Nuclear Structure in Nonmesonic Weak Decay of Hypernuclei

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A general shell model formalism for the nonmesonic weak decay of the hypernuclei has been developed. It involves a partial wave expansion of the emitted nucleon waves, preserves naturally the antisymmetrization between the escaping particles and the residual core, and contains as a particular case the weak Λ-core coupling formalism.
Starting from a widely accepted effective coupling Hamiltonian involving the exchange of the complete pseudoscalar and vector meson octets (π,η,K,ρ,ω,K^*), the strangeness-changing weak $\Lambda N \rightarrow NN$ transition potential is derived, including the first order nonlocality corrections and the kinematical effects due to the difference between the Λ and nucleon masses, which have been systematically omitted in the literature. Our analysis shows that the main amendment coming from the nonlocality of the potential are new parity violating operators induced by the vector mesons, while the effective pion mass, which increases by $\sim 35\%$ the range of the corresponding transition potential, is the major kinematical effect.
The extreme particle-hole model (EPHM) is worked out in detail. Simple formulae, which clearly exhibit the interplay between different mesons in each one of the partial wave channels, are presented for the neutron and proton induced decays, Γ_n and Γ_p, in ${}^{12}_{\Lambda}C$. With the commonly used parametrization in the one-meson-exchange model (OMEM), the calculated rate $\Gamma_{NM} = \Gamma_n + \Gamma_p$ is of the order of the free Λ decay rate Γ^0($\Gamma^{\rm th}_{NM} \cong \Gamma^0$) and is consistent with experiments. Yet, the measurements of the ratio $\Gamma_{n/p} = \Gamma_n/\Gamma_p$ and of Γ_p ($0.5 \leq \Gamma^{\rm exp}_{n/p} \leq 2$; $\Gamma^{\rm exp}_p \leq 0.5\ \Gamma^0$) are not well accounted for by the theory ($\Gamma^{\rm th}_{n/p} \lesssim 0.42$; $\Gamma^{\rm th}_p \gtrsim 0.60\ \Gamma^0$). By varying the OMEM parameters, it was possible to reproduce all three data simultaneously, obtaining: $0.87 \lesssim \Gamma^{\rm th}_{NM}/\Gamma^0 \lesssim 1.30$, $1.06 \lesssim \Gamma^{\rm th}_{n/p} \lesssim 1.42$, and $0.41 \lesssim \Gamma^{\rm th}_p/\Gamma^0 \lesssim 0.55$.
The EPHM results for Γ_n and Γ_p were confronted with the nuclear matter calculations for the OMEM, based on the Polarization Propagator Method (PPM) and extended to ${}^{12}_{\Lambda}C$ via the Local Density Approximation. It was found that both models yield qualitative similar results and that the exact evaluation of the exchange terms is required in nuclear matter.