INTERACTION OF STRANGE PARTICLES WITH NUCLEONS*

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The interaction of the strange particles (Λ, K^+) with nucleons is investigated. A comparison of calculated (within CBUU model) and measured K^+ spectra in proton–nucleus reactions is made and shows good agreement. Experimentally determined production cross sections of heavy Λ hypernuclei in collisions of protons with Bi and U targets, obtained at COSY-Jülich, are compared with calculated values and agreement is obtained if rescattering of the Λ particles on nucleons is taken into account. The lifetimes of heavy Λ hypernuclei produced on Bi and U targets were measured. The value obtained for Bi (161±7±14)ps (the most precise value in literature) and the new value of the lifetime obtained for U (152±10±25)ps are consistent with possibility of the violation of $\Delta I = 1/2$ rule for nonmesonic Λ decay.

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1. Introduction

The interaction of the Λ particles with nucleons can be studied efficiently only via ΛN interaction in hypernuclei because there are no Λ beams and Λ targets available. In the present contribution we would like to show that it is possible to extract an information on strong and weak ΛN interaction

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by studying production and decay of heavy hypernuclei. The strong ΛN interaction manifests itself in hypernucleus production due to the fact that rescattering of Λ particles on nucleons significantly increases the sticking probability of the Λ particles. The weak interaction is responsible for decay of the Λ particle in the so called nonmesonic decay: $\Lambda + N \to N + N$. Such a process dominates the decay of heavy hypernuclei because the mesonic decay — which prevails for free Λ particles — is then strongly prohibited by the Pauli exclusion principle.

2. The K^+ spectra in $p + A$ reactions

To investigate the validity of the Coupled Channel Boltzmann–Uehling–Uhlenbeck model (CBUU), K^+ spectra were calculated and compared with experimental data. This is also a test for Λ production, since K^+ mesons are produced simultaneously with the Λ particles in the associated strangeness production process ($p + N \to K^+ + \Lambda + N$ or $\pi + N \to K^+ + \Lambda$). The data sets for p+Pb [1], at 2.1 GeV were compared with calculated values and very good agreement was achieved (see Fig.1 — the calculations represented by a continuous line). Other data sets were also described accurately [2, 3].

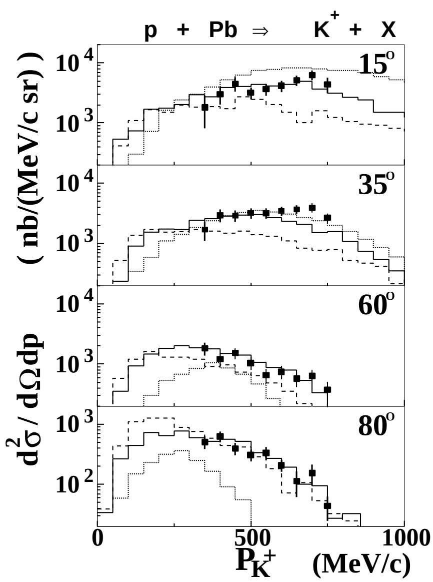

Fig. 1. The calculated K^+ spectra (lines) for p+^{208}Pb collisions at 2.1 GeV in comparison to the data [1]. The dotted, solid and dashed line are calculated for K^+N elastic cross section values of 0 mb, 10 mb and 20 mb, respectively.

An important aspect of the propagation of particles in nuclear matter is rescattering. The K^+ mesons are very good for rescattering studies because they are not absorbed in nuclei. In figure 1 CBUU calculations for different values of K^+N elastic cross section are presented. The best agreement with measured data is achieved for cross section value about 10 mb what agrees well with the data for K^+N elastic scattering [4].

3. Rescattering of Λ particle on nucleons

The effect of the ΛN elastic cross section on the production cross section of hot hypernuclei is presented in Fig. 2 for $p+^{238}$U reaction as a function of proton energy [5].

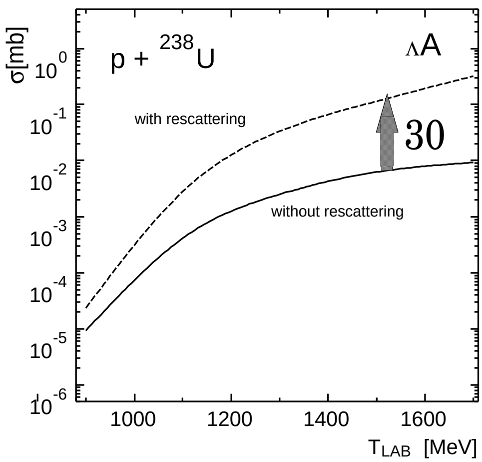

Fig. 2. Energy dependence of the production cross section of heavy hypernuclei in the $p+^{238}$U reaction with and without taking into account ΛN rescattering

Without taking into account ΛN rescattering the expected production cross section is almost 30 times smaller for energies above 1.5 GeV than in case with rescattering included. Measured production cross section agree well with theoretical value if rescattering is taken into account, see Table I.

TABLE I

Comparison between calculated and measured production cross sections of hypernuclei produced by protons on U and Bi targets [5–7].

	theory	experiment
U(1.5 GeV)	110 μb	150^{+150}_{-80} μb
Bi(1.9 GeV)	330 μb	350 ± 140 μb

4. The Λ lifetime in nuclei and $\Delta I = 1/2$ rule

The lifetime of hypernuclei is determinated by the lifetime of the Λ particle in the nuclei. The mesonic decay of Λ-particle — which dominates for free Λ — is strongly blocked in hypernuclei due to Pauli principle. Therefore the nonmesonic decay $\Lambda + N \to N + N$ plays an important role for hypernuclei. Such a decay of the Λ particle in heavy hypernuclei can by induced by its interaction with protons or with neutrons. The measurement of the mass dependence of the hypernucleus lifetime gives the possibility to determine the ratio of the Λ decay induced by neutrons R_n and by protons R_p [8]. A ratio R_n/R_p larger than 2 implies a violation of the $\Delta I = 1/2$ rule for nonmesonic decay. The new experimental data for the lifetime of heavy hypernuclei of ([161 ± 7(stat.) ± 14(syst.)]ps for Bi [7] and [152 ± 10(stat.) ± 25(syst.)]ps for U target [9]) are presented together with theoretical calculations in Fig. 3. They show that $\Delta I = 1/2$ rule may be violated on the confidence level of 0.85 for nonmesonic decay, more restrictive than that found in Ref. [8].

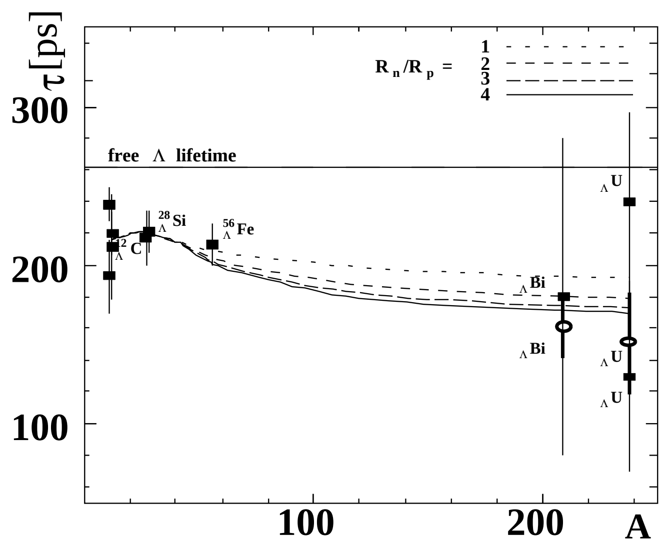

Fig. 3. Theoretical calculations of the lifetime of heavy hypernuclei as a function of the mass together with experimental data for different values R_n/R_p [8].

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