The nuclear interaction is known to be described as the interaction of quarks and gluons in the short-range part and the interaction of mesons and nucleons in the medium- and long-range part. In this view with the flavor symmetry for light quarks ($u$, $d$, and $s$), theories of the nuclear interaction can be extended to the interaction between the octet baryons ($N$, $A$, $\Sigma$, and $\Xi$). Nowadays, theories describing the baryon-baryon (BB) interaction have been developed [1, 2, 3]. However, most of the experimental knowledge is for the NN interaction, and, as for the YY interaction, the number of observables and their accuracy is restricted. Experiments to investigate hypernuclear structure are effective and have been performed energetically. However, comprehension of the experimental data needs to solve the difficulties of few-body system. The YY interaction is directly observed in the scattering experiment of hyperon and nucleon. The YY scattering experiments were mainly performed in 1970’s with use of bubble chambers. In this experiment, we aimed at adding more data in the YY interaction with use of the modern active target technique. New data for the YY interactions directly observed by YY scattering will give information on better understanding of not only the YY interaction but of the NN and BB interaction.

KEK 12 GeV proton synchrotron (KEK-PS), series of experiments for the investigation of the hyperon-proton scattering were performed. The first one was the KEK-PS E251 experiment, which reported 11 events of $\Sigma^+p$ elastic scattering [4]. The next one was the KEK-PS E289 experiment, which measured $\Sigma^-p$ elastic scattering cross-sections at KEK-PS.

**Measurement of $\Sigma^-p$ elastic scattering cross-sections at KEK-PS**


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**Abstract.** An experiment to measure the $\Sigma^-p$ scattering cross sections was carried out at KEK 12 GeV proton synchrotron. A scintillating fiber active target system was used as a hydrogen target for the hyperon production and subsequent hyperon-nucleon scattering. Out of $1.3 \times 10^4$ hyperon production events, 31 events were identified as $\Sigma^-p$ elastic scattering events in the momentum region of $350 < p^+ < 750$ MeV/c. Differential cross sections in the angular region of $-0.8 < \cos \theta_{cm} < 0.8$ and integrated cross sections with respect to the incident momentum were obtained. They were compared with the theoretical calculations.

**Keywords:** $\Sigma^-p$ elastic scattering, Hyperon-nucleon interaction, Differential cross sections

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The calculation can be excluded at a significance level of 5% from these results. Better agreement with the experimental data than the NSC97 calculations. The NSC97a and the E251. The result is shown in Table 1. The RGM calculations showed the

- The produced hyperon traveled through the active target and scattered on protons. The active target system recorded tracks of charged particles relevant to the production and scattering of hyperons as digital image data. In 420 hours of data acquisition, we have collected $1.3 \times 10^6$ hyperon production events which was selected by the off-line analysis of the spectrometer. Human scanners looked into the image data of the selected events to identify the scattering of the hyperons on the protons. After the unified analysis of the informations of image data provided by the human scanners and the informations of the spectrometer analysis, 31 events were identified as $\Sigma^+ p$ elastic scattering events. They distributed in the momentum region of $350 \leq p_T \leq 750$ MeV/c and in the angular region of $-0.8 < \cos \theta_{CM} < 0.8$. The efficiencies and acceptances of the analyzing process, including the efficiencies of the human scanners, were estimated using the Monte Carlo simulation with the image simulator. The parameters to simulate image data were tuned so as to reproduce the thickness and brightness of the tracks of the charged particles.

The differential cross sections were obtained by merging all the incident momenta of $\Sigma^+$ (see Figure 2). These experimental data were compared with theoretical calculations in Figure 1 and 2. We chose Nijmegen Soft Core (NSC) 97a, 97c, and 97f [9] models and RGM-FSS and -fss2 [10] for the theoretical calculations to be compared. We performed chi-squared analysis using data points of this work and the E251. The result is shown in Table 1. The RGM calculations showed the better agreement with the experimental data than the NSC97 calculations. The NSC97a calculation can be excluded at a significance level of 5% from these results.
Figure 1. Differential cross sections of $\Sigma^+ p$ elastic scattering compared with (a) NSC97 calculations and (b) RGM calculations. Theoretical calculations are made for the incident momentum of 450 MeV/c.

Figure 2. Integrated cross sections of $\Sigma^+ p$ elastic scattering compared with (a) NSC97 calculations and (b) RGM calculations. Theoretical calculation in each incident momentum was integrated over the angular range of $-0.8 < \cos \theta_{CM} < 0.8$.

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