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Production of the Doubly Strange H Dibaryon*

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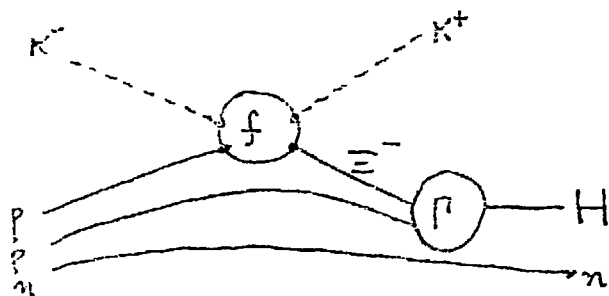
PRODUCTION OF THE DOUBLY STRANGE H DIBARYON

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There is much current interest in the spectroscopy of multiquark states. Predictions abound for the existence of baryonium ($Q^2\bar{Q}^2$) and six-quark dibaryon (Q^6) resonances¹, for instance. In the strangeness $S = -2$ sector of Q^6 , the MIT bag model² predicts a dibaryon H with quantum numbers $J^\pi = 0^+$, isospin $I = 0$, and mass $M_H \approx 2150 \text{ MeV} \approx 2M_\Lambda - 80 \text{ MeV}$. The H has quark composition $uuddss$, so all quarks can occupy the $1s$ state; it is unique in that it possesses no strong decay modes. The fact that the H mass is considerably below the $\Lambda\Lambda$ or ΞN thresholds precludes its interpretation as a deuteron-like object bound by conventional long-range meson exchange forces.

The H has been searched for in the reaction $p+p \rightarrow K^+K^+H$ by Carroll et al.³, with an upper limit of about 100 nb/sr^2 for two K^+ 's at $\pm 18^\circ$ in the lab system. Some crude cross section estimates we have made for this process indicate much smaller cross sections than this limit.

A more natural way to produce the H, in our view, is via the (K^-, K^+) reaction on a diproton in a nuclear target, i.e. $K^-(pp) \rightarrow K^+H$. For the simplest case of a ^3He target, the process is shown in the figure.



$^3\text{He} (K^-, K^+) H n$

The differential cross section for the $K^-p \rightarrow K^+ \Xi^-$ reaction at 0° has a peak value of about $|f|^2 \approx 35 \text{ } \mu\text{b/sr}$ around $p_{K^-} \approx 1.8 \text{ GeV/c}$. The (pp) pair must be in the 1S_0 state, so no spin flip is required to produce the H (also 1S_0). The vertex function (decay amplitude) Γ is calculated in a non-relativistic quark model, and describes the fusion of two 3 quark systems (p and Ξ^-) into a six quark state (H) of radius R . When we use harmonic oscillator wave functions for the quarks, we find

$$\Gamma_{(\vec{p}_1, \vec{p}_2)} = \Gamma_0 e^{-\frac{R^2}{12} (\vec{p}_1 - \vec{p}_2)^2}$$

depending only on the relative momentum $\vec{p}_1 - \vec{p}_2$ of the p and Ξ^- . Γ_0 includes a geometrical factor and also a color, spin and flavor recoupling coefficient obtained from the approximate wave function $\psi_H = \sqrt{4/5} |8_c \times 8_c\rangle + \sqrt{1/40} |\Lambda\Lambda\rangle + \sqrt{3/40} |\Xi\Xi\rangle + \sqrt{1/20} |\Xi N - N \Xi\rangle$ for the H. Since the Ξ^- typically has a lab momentum $|\vec{p}_1|$ of about 400 MeV/c, nuclear Fermi motion enables us to reach the region of phase space where $|\vec{p}_1 - \vec{p}_2|$ is fairly small, and $\Gamma \approx \Gamma_0$. This is not the case in the $pp \rightarrow K^+ K^+ H$ reaction, where the analogous $\Lambda\Lambda$ or $\Xi^- p \rightarrow H$ quark fusion processes correspond to large values of $|\vec{p}_1 - \vec{p}_2|$ and hence tiny cross sections for H production. Using oscillator wave functions for ^3He , we estimate $(d\sigma/d\Omega_{K^+})_{0^\circ} \approx 2 \text{ } \mu\text{b/sr}$ for the $^3\text{He}(K^-, K^+)Hn$ cross section at 1.9 GeV/c in the closure approximation, using plane waves⁴. One could also detect the neutron in coincidence with the K^+ , to more clearly pin down the H. Such cross sections are accessible experimentally. Since the H represents a very important prediction of the Bag Model, we urge that a (K^-, K^+) experiment on a nuclear target be done in order to search for it.

References

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