G. Buchalla

24. 10. 2000

CERN MUON WEEK

Kaon Physics

- Motivation

- Overview

- $K_L \to \pi^0 e^+ e^-$

- Summary

- Experimental Prospects

    $\to$ talk by A. Ceccucci

K physics:

- strangeness $\longrightarrow$ quarks, QCD
- P violation ('θ-τ') $\longrightarrow$ chiral gauge forces
- CP violation $\longrightarrow$ matter $\neq$ antimatter
  $\qquad\qquad\qquad\qquad\qquad$ 3 generations
- FCNC suppression $\longrightarrow$ GIM, charm
  $\quad K_L \to \mu^+ \mu^-$, $K - \bar{K}$

☐ crucial insights into fundamental physics

☐ indirect probe of high scales $\quad m_c, m_t, CPV, \ldots$

future:

- precision flavour physics
  $K \to \pi \nu \bar{\nu}$, $K_L \to \pi^0 e^+ e^-$ $\longrightarrow$ SM, CKM tests
  $\qquad\qquad K_L \to \mu e$ $\longrightarrow$ New Physics ?

☐ flavour: least understood SM sector

☐ necessary to complement direct searches
$\qquad\qquad\qquad\qquad\qquad\qquad$ B physics

Talks:

4 May

G. Isidori : Perspectives for Rare Kaon Decays

G. Kalmus : Possible Operating Conditions for Kaon Physics Using a MSR Source

A. Ceccucci : Experimental Prospects

G. D'Ambrosio : Recent Developments in the Theory of Rare and Radiative Kaon Decays

19 October

G. Barr : Hadron Production at HARP

M. Chizhov : Charged-Lepton-Flavour Violation in K Decays in Supersymmetric Theories

G. Isidori : Probing CP Violation with $K_L \to \pi^0 e^+ e^-$

Overview

☐ $K_L \to \pi^0 \nu \bar{\nu}$ 'golden mode' direct CPV

$K^+ \to \pi^+ \nu \bar{\nu}$

- short-distance
- semileptonic
→ clean
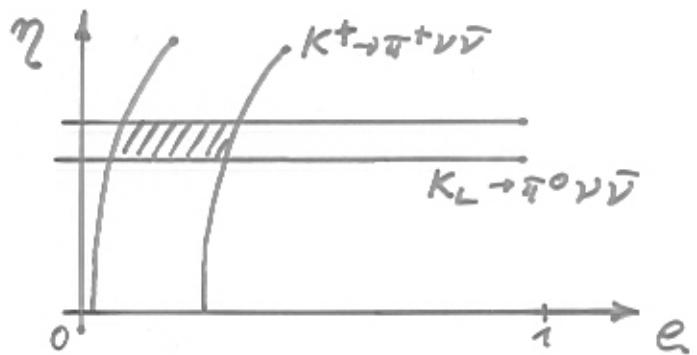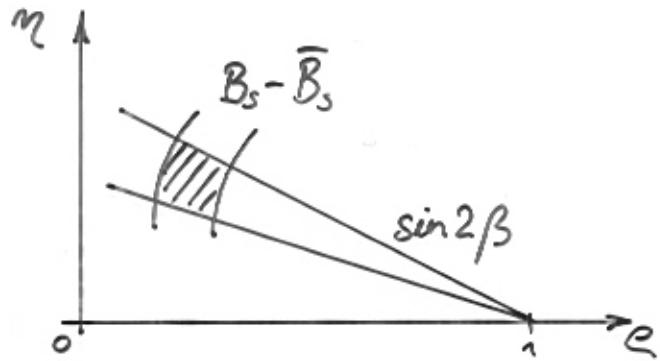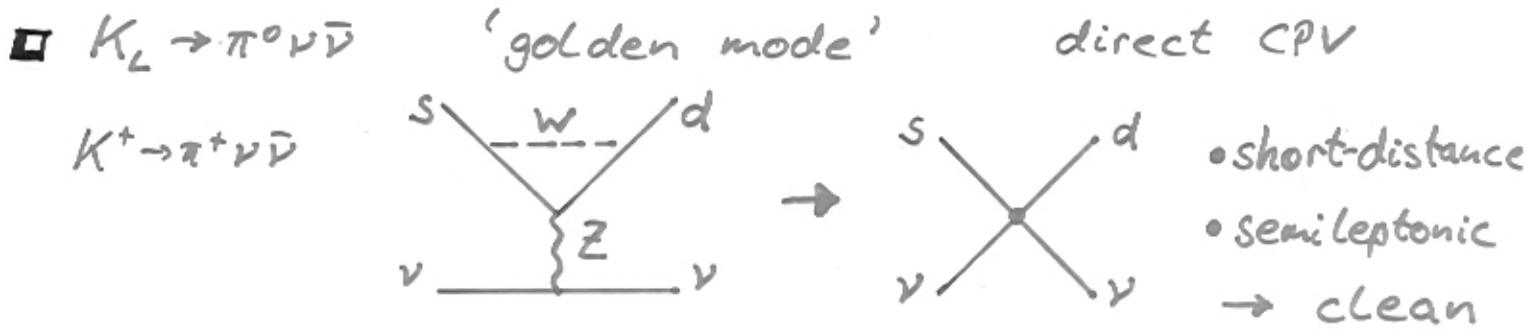
$K_L \to \pi^0 e^+ e^-$

☐ LFV: $K_L \to \mu e$, $K \to \pi \mu e$ Belyaev, Chizhov, Dorokhov, Ellis, Gómez, Lola

$K_L \to \mu e$ MSSM

Δm_K, $\mu \to e \gamma$
$\mu N \to e N$
$BR \lesssim 10^{-15}$

$\not{R}$
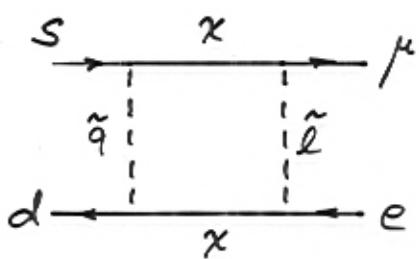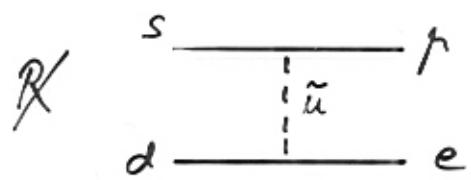
→ bounds on RPV couplings

☐

$K_L \to \pi^+ \pi^- \nu \bar{\nu}$, $K^\pm \to \pi^\pm e^+ e^-$; $K^+ \to \pi^- \ell^+ \ell^+$

μ-polarization: $K^+ \to \pi^0 \mu^+ \nu$, $K^+ \to \mu^+ \nu \gamma$, $K_L \to \mu^+ \mu^-$

$K_L \to \pi^0 e^+ e^-$

CPV
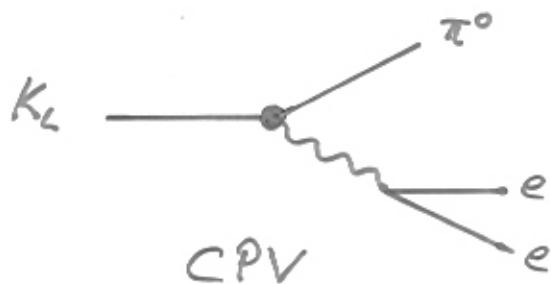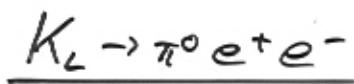
direct   indirect
short-distance long-distance
                     ↕
          measure $K_S \to \pi^0 e^+ e^-$
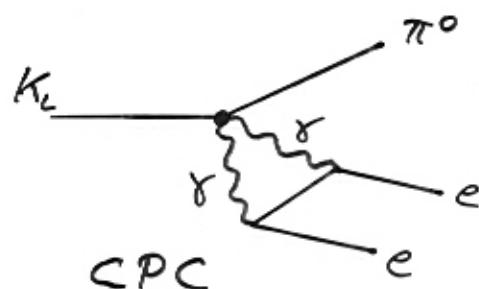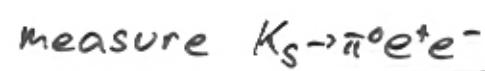
$BR \approx 5 \cdot 10^{-12}$ $\approx 10^{-12} - 10^{-10}$

$\underbrace{\qquad\qquad\qquad\qquad}_{\text{interference}}$

CPC

long-distance

$\chi PT, \quad K_L \to \pi^0 \gamma \gamma$

$\lesssim 2 \cdot 10^{-12}$

Greenlee
bckgr.

$BR \approx 6 \cdot 10^{-7}$

- complementary to $K_L \to \pi^0 \nu \bar\nu$

- cuts : $B(K_L \to e^+ e^- \gamma \gamma) \lesssim 10^{-10}$

     B_{CPC} : $r_{CPC} = 0.23$ $\varepsilon_{CP} = 0.8$ ←

▶ $\dfrac{SD\text{-}signal}{bckgr} \sim \dfrac{1}{10}$ ← ±10%
                 ← ± 1% → 10^4 ev. → $\sim 10^{15}$ K_L dec.
                                  @ $\varepsilon = 0.1$

▶ $K_L - K_S$ interference in $K^0(t) \to \pi^0 e^+ e^-$

    $\gtrsim 10^{15}$ decaying K_L

                   G.B., D'Ambrosio, Isidori

Summary

- review of opportunities for high-sensitivity K experiments
    - detailed tests of flavour sector
    - precision CKM
    - New Physics search

- identify highlights

$$K^+ \to \pi^+ \nu \bar{\nu} \, , \quad \underline{K_L \to \pi^0 \nu \bar{\nu}} \qquad ; \qquad \underline{K_L \to \pi^0 e^+ e^-}$$

LFV

   - phenomenology of $K_L \to \pi^0 e^+ e^-$
   - $K_L \to \mu e$, $K \to \pi \mu e$ in SUSY

- outline of machine requirements

  high intensity p source $\qquad$ 20 - 120 GeV

- review of current and future
  rare K decay experiments
        BNL, CERN, FNAL, Frascati, KEK

□ excellent opportunities $K \to \pi \nu \bar{\nu}$, $K_L \to \pi^0 e^+ e^-$, ...

□ crucial for flavour physics — long term interest

□ MSR complex $\to$ 2nd generation precision K physics