Measuring the ΛN Odd State Interaction

An important ingredient for strange matter and neutron stars

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In nuclear matter, odd (p) and even (s) state interactions contribute to binding in a ratio of 5:3. In strange matter, a bound state of hyperons and nucleons, odd state interactions will be similarly important. Neutron stars are expected to contain a significant hyperon component based on simple exclusion principle arguments. Recent experimental measurement of neutron star temperature far below that expected for conventional nucleon composition.

Despite its importance, the odd state interaction for the Λ particle is not well determined. For example, potential models such as NSC 97 which work well for much hypernuclear data have a repulsive odd state interaction for lambda-nucleon. In contrast, an analysis of ${}^{13}_{\Lambda}$C data by Millener et al. derived an attractive odd state interaction about 1/2 as large as the even state interaction. Here the data shows two $1/2^-$ states with p shell lambdas split by 6 MeV. However, the p-state Λ in ${}^{13}_{\Lambda}$C is just bound, so its wave function is poorly know - small changes in binding give large change in wave function and hence in the conclusions as to the size of the odd state interaction. A heavier system would not suffer from these uncertainties.

We consider the study gamma transitions of p-state Λ particles in ${}^{89}_{\Lambda}$Y as a means to determine the ΛN odd state interaction. An analysis of ${}^{89}_{\Lambda}$Y similar to that done by Millener et al. for ${}^{13}_{\Lambda}$C would derive the odd state interaction in an unambiguous way. This is an important ingredient for understanding neutron stars (see for example Yamamoto et al. in HYP2000 proceedings).

The experiment could be performed at the BNL AGS. Using the reaction $K^-+{}^{89}Y \rightarrow {}^{89}_{\Lambda}Y+\pi^-$ with p_{K^-}=1.8 GeV/c, to populate Λ p-states, their gamma-ray transitions could be observed using the upgraded Hyperball germanium detector array, in modest running time under available beam conditions.

The excitation energy of the Λ p-states in ${}^{89}_{\Lambda}$Y is 6.0$\pm$.15 MeV according to H. Hotchi PhD thesis; this is well above the neutron and proton separation energies of the core. Thus the Λ p-states are particle stable and decay by gamma emission. The Λ p-states are split into several component and by a similar analysis as in the ${}^{13}_{\Lambda}$C case, the splittings determine the odd state interaction, but here without ambiguity.