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THE Λ HYPERNUCLEAR SPECTROSCOPY WITH THE SKS SPECTROMETER AT KEK 12 GeV PS

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ABSTRACT

A spectroscopic study of Λ hypernuclei by the (π^+,K^+) reaction has been performed for the wide hypernuclear mass range using a new superconducting kaon spectrometer (INS-SKS) at the KEK 12 GeV PS. A ${}^{12}_{\Lambda}$C spectrum with 2 MeV (FWHM) energy resolution was measured and core excited states of ${}^{12}_{\Lambda}$C were clearly identified for the first time. It is discussed that the excitation energies and cross sections of these states will be closely related with the choice of ΛN interaction models as well as hypernuclear structure. Hypernuclear spectra of ${}^{10}_{\Lambda}$B, ${}^{28}_{\Lambda}$Si, ${}^{89}_{\Lambda}$Y, ${}^{139}_{\Lambda}$La and ${}^{208}_{\Lambda}$Pb were also obtained and binding energies of a Λ hyperon were deduced for each Λ orbital. The mass number dependence of the Λ binding energies is, within the present experimental errors, consistent with a calculation based on the Woods-Saxon potential.

1. Introduction

In the spectroscopy of Λ hypernuclei, we naively intend to explore a new degree of freedom in a nucleus by embedding a Λ hyperon (or s quark) as an impurity in nuclear matter. It will be possible because a Λ hyperon is free from the Pauli exclusion principle in contrast to a nucleon in a nucleus and discrete hypernuclear states can be formed even in the deeply bound region. Although $(e,e'p)$ or $(p,2p)$ reactions, for example, can be used to probe interior of a nucleus by knocking out a deeply bound nucleon, those deep hole states have large spreading widths and cannot be observed as peaks in excitation spectra.[1] In the case of Λ hypernuclei, on the other hand, intrinsic widths of bound hypernuclear states are expected to be narrow enough, because isospin of a Λ hyperon is zero, the ΛN interaction is weaker and no exchange term is needed.[2,3] Therefore, Λ hypernuclei provide quite a promising opportunity for spectroscopy. Furthermore, information on the effective ΛN interaction in a nucleus can be extracted through the structure of Λ hypernuclei. The spectroscopic study is indispensable for revealing the ΛN interaction particularly in view that we do not have easy access to hyperon beams. Thanks to recent intensive theoretical investigations, it became possible to relate hypernuclear properties to the hyperon-nucleon interaction in free space through the G-matrix method. In this regard, high quality spectroscopic information on Λ hypernuclei has increasing importance. In addition, weak decay of Λ hypernuclei also attracts strong interests, since it undergoes from hypernuclear ground states. The weak decay process in nuclear matter is unique in studying the weak interaction itself but at the same time it is expected to carry information on a hyperon deeply bound in a nucleus. For these investigations, it is of vital importance to abundantly produce bound states of Λ hypernuclei.

A new generation of hypernuclear experiments started recently using the (π^+,K^+) reaction, in which high-spin bound states of Λ hypernuclei are preferentially populated thanks to the large momentum transfer. The (π^+,K^+) reaction, although it requires an intense 1 GeV/c pion beam, is now believed to be one of the most appropriate reactions for spectroscopic study of Λ hypernuclear bound states because of its selective nature in populating hypernuclear states. The BNL group[4] first demonstrated Λ hyperon shell structure from ${}^{9}_{\Lambda}$Be to ${}^{89}_{\Lambda}$Y in the (π^+,K^+) reaction; later ${}^{12}_{\Lambda}$C and ${}^{56}_{\Lambda}$Fe were also studied at the KEK 12 GeV PS.[5] Those experiments, together with recent theoretical investigations,[6-8] have established the value of the (π^+,K^+) reaction. In the present paper, we report on a recent study of Λ hypernuclei by the (π^+,K^+) reaction with a new spectrometer at KEK 12 GeV PS.

2. The SKS spectrometer

The superconducting kaon spectrometer (INS-SKS)[9] has been installed in the north experimental area of the KEK 12 GeV proton synchrotron in order to intensively pursue spectroscopic study of Λ hypernuclei by the (π^+,K^+) reaction. A schematic drawing of the experimental area and the K6 beam line which delivers electrostatically separated secondary beams to the SKS spectrometer is shown in Fig. 1. The K6 beam channel provides beams in the momentum region up to 1.2 GeV/c with intensity of a few times 10^6/spill. In Fig. 2, pion beam intensity in the GeV/c region in meson factories, proton synchrotrons and once proposed facilities are compared. The KEK 12 GeV PS together with BNL AGS provides a good opportunity for pion induced reactions in the 1 GeV/c region not accessible in the meson factories.

The SKS spectrometer was designed so that a good momentum resolution and a large solid angle be simultaneously achieved in the 1 GeV/c region.[9] The design characteristics of the SKS are summarized in Table 1. Fig. 3 shows a schematic diagram of the SKS spectrometer system which consists of a beam spectrometer that measures incident pion

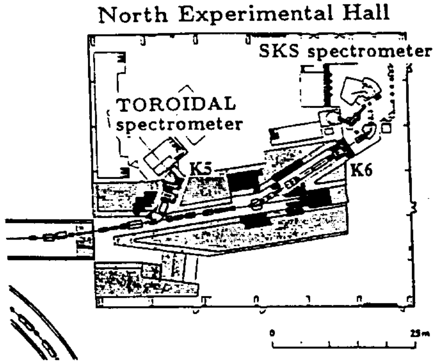

Figure 1. Schematical view of the north experimental area at the KEK 12 GeV PS

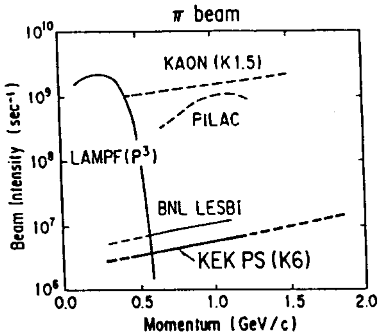

Figure 2. Pion beam intensity as a function of beam momentum at various facilities.

momentum particle by particle and a scattering particle spectrometer which determines momentum of a kaon emitted from the target.

Table 1
Characteristics of the SKS spectrometer

1. Momentum resolution $(\Delta p/p)_{FWHM}$	1/1000 at 720 MeV/c
2. Maximum momentum	1.1 GeV/c
3. Momentum range	20 %
4. Bending angle	100 degrees at 720 MeV/c
5. Solid angle	100 msr
6. Flight path	5 m for the central trajectory
7. Angular range	-25 ∼ 55 degrees.

The beam spectrometer is comprised of a QQDQQ optical system, timing counters and drift chambers. The $\langle x|\theta\rangle$ term of the transfer matrix can be adjusted to be zero so that effect of multiple scattering on the momentum resolution should be kept small. The drift chambers, with 2.5 mm drift distance, measure beam particle trajectories with $\sigma \approx 250$ μm position resolution for a beam rate up to several times 10^6 Hz. The SKS spectrometer consists of a large superconducting dipole magnet, drift chambers and trigger counters. The superconducting magnet[11], which has large bending power (100 degrees for 720 MeV/c) and a wide aperture, is indispensable for achieving the large acceptance and

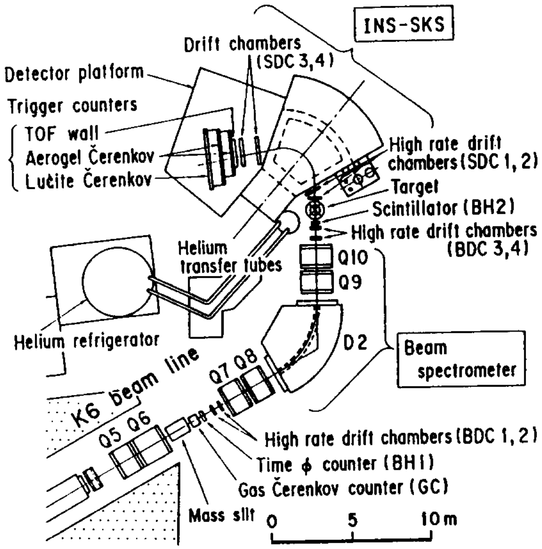

Figure 3. The SKS spectrometer system which consists of the beam spectrometer and the scattered particle spectrometer

good momentum resolution at the same time. The flight length of particle trajectories is made as short as 5 m in order to minimize kaon decay in flight. Two layers of silica aerogel Čerenkov counters(n = 1.06), which are sensitive to pions but not to kaons in the relevant momentum region around 700 MeV/c, play an essential role in the identification of kaons at the trigger stage.[10] Missing masses in the (π^+, K^+) reaction are derived event by event from momenta of a pion and a kaon by solving equations of motion. The momentum resolution of the spectrometer was found to be 0.1 % FWHM by letting beam particles go through the two spectrometers.

3. $^{12}_{\Lambda}$C Hypernucleus

The measured $^{12}_{\Lambda}$C hypernuclear spectrum is plotted in Fig.4. In the spectrum, four peaks were observed. The two prominent peaks, #1 and #4, were reported in previous (π^+, K^+) experiments.[4,5] These peaks correspond to states in which a Λ hyperon in s or p orbitals couples to the ^{11}C ground state. The energy resolution of the spectrum is evaluated from the width of the ground state peak, #1, to be 2.0 ± 0.1 MeV (FWHM). Thanks to the good resolution of the spectrometer, two smaller peaks which are indicated as #2 and #3 in the figure are clearly observed for the first time. The spectrum was fitted assuming four Gaussian peaks and a quasi-free contribution in the unbound region. The quasi-free part was fitted with a quadratic function rising from B_Λ = 0 MeV by convoluting the experimental resolution. Table 2 summarizes the excitation energies and the cross sections of these four peaks, where only statistical errors are quoted. The cross sections are those averaged over the SKS spectrometer acceptance covering from 0.6 to 15 degrees. Those at 3 and 10 degrees for the ground state can be obtained by multiplying the quated value by 1.4 and 0.8, respectively, if we assume the angular distribution of the kaons calculated by Itonaga *et. al.*[12]

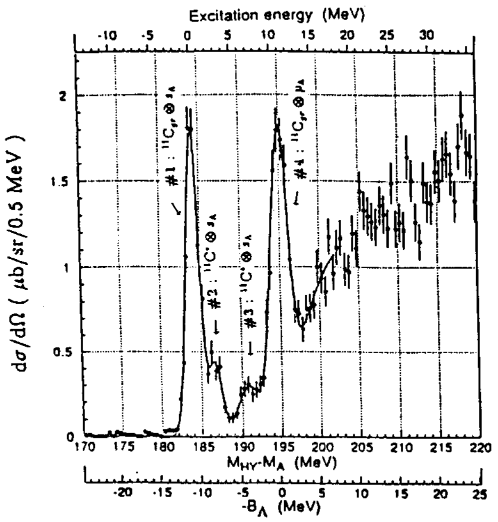

Figure 4. Excitation spectrum of $^{12}_{\Lambda}\mathrm{C}$ observed in the (π^+, K^+) reaction at $p_\pi = 1.06$ GeV/c with the SKS spectrometer. The energy resolution is 2.0 ± 0.1 MeV(FWHM).

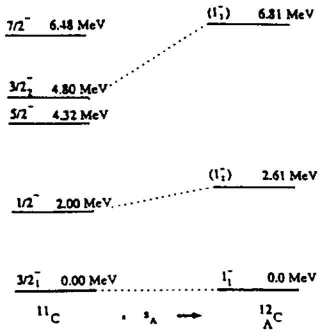

Figure 5. ^{11}C energy levels and expected $^{12}_{\Lambda}\mathrm{C}$ hypernuclear states based on the weak coupling of a Λ hyperon to the nuclear core.

Since a Λ hyperon couples weakly to the nuclear core due to weakness of the ΛN interaction, the $^{12}_{\Lambda}\mathrm{C}$ hypernuclear states are expected at excitation energies close to corresponding states of the core nucleus ^{11}C, as illustrated in Fig.5. The cross sections of the Λ hypernuclear states are to first order proportional to the $p_{3/2}$ and $p_{1/2}$ neutron hole strengths of the core ^{11}C nucleus, since the (π^+, K^+) reaction populates Λ hypernuclear states having a neutron-hole Λ-particle configuration. As seen in the Table 2, the newly-identified peaks at 2.6 and 6.7 MeV are at excitation energies close to those of the corresponding ^{11}C excited states. They carry intensities about 20 - 25 % of those of the ground state peak, which are similar to the spectroscopic factors of the $1/2^-$ and $3/2^-_2$ states in ^{11}C. Itonaga *et. al.*[13] calculated properties of *p*-shell Λ hypernuclei by diagonalizing the Hamiltonian $H = H_N^{(Cohen-Kurath)} + t_\Lambda + \xi l_\Lambda \cdot s_\Lambda + \sum v_{\Lambda N}$, which consists of the Cohen-Kurath interaction, the Λ kinetic energy, the Λ spin-orbit potential and the Λ-nucleon potential. The calculated $^{12}_{\Lambda}\mathrm{C}$ spectrum is in good agreement with the present spectrum that shows the two smaller peaks. The small peaks can be interpreted as corresponding to states in which a Λ hyperon in the *s* orbital and the ^{11}C excited states at 2.0 MeV ($1/2^-$) and 4.8 MeV ($3/2^-_2$), are weakly coupled. The observed excitation energies, however, seems to be too high to be explained by the DWIA calculation[13,12] and also by the "standard parameters"for the ΛN interaction with which *p*-shell hypernuclei were intensively investigated.[14,15]

Table 2
Excitation energies and cross sections for $^{12}_{\Lambda}\mathrm{C}$ hypernuclear states measured with the SKS spectrometer in the (π^+,K^+) reaction at $\pi^+ = 1.06$ GeV/c. The cross sections are those averaged over the SKS spectrometer acceptance.

Peak	State Assignment	Excitation Energy(MeV)	Peak Width(MeV)	Cross Section(μb/sr) ($0.6° \le \theta \le 15°$)
#1	1^-_1	0	2.0 ± 0.1	7.3 ± 0.4
#2	(1^-_2)	2.61 ± 0.14	2.0 ± 0.1	1.7 ± 0.2
#3	(1^-_3)	6.81 ± 0.28	3.3 ± 0.7	2.0 ± 0.4
#4	2^+	10.82 ± 0.07	2.6 ± 0.2	9.4 ± 0.6

Properties of light Λ hypernuclei were further studied using different hyperon-nucleon interactions such as Jülich A (JA), Jülich B(JB), Nijmegen F(NF) and Nijmegen Soft Core(NSC) interactions.[16–18] These investigations revealed that calculated spectroscopic properties of Λ hypernuclei strongly depend on the choice of interaction model.

In Fig.6, we compare both experimental and calculated ratios between the excitation energies of the 1^-_2 and 1^-_3 states in $^{12}_{\Lambda}\mathrm{C}$ and those of the $3/2^-_1$ and $1/2^-_1$ states in ^{11}C; $R = E(^{12}_{\Lambda}\mathrm{C}{:}1^-_2 \text{ or } 1^-_3)/E(^{11}\mathrm{C}{:}3/2^-_1 \text{ or } 1/2^-_1)$. The experimental ratios give much larger values than unity, indicating deviation from the weak coupling limit. The theoretical ratios for the JA, JB and NF interactions are close to unity while the Nijmegen soft-core model(NSC) results in relatively large excitation energies for the 1^- states.[19] The NSC potential is known to be characterized by its larger ratio of spin-singlet to spin-triplet strength compared to the other models. The present result seems to favor stronger spin-singlet strength of the ΛN interaction.

The width of the second prominent peak is also found to be broader than the spectrometer resolution. It can be interpreted as at least partly due to splitting of two spin-orbit partner states. The broadness is consistent with the difference between excitation energies of the two 2^+ states that was obtained in a detailed analysis of emulsion data for $^{12}_{\Lambda}\mathrm{C}$.[20]

4. Heavy Λ hypernuclei

In heavy Λ hypernuclei, a bound hyperon could be well inside a nucleus free from surface effects. Investigation of deeply bound hypernuclear states in heavy hypernuclei has, therefore, significance in pondering if a hyperon keeps its identity and is distinguishable

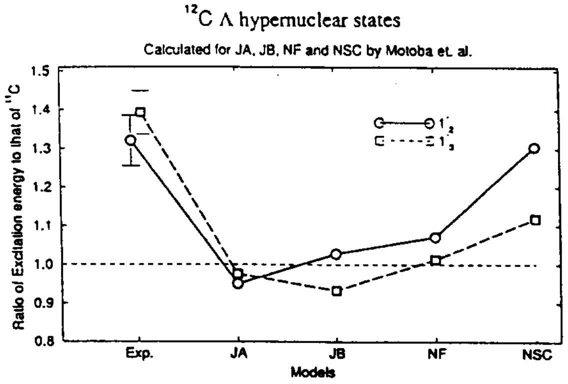

Figure 6. Ratios of excitation energies of the 1^-_2 and 1^-_3 states of $^{12}_{\Lambda}$C to those of the ^{11}C 2.0 MeV (1/2$^-$) and 4.8 MeV (3/2$^-$) states for different potential models of the ΛN interaction. JA, JB, NF, and NSC stand for Jülich A, Jülich B, Nijmegen F and Nijmegen soft core potentials, respectively.

as a baryon in a nucleus or be dissolved as quarks.[21] One may examine it, in one way, by determining binding energies of a Λ hyperon in a nucleus. In other words, the mass dependence of the binding energy for each shell model orbital will testify the validity of a potential to describe hypernuclear states. The depth of the potential felt by a Λ hyperon can be better determined from the single-particle levels of heavy Λ hypernuclei, since only a few Λ orbitals are bound in light hypernuclei and information on the Λ potential is limited. A systematic study of Λ hypernuclear bound states over the wide mass range will also deepen our understanding of the nature of the ΛN and ΛNN interactions in nuclear medium.[8,22] At CERN, hypernuclear spectra in the wide mass range up to $^{209}_{\Lambda}$Bi were measured by the (K$^-$, π^-) reaction.[23] However, spectra in the bound region were poorly populated due to characteristics of the reaction. The (π^+, K$^+$) reaction, on the other hand, is believed to provide much better opportunity for good spectra of the bound region particularly in heavy Λ hypernuclei.

In the present study, three heavy targets, ^{89}Y, ^{139}La and enriched ^{208}Pb, were used since they have $\nu g_{9/2}$, $\nu h_{11/2}$ and $\nu i_{13/2}$ neutron shells closed respectively. Fig.7 shows Λ hypernuclear spectra for $^{139}_{\Lambda}$La and $^{208}_{\Lambda}$Pb measured by the SKS spectrometer. The horizontal scales are given with M$_{HY}$ - M$_A$ where M$_{HY}$ stands for hypernuclear mass and M$_A$ mass of a target nucleus. Energy resolution of the present spectra was estimated to be 2.4 and 2.5 MeV for $^{139}_{\Lambda}$La and $^{208}_{\Lambda}$Pb, respectively, considering energy loss fluctuation due to target thickness and the energy resolution of the spectrometer. The spectrometer resolution for runs with the heavy targets was confirmed to be 2 MeV (FWHM) with the (π^+, K$^+$) reaction on a carbon target. The energy scale was adjusted so that the $^{12}_{\Lambda}$C hypernuclear spectrum gave binding energy of the ground state to be -10.76 MeV.

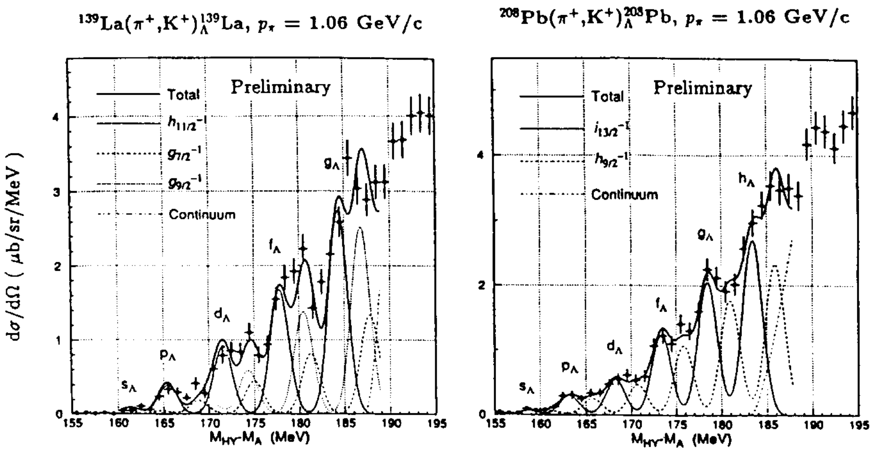

Figure 7. Λ hypernuclear spectra for $^{139}_{\Lambda}$La and $^{208}_{\Lambda}$Pb measured with the SKS spectrometer. The solid curves are those fitted assuming neutron holes in the sub-major shells in addition to the major shell.

The spectra show characteristic bump structure that will reflect Λ shell-model orbitals in the bound region, although they are less distinct than those of light Λ hypernuclei such as $^{12}_{\Lambda}$C shown in Fig. 4. It is supposedly because the selectivity of the (π^+, K$^+$) reaction hypernuclei are less enhanced for the heavier Λ because a neutron not only in the outer-most orbital but also in other orbitals can be converted to a Λ hyperon. The present spectra were, therefore, fitted by assuming Λ single particle states with two or three neutron hole series. For example in the case of $^{208}_{\Lambda}$Pb, $\nu h^{-1}_{9/2}$ neutron hole series in addition to the major $\nu i^{-1}_{13/2}$ series was taken into account as indicated in Fig. 7. The sub-major neutron hole series tend to make the spectrum smoother by filling the valleys of the major neutron hole series as expected from the calculated spectrum.[8] In the fitting, the energy difference of the two series was obtained from experimental values. The spectrum shapes for the two series were assumed to be the same except for the normalization. The fitted curves presented with thick solid lines well reproduce the experimental spectra as shown in Fig. 7. The binding energy of a Λ hyperon in each orbital was derived from the fitted parameters. In Fig. 8, we depict hypernuclear mass number dependence of the binding energies for each Λ orbital including the s orbital. All the plotted binding energies were obtained by the present experiment, although $^{28}_{\Lambda}$Si and $^{89}_{\Lambda}$Y binding energies were also given in the previous BNL experiment.[4] The dashed lines were drawn by assuming the Woods-Saxon potential for a Λ hyperon with the parameters given in ref.[8]. To first order, the calculated mass number dependence of the binding energy is in accord with the experimental one. The present result seems to be consistent with a picture that a Λ hyperon keeps its identity in a nucleus, although quality of the spectra should be further improved in the next generation experiments to draw a more solid conclusion.

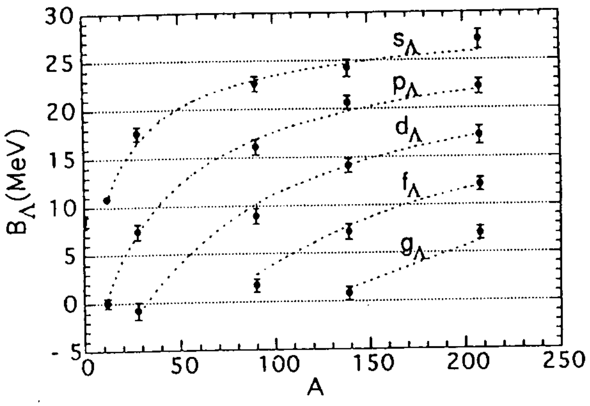

Figure 8. Mass number dependence of the Λ binding energies.

5. Summary

Using the (π^+, K^+) reaction, the Λ hypernuclear spectroscopy has been carried out with the INS-SKS spectrometer at KEK 12GeV-PS. Core excited states of $^{12}_{\Lambda}$C have been identified in the spectrum with 2 MeV(FWHM) energy resolution. The excitation energies and the cross sections of these states provided information on the spin dependent part of the ΛN interaction and hypernuclear structure. Furthermore, bound region spectra of $^{139}_{\Lambda}$La and $^{208}_{\Lambda}$Pb have been measured for the first time together with those of $^{10}_{\Lambda}$B, $^{28}_{\Lambda}$Si and $^{89}_{\Lambda}$Y. Based on the observed spectra, hypernuclear mass dependence of a Λ hyperon was deduced. It was found the dependence is in reasonable agreement, within the present experimental quality, with the calculated one based on the Woods-Saxon potential.

Experimental programs that intend to investigate the weak decay of Λ hypernuclei are also in progress taking advantage of the large acceptance of the spectrometer.

The SKS spectrometer was constructed in collaboration with Messrs T. Kitami, Y. Matsuyama, T. Morimoto, K. Omata of INS and with Profs. T. Shintomi, Y. Doi, Drs. M. Nomachi, O. Sasaki, Messrs. Y. Makida and Y. Kondo of KEK.

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REFERENCES

1. A.E.L. Dieperink and P.K.A.de Witt Huberts, Ann. Rev. Nucl. Sci. **40** 239 (1990).
2. H. Bandō, T. Motoba and Y. Yamamoto, Phys. Rev. **C31** 265 (1985).
3. A. Likar, M. Rosina and B. Povh, Z. Phys. **A324** 35 (1986).
4. C. Milner *et. al.*, Phys. Rev. Lett. **54** 1237 (1985).
   P. H. Pile *et al.*, Phys. Rev. Lett. **66** 2585 (1991).
5. M. Akei *et al.*, Nucl. Phys. **A534** 478 (1991).
6. C.B. Dover, L. Ludeking and G.E. Walker, Phys. Rev. **C22** 2073 (1980).
7. H. Bandō and T. Motoba, Prog. Theor. Phys. **76** 1321 (1986).
8. T. Motoba, H. Bandō, R. Wünsch and J. Zofka, Phys. Rev. **C38** 1322 (1988).
9. O. Hashimoto, T. Nagae, T. Fukuda, S. Homma, T. Shibata, Y. Yamanoi, T. Shintomi, J. Imazato, Y. Makida, T. Mito and S. Kato, Il Nuovo Cimento **102A** 679 (1989).
10. T. Hasegawa, O. Hashimoto, T. Nagae and M. Sekimoto, Nucl. Instr. Meth. **A342** 383 (1994).
11. T. Shintomi, K. Aoki, Y. Doi, Y. Kondo, Y. Makida, O. Hashimoto, T. Hasegawa, T. Kitami, T. Miyachi, T. Nagae and M. Sekimoto, IEEE Trans. on Magnetics, **MAG-28** 585 (1992).
12. K. Itonaga, T. Motoba, O. Richter and M. Sotona, Phys. Rev. **C49** 1045 (1994).
13. K. Itonaga, T. Motoba and H. Bandō, Prog. Theor. Phys. **84** 291 (1990).
14. D.J. Millener, A. Gal, C.B. Dover and R.H. Dalitz, Phys. Rev. **C31** 499 (1985).
15. V.N. Fetisov *et. al.*, Z. Phys. **A339** 399 (1991).
16. Y. Yamamoto and H. Bandō, Prog. Theor. Phys. Suppl. **81** 9 (1985).
17. Y. Yamamoto *et. al.*, Czech. J. Phys. **42** 1249 (1992).
18. J. Hao *et. al.*, Phys. Rev. Lett. **71** 1498 (1993).
19. T. Motoba, private communication (1993).
20. R.H. Dalitz, D.H. Davis and D.N. Tovee, Nucl. Phys. **A450c** 311 (1986).
21. C.B. Dover, Proc. Int. Symp. on Medium Energy Physics, p.257, Beijing (World Scientific, Singapore, 1987).
22. D.J. Millener, C.B. Dover and A. Gal, Phys. Rev. **C38** 2700 (1988).
23. R. Bertini *et. al.*, Nucl. Phys. **A360** 315 (1981).