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We have measured the Σ^+ magnetic moment by observing the precession of polarized sigmas in the magnetic field of the Berkeley 25-inch hydrogen bubble chamber. From an exposure of 1.2×10^6 pictures, 31 000 reactions of the type $K^- p \to \Sigma^+\pi^-$, $\Sigma^+ \to p\,\pi^0$ have been analyzed. The incident momenta range from 340 to 430 MeV/c.

The sigmas produced at this energy are well polarized from interference between a resonant $D_{3/2}$ amplitude, $Y_0^*(1520)$, and a dominant S-wave background. The polarizations determined directly from this sample of events were reported previously.[1] The mean polarization of the events used in this determination was 0.47. The value of the decay asymmetry parameter used was -0.986.

Only those events originally identified by the scanner as $\Sigma^+ \to p\,\pi^0$ were included for the determination of the magnetic moment. After fitting with the programs TVGP and SQUAW, 1% of the events remained ambiguous with $\Sigma^+ \to n\,\pi^+$, and these were excluded. Events were accepted with a confidence level greater than 0.001 and a lifetime greater than one mean life, 0.81×10^{-10} sec. Thus, 13 545 sigmas were accepted with a mean length of 1.55 cm. The magnetic field, known to better than 0.5%, had the mean value 18.7 kG.

For each event the known polarization four-vector $S^{\mu} = (\underset{\sim}{P}, 0)$ was precessed in the laboratory for its lifetime with the following equation:

$$\frac{dS_{\mu}}{d\tau} = -\frac{1}{m_{\Sigma}^{2}} p_{\mu} S_{\alpha} \frac{dp^{\alpha}}{d\tau} - \frac{\mu_{\Sigma} e}{m_{p}} \left(F_{\mu\beta} - \frac{1}{m_{\Sigma}^{2}} p_{\mu} p^{\alpha} F_{\alpha\beta}\right) S^{\beta},$$

where τ is the proper time, p^{μ} is the four-momentum, m_p is the proton mass, and

$$F_{\alpha\beta} = \begin{vmatrix} 0 & H_z & -H_y & E_x \\ -H_z & 0 & H_x & E_y \\ H_y & -H_x & 0 & E_z \\ -E_x & -E_y & -E_z & 0 \end{vmatrix} .$$

The second term is dependent on μ_{Σ} and reduces to $(\mu_{\Sigma} e/m_p)\,(\underset{\sim}{P} \times \underset{\sim}{H})$ in the sigma rest frame. The first term is independent of μ_{Σ} and is the contribution from the change in the sigma momentum described by:

$$n = 1, 3 \quad \frac{dp^{n}}{d\tau} = \frac{Qe}{m_{\Sigma}} p^{\alpha} F^{n}_{\alpha} + \frac{p^{n}}{|\underset{\sim}{p}|} \frac{d|\underset{\sim}{p}|}{d\tau}$$

$$n = 4 \quad \frac{dp^{4}}{d\tau} = \frac{Qe}{m_{\Sigma}} p^{\alpha} F^{4}_{\alpha} + \frac{|\underset{\sim}{p}|}{p^{4}} \frac{d|\underset{\sim}{p}|}{d\tau} .$$

Here Q is the charge, +1, and the second terms come from the momentum loss due to ionization. Our metric is $g_{44} = -g_{11} = -g_{22} = -g_{33} = 1$.

For each event the final polarization in the laboratory was transformed through the production center of mass into the sigma rest frame at decay. A likelihood function was constructed from the probabilities $(1 + \alpha \underset{\sim}{P}(\mu_{\Sigma}) \cdot \hat{n})$, where $\hat{n}$ is the decay proton direction in the sigma rest frame at decay

$$\mathcal{L}(\mu_\Sigma) = \prod_i (1 + \alpha \underset{\sim}{P}_i(\mu_\Sigma) \cdot \hat{n}_i).$$

The value of μ_Σ was varied, giving a likelihood function with a maximum at $\mu_\Sigma = 2.20 \pm 1.00$ (see Fig. 1). The unit is $e\hbar/2m_p c$, one Bohr nucleon magneton. Likelihoods were also determined for various lifetime intervals, and the results are shown in Fig. 2. The value is in agreement with the value $\mu_{\Sigma^+} = \mu_p = 2.79$ predicted by SU_3.

We acknowledge the continuing support of Professor Luis W. Alvarez. We also wish to thank the 25-inch bubble chamber crew and our scanners and measurers for their help.

FOOTNOTE AND REFERENCE

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1. Roger O. Bangerter, A. Barbaro-Galtieri, J. P. Berge, J. J. Murray, F. T. Solmitz, M. L. Stevenson, and R. D. Tripp, Phys. Rev. Letters 17, 495 (1966); M. Watson, M. Ferro-Luzzi, and R. D. Tripp, Phys. Rev. 131, 2248 (1963).

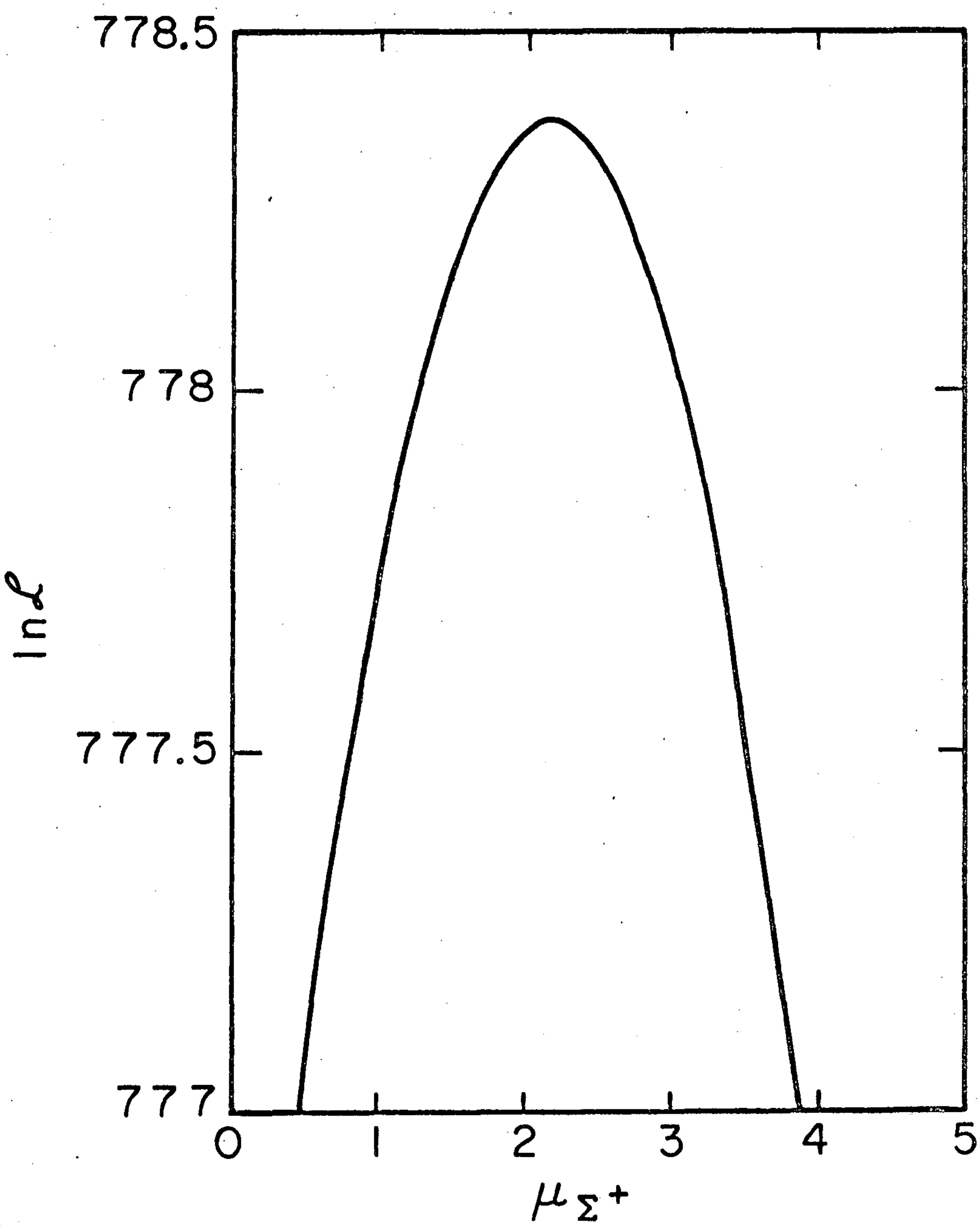

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Fig. 1. Plot of ln ℒ vs μ.

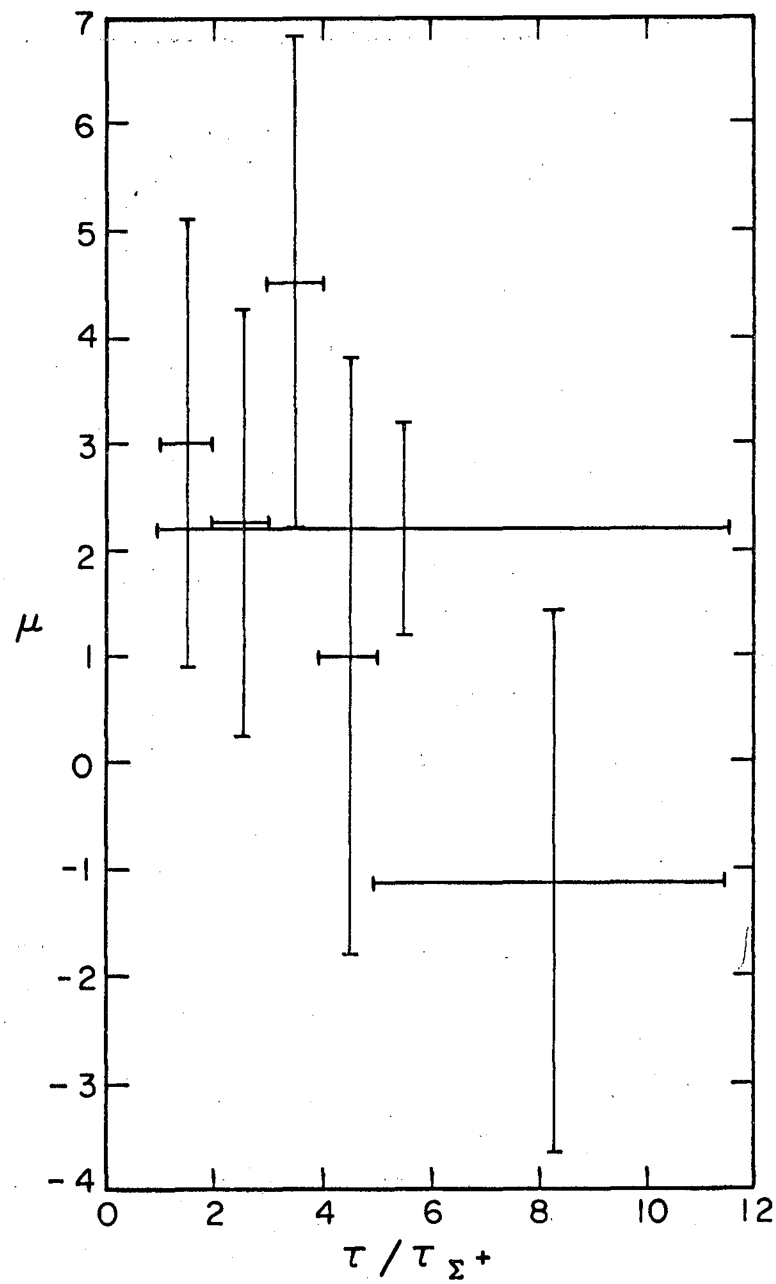

Fig. 2. μ_Σ determined for various lifetime intervals.

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