RESULTS ON ϵ'/ϵ AND RARE K_L DECAYS FROM KTEV

MICHAEL ARENTON

Physics Dept., University of Virginia, Charlottesville, VA 22904

Results from the KTeV experiment at Fermilab on measurement of ϵ'/ϵ and rare K_L decays are summarized.

1 Introduction

This paper summarizes some of the more recent results on the measurement of the direct CP violation parameter ϵ'/ϵ and rare K_L decays obtained by the KTeV experiment at Fermilab. KTeV uses a new large acceptance, high resolution and high rate spectrometer to achieve a highly significant measurement of ϵ'/ϵ. The experimental sensitivity to many rare K_L decay modes was substantially extended , reaching the necessary levels to observe or place interesting limits on a number of rare processes and make high statistics measurements of other modes previously only observed with small event samples.

2 Measurement of ϵ'/ϵ

The direct CP violation parameter ϵ'/ϵ is measured from the double ratio of the decay rates of K_L and K_S into $\pi^+\pi^-$ and $\pi^0\pi^0$ pairs:

$$\frac{\Gamma(K_L \to \pi^+\pi^-)/\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_L \to \pi^0\pi^0)/\Gamma(K_S \to \pi^0\pi^0)} \approx 1 + 6\mathrm{Re}\,(\epsilon'/\epsilon)$$

KTeV has published [1] a measurement based on 20% of the data taken in the 1996/1997 runs. The signals were extracted with a background level of about 0.09% for the $\pi^+\pi^-$ mode and 1.2% or better for the $\pi^0\pi^0$ mode. The resulting samples contained 8.6×10^5 and 1.4×10^6 events of the neutral mode in the vacuum and regenerator beams respectively, and 2.6×10^6 and 4.5×10^6 in the charged mode. A detailed Monte Carlo simulation, which was calibrated with other high statistics K decay modes, was used to correct for the different acceptance of K_L and K_S decays. The final fit for ϵ'/ϵ was done "blind", hiding the result until all corrections had been evalulated. The result is $\mathrm{Re}\,(\epsilon'/\epsilon) = [28.0 \pm 3.0(stat) \pm 2.8(syst)] \times 10^{-4}$.

The additional 5× data sample taken in 1997 is currently being intensively analysed. Several of the systematic uncertainties appear to be under better control. Additionally a further 2× more data was taken in a run in 1999.

3 Rare decays

KTeV has for many rare K_L decay modes made either first measurements, new measurements with greatly increased statistics, or substantially more sensitive upper limits on branching fractions. New measurements have been made of the decays $e^+e^-\gamma\gamma$ [2], $\mu^+\mu^-\gamma\gamma$ [3] $e^+e^-e^+e^-$, $e^+e^-\mu^+\mu^-$ [4], $\pi^0 \to e^+e^-$, [5] and $\pi^+\pi^-e^+e^-$, among others. Upper limits have been set on $\pi^0e^+e^-$ [6], and $\pi^0\mu^+\mu^-$ [7], and $\pi^0\nu\overline{\nu}$ [8] [9]. A high statistics study of $\mu^+\mu^-\gamma$ has been performed [10] , and a very high statistics study of $e^+e^-\gamma$ is in progress. A particularly interesting result is the observation of an indirect CP violating effect in the mode $\pi^+\pi^-e^+e^-$, where an asymmetry in the distribution of the angle ϕ between the planes defined by the $\pi^+\pi^-$ and e^+e^- pairs of $[13.6 \pm 2.5(stat) \pm 1.2(syst)]\%$ was observed, consistent with theoretical expectations. [11] This asymmetry arises from interference of inner-bremsstrahlung and direct emission amplitudes. There is also expected to be a smaller amplitude cooresponding to the K_L charge radius. Continuing analysis of the angular distributions of this decay may lead to an interesting measurement of the K_L charge radius. Additional data taken in 1999 will increase rare decay sensitivities by factors of 2 to 2.5 for various modes.

Acknowledgments

This work was supported by the U.S. Department of Energy, the National Science Foundation, and the Ministry of Education and Science of Japan.

References

1. A. Alavi-Harati *et al Phys. Rev. Lett.* **83**, 22 (1999).
2. P. Mikelson, Ph.D. dissertation, University of Colorado, 1999.
3. A. Alavi-Harati *et.al.,hep-ex/0001005, Phys.Rev. D. in press.*
4. *A. Lath, talk given at DPF 99, UCLA, Los Angeles, January 1999.*
5. *A. Alavi-Harati et.al.,* Phys. Rev. Lett. **83**, *922 (1999)*
6. *A. Alavi-Harati et.al., hep-ex/0009030., submitted to Phys. Rev. Lett.*
7. *A. Alavi-Harati et.al.,* Phys. Rev. Lett. **84**, *5279 (2000)*
8. *A. Alavi-Harati et.al.,* Phys. Rev. *D* **61**, *072006 (2000)*
9. *J. Adams et.al.,* Phys. Lett. *B* **447**, *240 (1999)*
10. *G.B. Quinn, Ph.D. dissertation, University of Chicago, 2000.*
11. *A. Alavi-Harati et.al.,* Phys. Rev. Lett. **84**, *408 (2000)*