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Production of ΛΛ Hypernuclei in the (K^-,K^+) Reaction*

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PRODUCTION OF ΛΛ HYPERNUCLEI IN THE (K^-,K^+) Reaction

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Very little data exists on doubly strange ΛΛ hypernuclei; only the ground states of $^{6}_{\Lambda\Lambda}He$ and $^{10}_{\Lambda\Lambda}Be$ have been seen in emulsion experiments[1]. With existing K^- beam lines and magnetic spectrometer systems at CERN and Brookhaven, and the prospect of much higher K^- intensities at an eventual "kaon factory", one is invited to consider the possibility that discrete states of ΛΛ hypernuclei may be observed directly in the (K^-,K^+) reaction on nuclear targets. We report here on some DWBA estimates of the relevant cross sections.

Formation of ΛΛ hypernuclei requires a two-step process, either $K^-p \to \pi^0\Lambda$ followed by $\pi^0 p \to K^+\Lambda$ or $K^-p \to K^+\Xi^-$ followed by $\Xi^- p \to \Lambda\Lambda$. These sequences are rather well separated kinematically, the former peaking around $p_{K^-} \approx 1.1$ GeV/c, the latter near 1.9 GeV/c. We concentrate on the process involving a virtual π^0, since the elementary cross sections for the two stages are known. Some early estimates[2] for ΛΛ formation cross sections used harmonic oscillator wave functions, the Glauber approximation, and a crude treatment of absorption effects. To perform a more realistic calculation, we have adapted the coupled channel[3] code CHUCK to the ΛΛ case. Back coupling is neglected, so the results are equivalent to second order DWBA. We include the full distortions of the K^-, π^0 and K^+ waves, using optical potentials of Woods-Saxon shape; bound state wave functions for p and Λ are also obtained for a Woods-Saxon potential, adjusted to reproduce the appropriate separation energies.

We have investigated the reactions $^{16}O(K^-,K^+)^{16}_{\Lambda\Lambda}C^*$ and $^{28}Si(K^-,K^+)^{28}_{\Lambda\Lambda}Mg^*$ at 1.1 GeV/c as typical examples. Because of the sizable momentum transfer $q \approx 400$ MeV/c, even at 0°, high spin states of the ΛΛ hypernucleus are preferentially populated. For the low spin $^{16}_{\Lambda\Lambda}C$ ground state (0^+), formed in the transition $[_p(P_{1/2}) \to {}_\Lambda(S_{1/2})]^2_{\Delta L=1}$, the $0°(K^-,K^+)$ cross section is tiny, of order 30 pb/sr. The highest spin bound state of $^{16}_{\Lambda\Lambda}C$ that we can make without benefit of spin flip (which is very small) is $[_p(P_{1/2}) \to {}_\Lambda(P_{3/2})]^2_{\Delta L=2}$, coupled to 4^+, with a cross section of about 0.25 nb/sr. The transition $[_p(P_{1/2}) \to {}_\Lambda(2S_{1/2})]_{\Delta L=1} \otimes [_p(P_{1/2}) \to {}_\Lambda(d_{5/2})]_{\Delta L=3}$ to a 4^+ continuum state is larger (about 3 nb/sr). In the intermediate channel $\pi^\circ + {}^{16}_{\Lambda}N$, we have considered only weak coupling configurations $^{16}_{\Lambda}N = {}^{15}N(g.s.) \otimes (\ell j)_\Lambda$; core excitations of ^{15}N as well as ΛN and ΛΛ residual interactions have been ignored. The spectrum in the reaction $^{28}Si(K^-,K^+)^{28}_{\Lambda\Lambda}Mg^*$ is somewhat richer. Here again, the cross section to the $^{28}_{\Lambda\Lambda}Mg$ ground state is negligible. However, transitions to high spin states dominate, for instance $[_p(d_{3/2}) \to {}_\Lambda(P_{3/2})]^2_{\Delta L=3}$, $[_p(d_{3/2}) \to {}_\Lambda(2S_{1/2})]_{\Delta L=2} \otimes [_p(d_{3/2}) \to {}_\Lambda(d_{5/2})]_{\Delta L=4}$ and $[_p(d_{3/2}) \to {}_\Lambda(d_{5/2})]^2_{\Delta L=4}$ to 6^+, 6^+ and 8^+ states, respectively. These cross sections, although small, are well worth measuring. The excited states of high spin emphasized by the (K^-,K^+) reaction could give us new information on the ΛΛ residual interaction.

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