Study of Spin-Orbit Splitting in ${}^{13}_{\Lambda}C$

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Study of Spin-Orbit Interaction in Hypernuclei

Why spin-orbit interaction U_{LS} ?

Central part of Λ-nucleus interaction is relatively well known, but spin dependent part.

- systematic studies on levels of hypernuclei with (π^+,K^+) reaction

$$U_C(\Lambda) \approx \frac{2}{3} U_C(N)$$

small s-quark contribution to long-range Λ-N interaction ?

- we just can say

$$U_{LS}(\Lambda) \ll U_{LS}(N)$$

experimental information is still poor and theoretical ambiguity is still large

important input to models of structure of hypernuclei

information on spin dependence of elementary Λ-N interaction

- spin-orbit potential U_{LS} is sensitive to relatively short-range part
- contrasted with central potential U_C which is sensitive to long-range part

Study of Spin-Orbit Interaction in Hypernuclei

Experimental Situation

sources of information on spin-orbit splitting ΔBE_{LS}

- emulsion experiment
  - systematic re-analysis recently
- experiment with magnetic spectrometer
  - many trials using existing data
    - (in-flight K^-, π^-), (π^+, K^+), angular dependence
- γ-ray measurement
  - some data but not so many data for spin-orbit

experimental results are not conclusive yet

- small but finite spin-orbit splitting ΔBE_{LS} or consistent with zero
- limited energy resolution and statistics
- no dedicated experiment, need new dedicated experiments

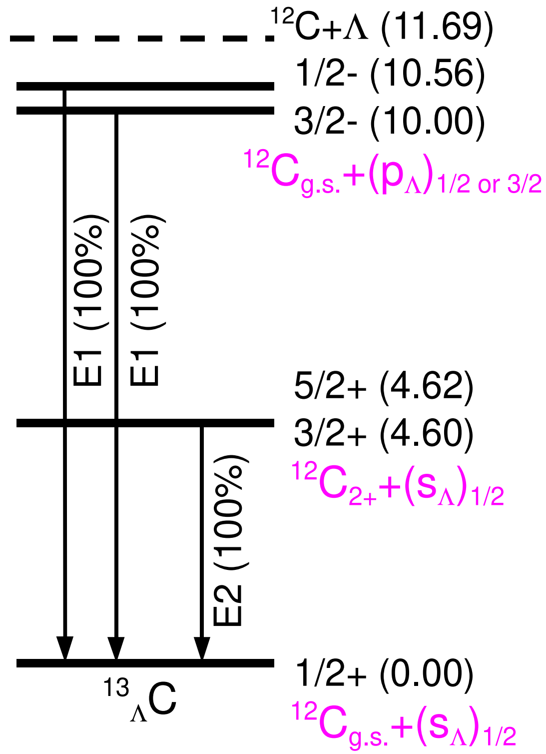
Basic Ideas of E929 Experiment

Requirements and Solutions

choose $^{13}{}_{\Lambda}C$

- smaller ambiguity in estimation of ΔBE_{LS}

$$\Delta BE_{LS}(p-shell) = Ex(1/2^{-}) - Ex(3/2^{-})$$



need good energy resolution and good statistics

- measurement based on γ-ray detection
- not Ge but NaI(Tl) for good statistics
  - $\Delta E\gamma$ ~ 700keV(FWHM) at $E\gamma$ = 10MeV
  - efficiency~0.1 with array of NaI(Tl)
- γ-ray transition in $^{13}{}_{\Lambda}C$ has been measured with NaI(Tl) (AGS/E781, PRL 78 (1997) 4343, $1/2^{-} \rightarrow$ g.s. only)
- large acceptance magnetic spectrometer
  - tag $^{13}{}_{\Lambda}C$ formation, roughly select 10 MeV excitation region

Basic Ideas of E929 Experiment

systematic errors should be small to get clear conclusion

- measure two γ-ray transitions simultaneously
- separate two γ-ray transitions by using angular dependence of (in-flight K^-, π^-) reaction

  small angle (~3°): $1/2^-$ dominant ($\Delta L=0$)

  large angle (~13°): $3/2^-$ dominant ($\Delta L=2$)
- sensitivity of ΔBE_{LS} down to 100keV

need good S/N ratio

- strong background from K^- decay in-flight

  about 0.1% of beam decays into spectrometer acceptance
- live target (^{13}C benzene scintillator) to tag decay of hypernucleus

$$^{13}_{\Lambda}C^* \underset{\gamma}{\rightarrow} {}^{13}_{\Lambda}C_{g.s.} \underset{n.m.}{\rightarrow} p+n+X$$

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