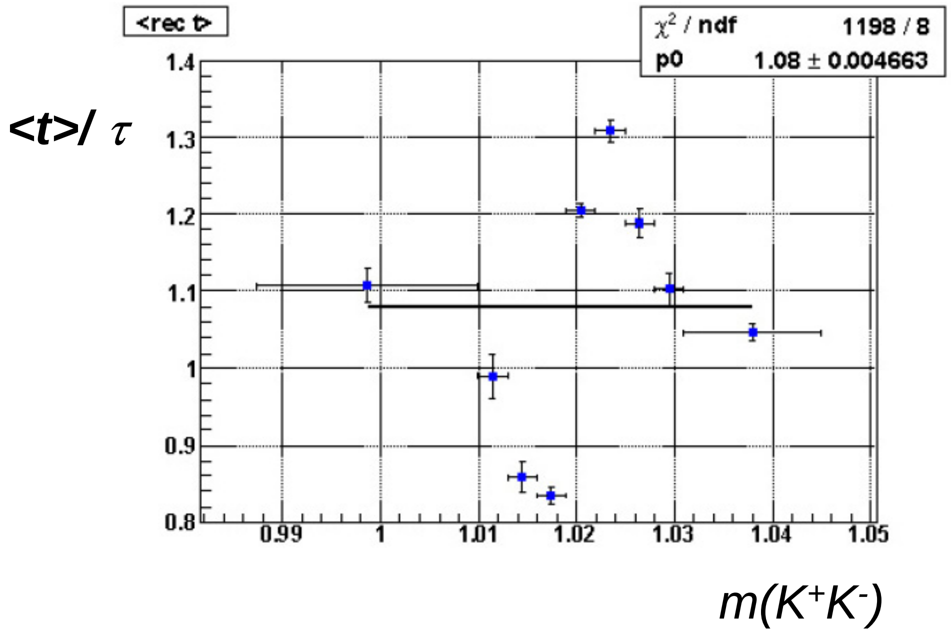


General Exp. Remarks

$$\mathcal{L}_i(x,y) = \int_0^\infty dt' \frac{d\Gamma}{dt'}(t';x,y)\left[e^{(t_i-t')^2/2S_1\sigma_i^2} + e^{(t_i-t')^2/2S_2\sigma_i^2}\right]$$

Decay-t resolution
- example of $\mathcal{L}$;
  - → interplay with Sect. "Mixing and time dependent analyses"
- give examples of values (e.g. for Kπ)?

- biases, non-zero t_0; examples?



Summary

Introductory subsections
(with exception of NP)
ready to be discussed
and edited

Plan:
list of references to be divided
among exp. subsect.;

after general part ok →
start work on individual
experimental subsect.
(divide among contributors)