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A Measurement of the b Charge Separation in the ALEPH Data

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In the hadronic charge asymmetry studies [1] $\sin^2(\theta_w)$ is extracted from measurement of the average charge flow between the forward and backward hemisphere, Q_{fb}, in the following way:

$$\langle Q_{fb}\rangle = C_{acc}\,\mathcal{A}_e\,\frac{2\cdot\Sigma_f\delta^f\,g_v^f g_a^f}{\Sigma_f((g_v^f)^2\;+\;(g_a^f)^2)} \tag{1}$$

where

$\langle Q_{fb}\rangle$ is the average charge flow as measured in the data,
C_{acc} is the correction for the experimental polar angle acceptance,
$\mathcal{A}_e$, the left-right asymmetry for electrons, is used to extract $\sin^2(\theta_w)$,
$\Sigma\delta^f\,g_v^f g_a^f$ contains the typical charge separations for the different quark flavours.

In the study done so far the charge separations have been extracted from the Monte Carlo. However, due to uncertainties on the model parameters and the fact that the predictions are model dependent, the term $\Sigma\delta^f\,g_v^f g_a^f$ is only known to 20 %.
Hopefully in future the determination of this term can be improved by extraction of important parameters, such as the s/u-ratio in Lund, etc., from the the ALEPH data. A reduction on the uncertainty range of the other parameters will also help to reduce the systematic error. Finally a better modelling of the hadronic events may bring the predictions by Lund and Herwig closer to each other.
Alternatively one can try to extract the charge separations from the data themselves. In this note I present this measurement for b quarks. In the measurement of B^0-$\bar{B}^0$ mixing using a jet-charge method [2] a lepton-signed hemisphere charge is defined:

$$Q_{lH} = -q_l\cdot Q_H^{opposite}. \tag{2}$$

After correction for background contributions from charm, misidentified hadrons and non-promt leptons, $\langle Q_{lH}\rangle_b$ in the 1989 and 1990 data is measured to be:

$$\langle Q_{lH}\rangle_b = 0.0863\pm0.0069\,(stat.)\pm0.0018\,(sys.). \tag{3}$$

The lepton-signed hemisphere charge in b-events can directly be related to the b charge separation. Correcting for the possible mixing on the lepton side $\langle Q_{lH}\rangle_b$ can be written as:

$$\langle Q_{lH}\rangle_b = (1-2\chi)\cdot Q_{bH}, \tag{4}$$

where

χ is the probability that the B^0 mixed before decaying,

Q_{bH} is the charge in a single b hemisphere.

By definition:

$$\delta^b = 2\cdot Q_{bH}. \tag{5}$$

Therefore δ^b can be extracted from $\langle Q_{lH}\rangle_b$ using:

$$\delta^b = 2\cdot \langle Q_{lH}\rangle_b/(1-2\chi). \tag{6}$$

So to extract δ^b the mixing parameter χ is needed. I will use the average value from the four LEP experiments [2]-[6], see table 1. Additional measurements by UA1 and CDF may also be used, however there is the uncertainty whether the B^0_d and B^0_s fractions in $p\bar{p}$ collisions are the same as those in the LEP data. In order to avoid such problems I have chosen not to include the $p\bar{p}$ measurements.

Using the average mixing probability at LEP the measured lepton-signed hemi-

Table 1: summary of B^0-$\bar{B}^0$ mixing results

Experiment	Numerical value
ALEPH dilepton [3]	$\chi = 0.137 \pm 0.017$
ALEPH jet charge [2]	$f_d\chi_d + 0.72\ f_s\chi_s = 0.113 \pm 0.032$
ALEPH combined[4]	$\chi = 0.134 \pm 0.015$
L3 [5]	$\chi = 0.121 \pm 0.018$
OPAL [6]	$\chi = 0.125 \pm 0.022$
LEP average	$\chi = 0.128 \pm 0.012$
CDF [7]	$\chi = 0.176 \pm 0.045$
UA1 [8]	$\chi = 0.148 \pm 0.034$

sphere charge translates into:

$$\delta^b = 0.232 \pm 0.019\,(stat.) \pm 0.005\,(sys.) \pm 0.007\,(\chi)\ =\ 0.232 \pm 0.021 \tag{7}$$

which represents a 9.0 % measurement of the b charge separation. This result is to be compared with the determination from Monte Carlo with an uncertainty of 20 %.

The central value for δ^b in the Lund Monte Carlo is $\delta^b = 0.241$ in a production where χ was set to 0.116. When correcting for the lower χ in the Monte Carlo $(\delta^b)_{MC}$ becomes 0.249 ± 0.047. This shows that the charge separation extracted

from the Monte Carlo is compatible with the value measured in the data.
A preliminary measurement in the 1991 data yielded:

$$\langle Q_{lH} \rangle_b = 0.0964 \pm 0.0052\,(stat.) \pm 0.0029\,(sys.) \quad (8)$$

leading to a combined measurement of:

$$\langle Q_{lH} \rangle_b = 0.0927 \pm 0.0042\,(stat.) \pm 0.0025\,(sys.). \quad (9)$$

The resulting δ^b is:

$$\delta^b = 0.249 \pm 0.011\,(stat.) \pm 0.007\,(sys.) \pm 0.008\,(\chi). \quad (10)$$

representing a 6 % measurement, which is identical to the charge separation obtained from Jetset. It should be emphasised at this point that the charge separation (10) is preliminary.

References

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