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Measurement of the Polarized Forward-Backward Asymmetry of s-Quarks at SLD

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Abstract

Measurements of fermion asymmetries at the Z^0 resonance probe a combination of vector and axial vector couplings of the Z^0 to fermions, $A_f = 2v_f a_f/(v_f^2 + a_f^2)$. The parameters A_f express the extent of parity violation at the Zff vertex and provide sensitive tests of the Standard Model. In SLC/SLD experiment, the availability of polarized electron beams enables to measure the parity violating parameter A_f directly by forming the left-right forward-backward asymmetry (polarized forward-backward asymmetry) which is the polar angle dependency of the Z^0 pole polarized cross section. This thesis presents a direct measurement of A_s by analyzing the polarized forward-backward asymmetry of s quarks in $e^+e^- \to Z^0 \to s\bar{s}$. In the Standard Model, s quark is expected to have the same parity violating parameter as b quark. If one can measure A_s precisely, the universality of the coupling constants can be examined by comparing with the measured A_b. The most important stage of this analysis is to select pure $s\bar{s}$ events as much as possible. Many fragmentation models predict that the primary s and $\bar{s}$ in such events materialize as "leading" strange particles, that tend to have higher momentum than the bulk of the particles from the fragmentation process. The identification of high momentum strange particles might therefore provide a clean tag of $e^+e^- \to s\bar{s}$ events.

The measurement described in this thesis was performed at the Stanford Linear Accelerator Center (SLAC), using about 150,000 hadronic Z^0 decays collected in 1993-1995 with the SLAC Large Detector (SLD) at the Stanford Linear Collider (SLC). The averaged polarization was 63.0% in 1993 SLD run and 77.3% in 1994-5 run.

The analysis used the charged tracks measured in the Central Drift Chamber (CDC) and Vertex Detector (VXD), along with identification information from the Cherenkov Ring Imaging Detector (CRID). 93729 hadronic events well-contained within the barrel region of the detector were selected and further required to be consistent with containing light (u, d, or s) primary quarks. For the latter purpose we considered events with a well-measured primary interaction point and required that all "quality" tracks in the event extrapolate to within three standard deviations of this point in the plane transverse to the beam axis. A total of 56470 events passed these cuts, with a light-quark purity, estimated from a Monte Carlo simulation, of 85%.

After the light flavor event selection, $Z^0 \to s\bar{s}$ events were selected with high momentum $K^{\pm}$, Λ, and K_s^0. Charged kaons were tagged using CRID. Pairs of oppositely charged tracks were considered as $\Lambda^0(\bar{\Lambda}^0)$ or K_s candidates if they formed a good vertex that was well-separated from the IP and the total momentum vector was consistent with intersecting the IP. If the higher momentum track was identified as a proton and $|M_{p\pi} - M_\Lambda| < 4\mathrm{MeV/c^2}$, then the pair was tagged as a $\Lambda^0(\bar{\Lambda}^0)$. Otherwise if $|M_{\pi\pi} - M_{K_s^0}| < 12\mathrm{MeV/c^2}$, the pair was tagged as a K_s.

In order to tag $s\bar{s}$ events with high purity and determine the s quark direction reliably, we considered events with at least one tagged strange particle in each hemisphere and used the one with highest momentum in each. At least one of these two particles was required to carry the sign of strangeness (*i.e.* to be a $K^{\pm}$ or $\Lambda(\bar{\Lambda})$) and if both did, they were required to have total strangeness 0. As a consequence of these requirements, 532 $s\bar{s}$ events (280 for $P_e < 0$ and 252 for $P_e > 0$) were tagged. The initial s quark direction ($\hat{u}$) was defined in terms of the event thrust axis ($\hat{t}$), the strangeness (s) and momentum ($\vec{p}$) of the tagged strange particle by, $\hat{u} = s(\vec{p}\cdot\hat{t})\hat{t}/ \mid \vec{p}\cdot\hat{t} \mid$. Fig.1 shows the distribution of $\cos\theta \equiv \hat{u}_z$ for left- ($P_e < 0$) and right- ($P_e > 0$) handed electron beam. According to the JETSET Monte Carlo, $s\bar{s}$ events were tagged with 67.4% purity, and non-s events were subtracted from tagged sample. Furthermore, mis-signing of initial quark direction was corrected using the Monte Carlo. Finally, the polarized forward-backward asymmetry was calculated. Fig.2 shows the polarized forward-backward asymmetry as a function of polar angle. In order to extract A_s, we fitted with the function $2|P_e|A_s\cos\theta/(1+\cos^2\theta)$, where $|P_e|$ was the averaged electron polarization of $73.0 \pm 0.5\%$ for 1993-95 runs. The best fit gave the value of $A_s = 0.85 \pm 0.17$. Comparing this result with current measured A_b value, no significant evidence is observed to violate the universality of the coupling constants and the universality is held within the error.

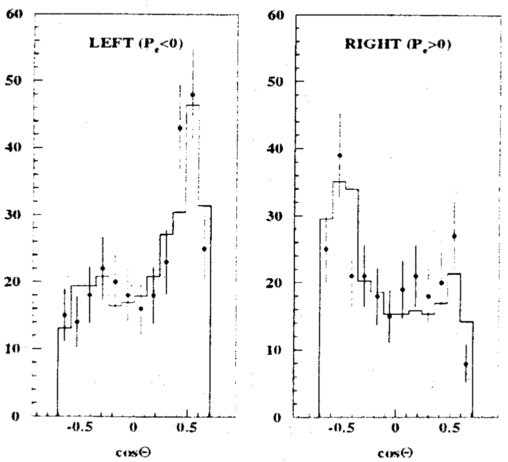

Fig. 1: Thrust axis $\cos\theta$, signed with the strangeness of tagged strange particles. The dots shows data and the histogram shows the Monte Carlo results.

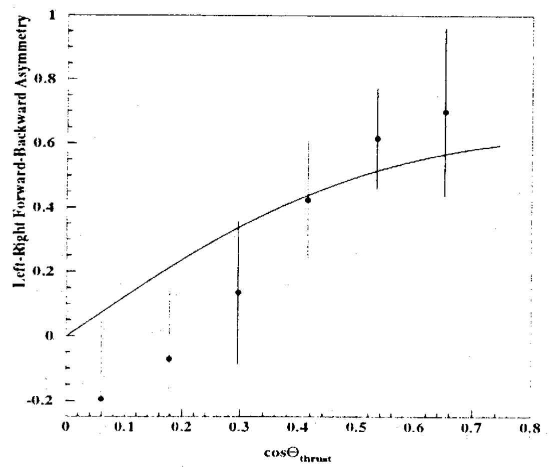

Fig. 2: Polarized forward-backward asymmetry with fitted curve, $2|P_e|A_s\cos\theta/(1+\cos^2\theta)$, where $|P_e|$ is the averaged electron polarization of $73.0\pm0.5\%$ for 1993-95 runs.