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## PRODUCTION OF $\Lambda\Lambda$ HYPERNUCLEI IN THE $(K^-, K^+)$ Reaction

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Very little data exists on doubly strange  $\Lambda\Lambda$  hypernuclei; only the ground states of  ${}^6_{\Lambda\Lambda}\text{He}$  and  ${}^{10}_{\Lambda\Lambda}\text{Be}$  have been seen in emulsion experiments<sup>1</sup>. 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  $\Lambda\Lambda$  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  $\Lambda\Lambda$  hypernuclei requires a two-step process, either  $K^-p \rightarrow \pi^0 \Lambda$  followed by  $\pi^0 p \rightarrow K^+ \Lambda$  or  $K^-p \rightarrow K^+ \Xi^-$  followed by  $\Xi^- p \rightarrow \Lambda\Lambda$ . 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  $\pi^0$ , since the elementary cross sections for the two stages are known. Some early estimates<sup>2</sup> for  $\Lambda\Lambda$  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<sup>3</sup> code CHUCK to the  $\Lambda\Lambda$  case. Back coupling is neglected, so the results are equivalent to second order DWBA. We include the full distortions of the  $K^-$ ,  $\pi^0$  and  $K^+$  waves, using optical potentials of Woods-Saxon shape; bound state wave functions for  $p$  and  $\Lambda$  are also obtained for a Woods-Saxon potential, adjusted to reproduce the appropriate separation energies.

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

#### References

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