Hyperball-2による質量数80領域におけるカイラルダブレットの探索

鈴木智和$^{A,B}$、小池武志$^B$、T. Ahn$^G$、遠藤卓哉$^A$、藤田正広$^A$、Y.Y. Fu$^F$、福地知則$^C$、P. Joshi$^D$、木下沙理$^B$、馬越$^B$、三浦勇介$^B$、宮下裕次$^{A,B}$、大熊三晴$^{A,B}$、G. Rainovski$^G$、佐藤望$^{A,B}$、篠塚勉$^A$、白鳥昂太郎$^B$、田村裕和$^B$、立岡未来$^{A,B}$、J. Timar$^E$、鵜養美冬$^A$、涌井崇志$^A$、山崎明義$^A$

東北大学サイクロトロンRIセンター$^A$
東北大学大学院理学研究科$^B$
立教大学$^C$
University of York, U.K$^D$
ATOMKI, Hungary$^E$
CIAE, China$^F$
SUNY at Stony Brook, U.S.A$^G$
Physics Motivation

- 1997 – Frauendorf & Meng;
  - The doubling of band in $^{134}$Pr is due to formation of handedness (chirality). [\textit{Nucl. Phys A617 131 (1997)}]
  - Three perpendicular angular momentum can form two systems of handedness, the right-handed and the left-handed system.

D. Tonev et. al.
PRL 96 052501 (2006)

$^{134}$Pr

Band 1

Band 2
Known regions with chiral candidates

\( A \sim 130 \)

**Odd-Odd** \((\pi h_{11/2} \nu h_{11/2}^{-1})\)
- \(^{132}\text{Cs},^{130}\text{Cs},^{128}\text{Cs},^{126}\text{Cs},^{124}\text{Cs}\)
- \(^{134}\text{La},^{132}\text{La},^{130}\text{La}\)
- \(^{134}\text{Pr},^{132}\text{Pr}\)
- \(^{136}\text{Pm}\)
- \(^{140}\text{Eu},^{138}\text{Eu}\)

**Odd-A** \((\pi (h_{11/2})^{2} \nu h_{11/2}^{-1})\)
- \(^{135}\text{Nd},^{135}\text{Ce}\)

\( A \sim 190 \)

**Odd-Odd** \((\pi h_{9/2} \nu i_{13/2})\)
- \(^{188}\text{Ir}\)

**Even-Even** \((\pi h_{11/2} (d_{5/2}, g_{7/2}) \nu (h_{11/2})^{2})\)
- \(^{136}\text{Nd}\)

\( A \sim 80 \) (unexplored)

**Odd-Odd** \((\pi g_{9/2} \nu g_{9/2}^{-1})\)
- \(^{80}\text{Br}(?)\)

**Odd-A** \((\pi (g_{9/2})^{2} \nu g_{9/2}^{-1})\)
- \(^{79}\text{Kr}(?)\)

\( A \sim 105 \)

**Odd-Odd** \((\pi g_{9/2}^{-1} \nu h_{11/2})\)
- \(^{106}\text{Ag},^{106}\text{Rh},^{104}\text{Rh},^{102}\text{Rh}\)
- \(^{100}\text{Tc}\)

**Odd-A** \((\pi g_{9/2}^{-1} \nu (h_{11/2})^{2})\)
- \(^{107}\text{Ag},^{105}\text{Rh},^{103}\text{Rh}\)
Doublet bands in $^{103}_{45}\text{Rh}_{58}$

J. Timar et. al. PRC 73 011301(2006)

Lifetime was measured at GAMMASPHERE in October 2005.
Hyperball-2

• Total of 20 detectors
  - Photo peak efficiency \(\sim 5\%\) at 1MeV
    • Eurisys Coaxial Ge
      - r.e. 60\% \(\times 4\)
    • Ortec Coaxial Ge
      - r.e. 60\% \(\times 10\)
    • Eurisys Clover type Ge \(\times 6\)
      - r.e. 20\%x4, 125\% with add-back
  - Transistor-reset type pre-amplifier

• Target Chamber
• Collimators and Copper absorbers
• High speed data taking system with FERA-VME (double buffering)
In-beam experiments with Hyperball-2

**Advantages**
- Large total photo peak efficiency (γ-γ-γ coincidence measurement)
- Possible to use high intensity (~10pnA) beam (high counting rate).

**Disadvantages**
- Few angles
  - Detectors placed mostly around 90deg. (lower angular correlation sensitivity)
- Detectors in upper and lower ring point off center
Experiments

- Course 33 at CYRIC, Tohoku University
- Reaction: $^{70}\text{Zn}(^{13}\text{C},4n)^{79}\text{Kr}$
  - Beam: $^{13}\text{C}^3+ @ 65\text{MeV}$ from 930 cyclotron
  - Target: 1mg/cm$^2$ 70% enriched $^{70}\text{Zn}$ (self-supporting and Pb backed)
- HPGGe array: Hyperball-2 for $\gamma$ ray detection
Choice of targets

1mg/cm$^2$ without backing
Peaks are broadened because of Doppler broadening. However, higher spin states can be observed than those with backed targets.

1mg/cm$^2$ with Pb backing
No Doppler broadening at lower spins.

In March experiment, 520+560µg/cm$^2$ self-supporting target was used.
Deduced Level Scheme

Self supporting target – 24 hours

(Additional 4 days beam time Mar. 7th – 10th, 2006.)
Summary

• Hyperball-2 was optimized for in-beam experiments and installed in CYRIC Tohoku University.

• $^{79}\text{Kr}$ was studied via $^{70}\text{Zn}(^{13}\text{C},4n)^{79}\text{Kr}$ for chiral doublet structures in the mass $\sim$80 region.

• Preliminary analysis has identified three side band member candidates.

• Additional data from March experiment are being analyzed.