FIRST OBSERVATION OF SPIN PRECESSION OF POLARIZED SIGMA - HYPERONS CHANNELED IN BENT CRYSTALS

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Spin precession of relativistic charge particles channeling in bent crystals was predicted by V.G.Baryshevsky in 1979 [1]. Realization of this idea could make it possible to measure magnetic moment of some short living particles such as, for example, Λ_C^+. According to [1] the spin precession angle (φ) is given by the expression:

$$\varphi = \gamma\Theta(g-2)/2 \quad (\text{for}\ \gamma >> 1),$$

where γ is the Lorentz factor, g is the gyromagnetic factor, Θ is the bending angle of the channeling particle The values of Θ,γ and φ being known, one can determine g and, consequently, the magnetic moment

$$\mu = (g\,q/2m\,c)\,S$$

where q, m, and S are the charge, the mass, and the spin of the particle.

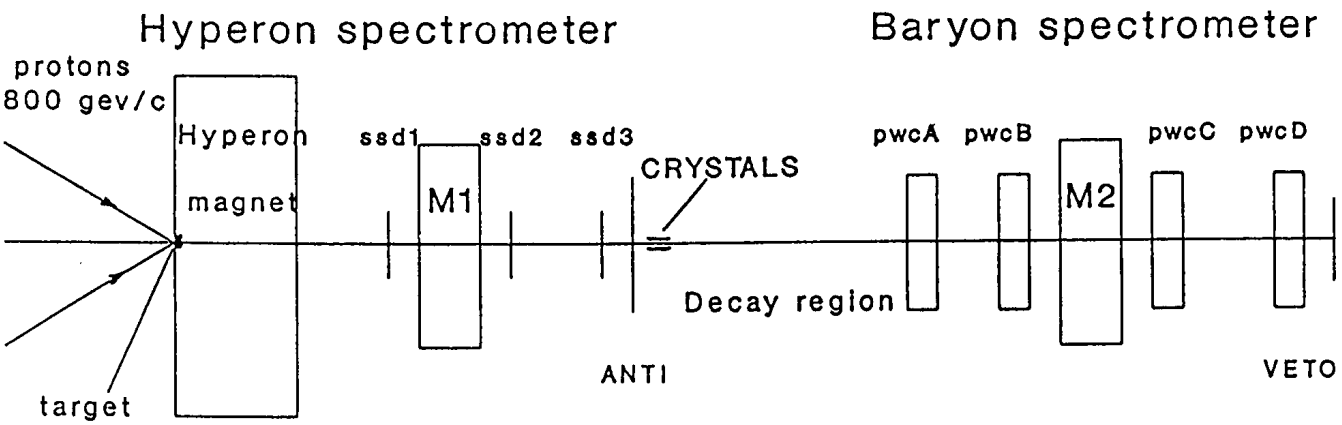

Fig.1.

In the course of the E761 experiment at Fermilab, we have undertaken an attempt to observe the rotation of the polarization vector of Σ^+ hyperons channelling in bent crystal. The decay mode $\Sigma^+ \to p\pi^0$ was used to determine the polarization vector. This mode is quite sensitive to the polarization of $\Sigma^+ s$ ($\alpha = -0.98$, B.R. $\approx 50\%$).

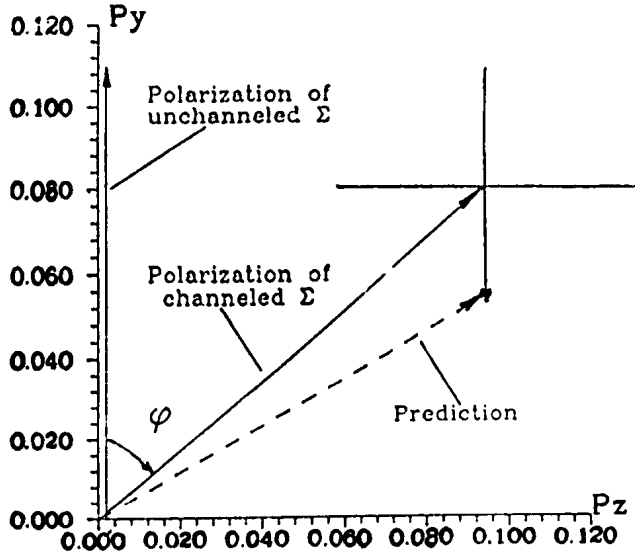

Fig.2.

Fig.1 shows the part of the E761 set up used in these measurements. The momentum and the trajectory of Σ^+ were measured in the Hyperon spectrometer (the hyperon magnet, the magnet M1 and the set of silicon strip detectors SSD1, SSD2, SSD3). The momentum and the trajectory of the outgoing proton were determined in the Baryon spectrometer (the magnet M2 and the set of multiwire proportional chambers PWCA, PWCB, PWCC, PWSD). Two silicon crystals with the orientation of the crystallographic plane (111) parallel to the crystal surface were located downstream of the Hyperon spectrometer. The upper crystal was bent down and the lower one was bent up. The bending angle was 1.65 *mrad*. Each of the crystals was 0.4 *mm* thick, 2.5 *cm* wide, and 4.5 *cm* long. The bent crystal served also as a set of eight Si detectors, each of them was 2.5 *mm* wide in the beam direction. These detectors were used to measure the particle energy losses as the particle passed through the crystal. Note that the energy loss for a particle in the channeling regime is about half of that for unchanneled particle. The amplitude analysis of the pulses from the Si detectors in combination with the analysis of the deflection angles of the particles in the vertical plane allowed to make clean selection of the particles that passed the whole length of the crystal in the channeling regime. On a trigger level, two scintillator counters were used to help the selection of the channeling particles. One of them (ANTI) was in front of the crystals with two holes of the sizes of the crystal cross sections. This counter vetoed the beam particles that missed the crystals. Another counter (VETO) at the end of the Baryon spectrometer was used to kill the undeflected (unchanneled) particles.

At the first stage of the data analysis, the channeling particles were selected using the described above criteria. These were mostly protons and pions with 1% admixture of Σ^+ hyperons. Then the $\Sigma^+ \to p\pi^0$ events were selected from analysis of the measured momenta of the beam particles and the outgoing particles. This analysis provided us with a very clean sample of the events that satisfied the requirement that $\Sigma^+ s$ pass the whole length of the bent crystal in the channeling regime. For these events, the decay asymmetries were measured, and the polarization vector components Px,Py,Pz were determined. The initial polarization was measured in the main program of the E761 experiment to be $P_{\Sigma^+} = (12 \pm 1)\%$, the polarization vector being oriented along the Y axis. If we use the world average for the magnetic moment $\mu_{\Sigma^+} = 2.42 \pm 0.05\,\mu_B$ than the predicted precession angle in our case should be $\varphi \approx (60)^0$ as it is shown by the dashed line in fig.2. The precession angle observed in our experiment proved to be $\varphi = (47{,}5 \pm 23{,}1)^0$ as it is also shown in fig.2 (here we demonstrate the preliminary data obtained only for one of the two crystals). The observed precession angle corresponds to

$$\mu^{\Sigma^+} = (2.08 \pm 0.63)\,\mu_B.$$

In these measurements, the error is dominated by the statistics as we had only 1200 events from the analysis. Further analysis will increase the statistics by factor of 2 or 3. Nevertheles, already at this stage of the analysis, it is possible to claim that we observe the spin precession phenomenon for relativistic particles channeling through a bent crystal.

Reference

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