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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 experiments¹. 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 $\pi^0p\rightarrow K^+\Lambda$ 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 π^0 , since the elementary cross sections for the two stages are known. Some early estimates² 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 channel³ 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^- , 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 $^{16}_\Lambda\text{O}(\text{K}^-, \text{K}^+)^{16}_\Lambda\text{C}^*$ and $^{28}_\Lambda\text{Si}(\text{K}^-, \text{K}^+)^{28}_\Lambda\text{Mg}^*$ at 1.1 GeV/c as typical examples. Because of the sizable momentum transfer $q \approx 400$ MeV/c, even at 0° , high spin states of the $\Lambda\Lambda$ hypernucleus are preferentially populated. For the low spin $^{16}_\Lambda\text{C}$ ground state (0^+), formed in the transition $[\{p_{1/2}\} + \Lambda(1/2)]_{\Delta L=1}^2$, the $0^\circ(\text{K}^-, \text{K}^+)$ cross section is tiny, of order 30 pb/sr. The highest spin bound state of $^{16}_\Lambda\text{C}$ that we can make without benefit of spin flip (which is very small) is $[\{p_{1/2}\} + \Lambda(3/2)]_{\Delta L=2}^2$, coupled to 4^+ , with a cross section of about 0.25 nb/sr. The transition $[\{p_{1/2}\} + \Lambda(2S_{1/2})]_{\Delta L=1} \otimes [\{p_{1/2}\} + \Lambda(d_{5/2})]_{\Delta L=3}$ 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 $^{16}_\Lambda\text{N} = ^{15}_\Lambda\text{N}(\text{g.s.}) \otimes \{qj\}_\Lambda$; core excitations of $^{15}_\Lambda\text{N}$ as well as ΛN and $\Lambda\Lambda$ residual interactions have been ignored. The spectrum in the reaction $^{28}_\Lambda\text{Si}(\text{K}^-, \text{K}^+)^{28}_\Lambda\text{Mg}^*$ is somewhat richer. Here again, the cross section to the $^{28}_\Lambda\text{Mg}$ ground state is negligible. However, transitions to high spin states dominate, for instance $[\{p_{3/2}\} + \Lambda(3/2)]_{\Delta L=3}^2$, $[\{p_{3/2}\} + \Lambda(2S_{1/2})]_{\Delta L=2}^2$, $\otimes [\{p_{3/2}\} + \Lambda(d_{5/2})]_{\Delta L=4}$ and $[\{p_{3/2}\} + \Lambda(d_{5/2})]_{\Delta L=4}^2$ 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 (K^-, K^+) reaction could give us new information on the $\Lambda\Lambda$ residual interaction.

References

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