THE FIRST MEASUREMENT OF μ_{Ξ^o}

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ABSTRACT

We[1] have measured $\mu_{\Xi^o} = -1.20 \pm .06$ nuclear magnetons. The precise measurements of the proton, neutron, Λ, and Ξ^o moments overconstrain the quark model, which predicts baryon moments with three quark moments or masses. The quark model predicts $\mu_{\Xi^o} = -1.44$, a 20 ± 5% discrepancy from our result.

A neutral hyperon beam was constructed by Wisconsin-Michigan-Rutgers at NAL 5 years ago, taking advantage of long hyperon lifetimes at high energy--for example, a 150 GeV/c Λ lives 10 meters. The beam is formed by placing a 5 meter magnet with a 4 mm diameter hole in its center after a production target. 400 GeV/c protons hit the target and a well-collimated neutral beam emerges downstream from the magnetic filter. A 12 meter decay zone follows the magnet and an MWPC spectrometer which detects mainly $\Lambda \to p\,\pi^-$ vees follows this. We looked first at the inclusively produced Λ's and found them highly polarized, 25% at a transverse momentum of 1.5 GeV/c. The polarization was unexpected and still isn't explained. The high energy polarized Λ beam allowed us to measure the Λ magnetic moment quite precisely because the Λ spins precess in the field of the magnetic filter up to 150° at full field.

The neutral beam also contained Ξ^o's, and we are reporting the recent result that they, also, are polarized, allowing us to make the first measurement of its moment. Only the Λ of the $\Xi^o \rightarrow \Lambda\ \pi^o$ decay was observed, but several characteristics of the decay chain allowed us to separate out the daughter Λ's from Ξ^o decay and to assure ourselves that the sample was 90% ± 5% Ξ^o's. The daughter Λ tags the Ξ^o polarization and we analyzed these Λ's for their polarization and their precession angle after the magnetic filter, proportional to the Ξ^o moment. We found $\mu_{\Xi^o} = -1.20 \pm .06$ nuclear magnetons.

A neutral point-like particle would have no magnetic moment. The Ξ^o moment is presumably due to its quark moments and SU(6) wave functions can be used to write the Ξ^o moment in terms of the u-quark and s-quark moments: $\mu_{\Xi^o} = \frac{4}{3}\mu_s - \frac{1}{3}\mu_u$. There are similar expressions for the precisely measured proton and neutron moments in terms of μ_u and μ_d; the Λ moment is the s-quark moment. The significance of our result is that we now have 4 precisely measured moments--p, n, Λ, Ξ^o, and 3 parameters--μ_u, μ_d, μ_s. Thus we have overconstrained the quark model and are probing it. Using the p, n, Λ moments, we can predict $\mu_{\Xi^o} = -1.44 \pm .006$ and we see that our result of -1.20 is 20 ± 5% away from this. Quark masses can also be obtained from the moments if we assume the quarks are point-like, but the discrepancy in the quark moments give an s-quark mass of 509 ± 4 MeV/c^2 if we use the Λ moment, or 716 ± 74 MeV/c^2 if we use the Ξ^o moment.

The wave functions used were the constituent quark model with the assumption that the quarks in a baryon have no internal orbital angular momentum. Questions at the end of the talk brought out whether the current quark model or the bag model might give different results. Both predict the same baryon moment relationships as the constituent model -- i.e., the discrepancy is still there.

1) G. Bunce, O.E. Overseth, P.T. Cox, J. Dworkin, K. Heller, T. Devlin, B. Edelman, R.T. Edwards, L. Schachinger, P. Skubic, R. Handler, R. March, P. Martin, L. Pondrom, M. Sheaff.