TRIUMF - RESEARCH PROPOSAL 	Experiment no.	Sheet 1 of 13

Title of proposed experiment

Investigation on halo features and structure of levels in ^{12}Be

Name of group

Spokesperson for group

Rituparna Kanungo

Email address

ritu@triumf.ca

Members of group (name, institution, status)

(For each member, include percentage of research time to be devoted to this experiment over the time frame of the experiment)

A. Andreyev	TRIUMF	Research Associate	10%
G.C. Ball	TRIUMF	Research Scientist	10%
L. Buchmann	TRIUMF	Research Scientist	10%
R.S. Chakrawarthy	TRIUMF	Research Associate	10%
B. Davids	TRIUMF	Research Scientist	5%
G. Hackman	TRIUMF	Research Scientist	10%
R. Kanungo	TRIUMF	Research Associate	50%
A.C. Morton	TRIUMF	Research Associate	10%
C. Pearson	TRIUMF	Research Associate	10%
J. Pearson	TRIUMF	Research Associate	10%
C. Ruiz	TRIUMF	Research Associate	10%
G. Ruprecht	TRIUMF	Research Associate	10%
H. Savajols	TRIUMF	Research Scientist	10%
A. Shotter	TRIUMF	Director	5%
P. Walden	TRIUMF	Research Scientist	10%
J.J. Ressler	Simon Fraser Univ.	Professor	10%
C. Andreiou	Univ. of Guelph	Post. Doc.	10%
D. Bandyopadhyay	Univ. of Guelph	Post Doc.	10%
P.E. Garrett	Univ. of Guelph	Professor	10%
C.E. Svensson	Univ. of Guelph	Professor	10%
A. Chen	McMaster Univ.	Professor	10%
J. Chen	Mc Master Univ.	Gradudate Student	15%
F. Sarazin	Colorado School of Mines	Professor	10%
C. Wu	LLNL	Research Scientist	10%
J.A.Becker	LLNL	Research Scientist	10%
R.A.E.Austin	Saint Mary's Univ.	Professor	10%

Start of preparations: July 2006 onwards

Date ready:

July 2006 onwards(tentative)

Completion date:

October 2006

Beam time requested:

12-hr shifts	Beam line/channel	Polarized primary beam?
16	ISACII	No

SUMMARY	

Do not exceed one page.

Examples of two-neutron haloes, even two decades after their first observation in ^{11}Li, have been hard to find in other isotopes. Some investigations have suggested such structure in the borromean neutron-rich Be and B isotopes. Particularly, the question remains whether such a structure exists in non-borromean nuclei. The lightest non-borromean candidate which attracts attention for a possible two-neutron halo is the ^{12}Be nucleus, which has a two-neutron separation energy of S_{2n}= 3.673±0.015 MeV. However, it is not clear yet, if indeed a halo exists in this nucleus.

Furthermore, there is an interesting observation of a long-lived 0^+ excited state in this nucleus, which brings up the question whether this excited state of ^{12}Be may have a halo nature. This isomeric state at excitation energy (E_{ex}) of 2.24 MeV was observed in the production of ^{12}Be from fragmentation of ^{18}O with a Be target. The lifetime of this state has not yet been measured. A mean lifetime ranging between 50ns to 11µs has been suggested based on its observation through fragmentation. The same production method for ^{12}Be has also been used for other reaction studies (such as knockout reaction and interaction cross section) investigating the ground state structure of the nucleus. There is thus a question as to whether these existing studies have a contamination of the isomer state component mixed in them. Therefore, the ground state structure of ^{12}Be remains unclear at present. It is also extremely important to determine the lifetime of the 0^+ excited state.

The nucleus ^{12}Be can be considered to be composed of ^{11}Be + n. Extensive studies have revealed a well defined halo structure for ^{11}Be, where the valence neutron abnormally occupies the $2s_{1/2}$ orbital with a large probability. A halo can exist in ^{12}Be if one neutron has a substantial probability of occupying the $2s_{1/2}$ orbital with the ^{11}Be core in its ground state. At first thought this would seem the most likely scenario thus filling up the s-orbital. On the other hand addition of a neutron to ^{11}Be, will cause n-n pairing to favour neutron occupancy in the *d*-orbital causing retardation of the halo. The present proposal is aimed at investigating the parentage of the $^{11}Be_{gs}$(core) + *n*(*s*-wave) configuration for the ground state and the 0^+ excited state in ^{12}Be.

This will be studied by the one neutron transfer reaction d(^{11}Be,p)^{12}Be using a ^{11}Be beam accelerated to 5.1*A* MeV at the ISAC-II facility. The ground state of ^{11}Be has a spin of $1/2^+$. The parentage of the ^{12}Be ground and 0^+ states will reveal if a halo exists in the ground state of ^{12}Be, or not. Furthermore, the long-lived isomeric state will be disentangled from the ground state (which is not possible in reactions investigated at fragmentation facilities) and its lifetime and structure information will be derived.

BEAM and SUPPORT REQUIREMENTS	

Experimental area

ISACII

Primary beam and target (energy, energy spread, intensity, pulse characteristics, emittance

Proton beam : 40-70 μA

Target : Ta

Secondary channel

Secondary beam (particle type, momentum range, momentum bite, solid angle, spot size, emittance, intensity, beam purity, target, special characteristics)

Particle type : ^{11}Be (2^+)

Energy = 5.1 *A* MeV

Spot size on target and downstream SSD position $\leq \pm 2$ mm (X and Y)

Intensity of secondary beam on reaction target : ^{11}Be: ~ 10^6/sec

TRIUMF SUPPORT:

Summarize all equipment and technical support to be provided by TRIUMF. If new equipment is required, provide cost estimates.

NOTE: Technical Review Forms must also be provided before allocation of beam time.

Development of ^{11}Be beam

Construction of support for mounting a Ge detectors downstream of target.

Construction of beam duct and silicon detector chamber.

NON-TRIUMF SUPPORT:

Summarize the expected sources of funding for the experiment.

Identify major capital items and their costs that will be provided from these funds.

SAFETY

Summarize possible hazards associated with the experimental apparatus, precautions to be taken, and other matters that should be brought to the notice of the Safety Officer. Details must be provided separately in a safety report to be prepared by the spokesperson under the guidance of the Safety Report Guide available from the Science Division Office.

There are no major safety hazards in this experiment.

1. Introduction

Nuclear halo structure has opened up a new dimension to nuclear physics. The halo is characterized by a high probability of finding one or two very weakly bound nucleons at a large radial distance from the more strongly bound core. Such a structure was first observed in ^{11}Li, where the two-neutrons abnormally occupy the $2s_{1/2}$ orbital giving rise to a two-neutron halo [1]. The two-neutron halo has been observed only for borromean nuclei whose one proton and one neutron removal sub-systems are unbound. Some investigations have suggested such structure in the borromean neutron-rich Be and B isotopes [2,3] which are yet to be fully confirmed. Particularly, the question remains whether such a structure exists in non-borromean nuclei. The lightest non-borromean candidate which attracts attention for a possible two-neutron halo is the ^{12}Be nucleus. However, it is not clear yet if indeed a halo exists in this nucleus.

Furthermore, there is an interesting observation of a low-lying, long-lived 0^+ excited state [4] in this nucleus. This brings up the question whether this excited state of ^{12}Be may have a halo nature. This isomeric state at excitation energy of 2.24 MeV was observed in the production of ^{12}Be from fragmentation of ^{18}O with a Be target. The lifetime of this state has not yet been measured. A mean life ranging between 50ns to 11μs has been suggested based on its observation through fragmentation. The same production method has also been used for other reaction studies (such as knockout reaction [5] and interaction cross section [6]) investigating the ground state structure of the nucleus. It is thus questionable whether these existing studies have a contamination of the isomer state component mixed in them. Therefore, the ground state structure of ^{12}Be remains unclear at present. Two other bound excited states, 2^+ (2.1 MeV) and 1^- (2.7 MeV), of ^{12}Be have been observed by inelastic scattering experiments [7,8] and also two-neutron transfer reaction [9].

The nucleus ^{12}Be can be considered to be composed of ^{11}Be + *n*. Extensive studies have revealed a well defined halo structure for ^{11}Be [6, 10-13], where the valence neutron abnormally occupies the $2s_{1/2}$ orbital with a large probability. A halo can exist in ^{12}Be if one neutron has a substantial probability of occupying the $2s_{1/2}$ orbital with the ^{11}Be core in its ground state. The present proposal is aimed at investigating the parentage of $^{11}Be_{gs}$(core) + *n*(*s*-wave) configuration for the ground state and the 0^+ excited state in ^{12}Be. If either the ground-state and/or the isomeric state is observed in very small amount in this reaction, then it will confirm the fact that such state(s) have very small component of ^{11}Be ground state in them, which will rule out their halo nature. It maybe mentioned here that the knockout reaction of ^{12}Be tagging the core de-excitation gamma rays from ^{11}Be found the spectroscopic factor for the $^{11}Be_{gs} + s_{1/2}$ configuration in ^{12}Be to be 0.42±0.06 [5].

We propose to investigate on these issues by the one neutron transfer reaction d(^{11}Be,p)^{12}Be using the ^{11}Be beam from the ISAC-II facility. The ground state of ^{11}Be is known to have an abnormal spin of $1/2^+$. Thus, the observation of the ground state of ^{12}Be and the 0^+ state of ^{12}Be will clearly only carry the information of the s-wave component present in these levels. A measurement of angular distribution is thus not necessary for confirming on the *s*-wave nature. The first report on the 0^+ isomer mentions only limits for the half-life based on its observation. That is derived assuming that all the ^{12}Be nuclei produced are in its isomeric state. It is thus crucial to measure the lifetime of the 0^+ excited state, which is also an important goal of this experiment.

The results of the experiment will disentangle the long-lived 0^+ excited state from the ground state of ^{12}Be (which is not possible in fragmentation facilities). Thus the s-wave component in ground and excited 0^+ state in ^{12}Be will be precisely determined. The lifetime of the 0^+ excited state will also be measured for the first time.

2. Experiment

The experiment will be performed at the ISAC-II facility using accelerated beam of ^{11}Be, at an energy of 5.1*A* MeV (which is the highest energy available for Be-beams at the first phase of ISAC-II). A $(CD_2)_n$ target of ~ 400 μg/cm^2 will be used. The kinematic curves of the reaction (Fig.1), show that the small centre of mass angle will lead to scattered protons being emitted at backward angles in the laboratory. This is an advantageous feature since it makes the detection of the protons free from other background reaction channels. The heavy recoil i.e. ^{12}Be, on the other hand is emitted in a narrow cone in the forward direction. The elastically scattered ^{11}Be is the strongest contaminant here.

The goals of the experiment are to measure the lifetime of the long-lived 0^+ excited state and to ascertain the parentage of the ground state, 2^+ first excited state and the 0^+ second excited state produced in this reaction. Thus, in addition to a clear particle identification one needs to have the ability to separate these levels. The ground state and the first excited state being separated by 2.1 MeV, the detection of protons alone in the backward direction is enough to clearly identify the ground state. However, the 2^+ and the 0^+ excited states differ only by 140 keV which makes their separation difficult by charged particle identification alone. These states will thus be separated using information from the gamma rays observed from their decay.

As mentioned above the 0^+ state is of long-lived nature and has two decay branches. We thus need to detect both prompt gamma rays from the 2^+ state as well as delayed gamma rays from the 0^+ state. The prompt gamma detection will be done using two segmented Ge clover detectors (TIGRESS array) placed around the target position. The ^{12}Be nuclei after scattering will be stopped in an annular silicon detector placed ~ 1m downstream of the target. This will provide us with the energy information of the scattered ^{12}Be nuclei, allowing accurate Doppler correction. The delayed gamma ray (140keV) will be detected using two Ge detectors placed around the silicon detector downstream of the target.

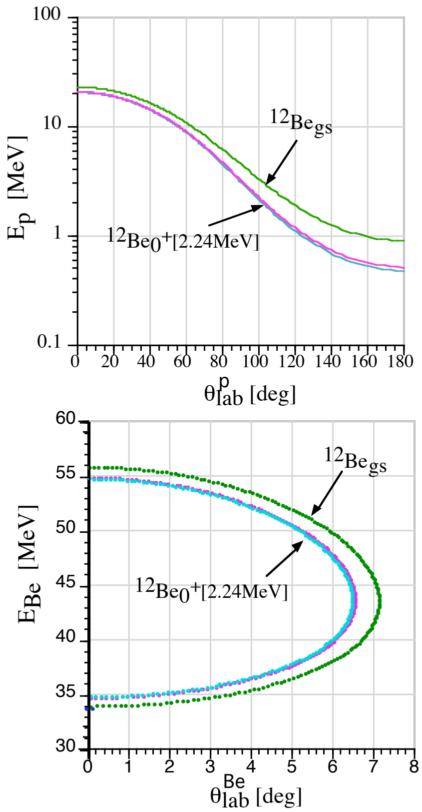

Fig.1 Kinematics for the reaction d(^{11}Be,p)^{12}Be. The top (bottom) panels show the energy and laboratory angle loci for the scattered proton (scattered ^{12}Be).

A schematic view of the setup is shown in Fig.2. The backward placed silicon detector covers proton scattering angles from θ_{lab} ~ 128°– 151° which corresponds to a centre of mass angle coverage of θ_{cm} ~ 6°– 18°. To achieve the goal of the experiment, a measurement of angular distribution will not be necessary as mentioned above. However the data taken will also allow us to determine the angular distribution. The forward placed silicon detector will cover θ_{lab} ~ 0.8°– 3°. This covers the centre of mass angles of θ_{cm} ~ 7°– 30° and 155°-175° by detection of ^{12}Be.

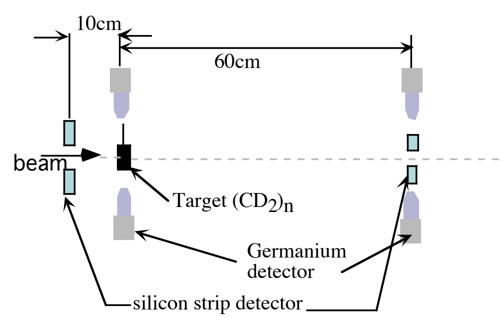

Fig.2 Schematic layout of the experimental setup.

Fig.3 shows a monte-carlo simulation of the identification condition in the silicon detectors, with the experimental conditions mentioned above. The TOF resolution has been assumed to be 500ps (σ) and the energy resolution of the silicon detectors is taken to be 2%(FWHM) at 4 MeV. The time-of flight is measured between the cyclotron RF and the silicon detector signals, with the flight path between target and detector position. It is seen (Fig.3a) that the ground state (green) is clearly separable from the first and second excited states (blue+pink). The separation between these excited states however is not possible. Fig.3b shows the identification condition of one radial strip selected in the silicon detector placed downstream of the target. Once again the ground and the excited states can be clearly separated. However the first and second excited states are not separable. The gamma ray information will be used for this distinction.

We will thus be able to obtain the fraction of ground state, first and second excited states populated in this reaction. If the ground and/or 0^+ second excited state is observed in fairly large amount it will help us to confirm on the existence of halo and deduce its extent. On the other hand a weak population of these levels will argue in favor of *d*-wave dominance due to pairing interaction. We will also be able to determine the *d*-wave component in the first (2^+) excited state.

The time decay curve for the delayed gamma ray after stopping of ^{12}Be in silicon will yield us with the lifetime information on the 0^+ excited state.

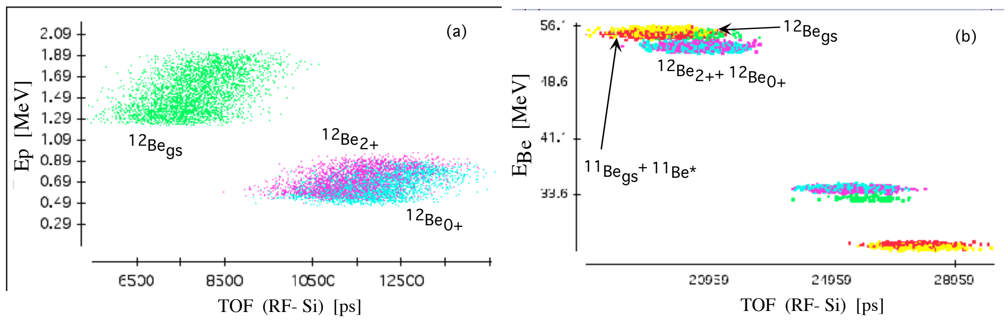

Fig.3 Simulation results for particle identification in the using TOF-E correlation for (a) upstream SSD (b) downstream SSD.

3. Count rate and beam time request

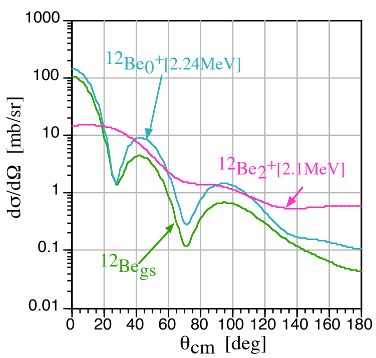

Fig.4 Angular distributions for the $d(^{11}\mathrm{Be},p)^{12}\mathrm{Be}$ reaction for ground, and first two excited states of ^{12}Be.

The experiment will be carried out using 5.1*A* MeV accelerated beam of ^{11}Be ions at ISACII. The expected yield on target is 10^6/sec (this is based on a calculated estimate from the beam development group). The target will be a 400 μg/cm^2 deuterated polyethelene $(CD_2)_n$ foil. Under these conditions the rate of ^{11}Be after Rutherford scattering from C in the target will amount to 10^3/sec within the total acceptance of the downstream silicon detector. This puts the upper limit on the beam intensity which we have considered.

The cross section for the d(^{11}Be,p)^{12}Be reaction was estimated by finite range DWBA calculations with global optical model parameters for the entrance and exit channels. The calculated angular distribution for the ground, and the first two excited states of ^{12}Be is shown in Fig.4.

The gamma detection efficiency of TIGRESS array (12 clovers) is shown in Fig. 5 based on a GEANT4 simulation [14]. This estimate has been linearly scaled to the use of two clovers only for the present proposal. That leads to an efficiency of 1% for the 2 MeV gamma ray. The 140 keV gamma ray is expected to have an efficiency of 4% (HPGe back configuration because suppressors need to be used for this), however due to its long-lived nature we consider the detection efficiency to be 1%.

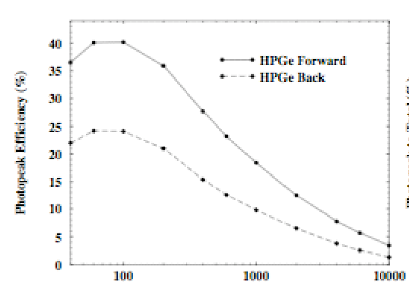

Fig.5 Simulated results for efficiency expected from the full TIGRESS array (12 clovers)

Assuming a spectroscopic factor of 0.1 the detected protons in the backward direction together with the gamma ray information for excited states, leads to the observation of ~16000 counts for the ground state, 64 counts for the first excited state and 160 counts for the second excited state over a period of 7 days. Thus 7 days would be the minimum data taking time which is necessary for a successful experiment. In addition one day will be necessary for electronics setup with beam, before data taking. A total of 16 shifts (=8 days) of beamtime is therefore requested for this experiment.

References :

[1] I. Tanihata et al., Phys. Rev. Lett. 58 (1985) 5676.
[2] M. Labiche et al., Phys. Rev. Lett. 86 (2001) 600.
[3] T. Suzuki et al., Phys. Rev. Lett. 89 (2002) 012501.
[4] S. Shimoura et al., Phys. Lett. B 560 (2003) 31.
[5] A. Navin et al., Phys. Rev. Lett. 85 (2000) 266.
[6] I. Tanihata et al., Phys. Lett. B 206 (1988) 592.
[7] H. Iwasaki et al., Phys. Lett. B 491 (2000) 8; Eur. Phys. Jour. A 13 (2002) 55.
[8] S. Shimoura et al., Nucl. Phys. A 738 (2004) 162.
[9] H.T. Fortune and G.B.-Liu, Phys. Rev. C 50 (1994) 1355.
[10] S. Fortier et al., Phys. Lett. B 461 (1999) 22.
[11] W. Geithner et al., Phys. Rev. Lett. 83 (1999) 3792.
[12] J.S. Winfield et al., Nucl. Phys. A 683 (2001) 48.
[13] G.-B. Liu and H.T.Fortune., Phys. Rev. C 42 (1990) 167.
[14] C. E. Svensson et al., J. Phys. G. 2005 (in press)

4. Data analysis

The analysis of the data will be performed using personal computers presently available at TRIUMF.

5. Readiness

Four Germanium clover detectors are expected to arrive at TRIUMF by spring 2006. The forward annular silicon CD detector is a part of Tigress auxiliary detector system, which is being prepared by the group from Mc Master University and is now under testing there. The LEDA detector (TUDA group) will be used as the proton detector for backward angles.

1. Search for an isomeric state in ^{19}C

   R. Kanungo, Z.Elekes H. Baba, , Zs. Dombrádi, Zs. Fülöp, J. Gibelin, Á. Horváth, Y. Ichikawa, E. Ideguchi, N. Iwasa, H. Iwasaki, S. Kawai, Y. Kondo, T. Motobayashi, M. Notani, T. Ohnishi, A. Ozawa, H. Sakurai, S. Shimoura, E. Takeshita, S. Takeuchi, I. Tanihata, Y. Togano[3], C. Wu, Y. Yamaguchi, Y. Yanagisawa, A. Yoshida, K. Yoshida

   Nucl. Phys. A (in press)

2. Low-lying excited states in $^{17,19}C$

   Z.Elekes , Zs. Dombrádi, R. Kanungo, H. Baba, Zs. Fülöp, J. Gibelin, Á. Horváth, Y. Ichikawa, E. Ideguchi, N. Iwasa, H. Iwasaki, S. Kawai, Y. Kondo, T. Motobayashi, M. Notani, T. Ohnishi, A. Ozawa, H. Sakurai, S. Shimoura, E. Takeshita, S. Takeuchi, I. Tanihata, Y. Togano[3], C. Wu, Y. Yamaguchi, Y. Yanagisawa, A. Yoshida, K. Yoshida

   Phys. Lett. B 614 (2005) 174

3. Excited states in neutron-rich boron isotopes

   R. Kanungo, Z.Elekes , H. Baba, Zs. Dombrádi, Zs. Fülöp, J. Gibelin, Á. Horváth, Y. Ichikawa, E. Ideguchi, N. Iwasa, H. Iwasaki, S. Kawai, Y. Kondo, T. Motobayashi, M. Notani, T. Ohnishi, A. Ozawa, H. Sakurai, S. Shimoura, E. Takeshita, S. Takeuchi, I. Tanihata, Y. Togano[3], C. Wu, Y. Yamaguchi, Y. Yanagisawa, A. Yoshida, K. Yoshida

   Phys. Lett. B 608 (2005) 206

4. Neutron removal studies on ^{19}C

   M. Chiba, R. Kanungo, B. Abu-Ibrahim, S. Adhikari, D. Fang, N. Iwasa, K. Kimura, K. Maeda, S. Nishimura, T. Ohnishi, A. Ozawa, C. Samanta, T. Suda, T. Suzuki, Q. Wang, C. Wu, Y. Yamaguchi, K. Yamada, A. Yoshida, T. Zheng, I. Tanihata

   Nucl. Phys. A 741 (2004) 29

5. Study of the reaction cross section of ^{17}C from reaction cross section measurement

   Cuie Wu, Y. Yamaguchi, A. Ozawa, R. Kanungo, I. Tanihata, T. Suzuki, D.Q. Fang, T. Suda, T. Ohnishi, M.Fukuda, N.Iwasa, T.Ohtsubo, T. Izumikawa, R. Koyama, W. Shinozaki, M. Takahashi

   Nucl. Phys. A 739 (2004) 3

6. One- and two-proton removal from ^{15}O

   H.Jeppesn, R. Kanungo, B. Abu-Ibrahim, S. Adhikari, M.Chiba, D. Fang, N.Iwasa, K. Kimura, K. Maeda, S. Nishimura, T. Ohnishi, A. Ozawa, C. Samanta T. Suda, T. Suzuki, I. Tanihata, Q. Wang, C. Wu, Y. Yamaguchi, K. Yamada, A. Yoshida, T. Zheng

   Nucl. Phys. A 739 (2004) 57

7. Two-proton halo in ^{17}Ne

   Rituparna Kanungo

Nucl. Phys. A 738 (2004) 293

8. Neutron configuration of ^{16}C studied via one- and two-neutron removal momentum distributions

T. Yamaguchi, T. Zheng, A. Ozawa, M. Chiba, R. Kanungo, T. Kato, K. Morimoto, T. Ohnishi, T. Suda, Y. Yamaguchi, A. Yoshida, K. Yoshida and I. Tanihata

Nucl. Phys. A 734 (2004) E73

9. Two-proton halo in ^{17}Ne

R. Kanungo

Nucl. Phys. A 734 (2004) 337

10. Production and decay properties of ^{272}111 and its daughter nuclei

K. Morita, K. Morimoto, D. Kaji,, H. Haba, E. Ideguchi, J.C.Peter, R. Kanungo, K. Katori, H. Koura, H. Kudo, T. Ohnishi, A. Ozawa, T. Suda, K. Sueki, I. Tanihata, H. Xu, A.V. Yeremin, A. Yoneda, A. Yoshida, Y.-L. Zhao and T. Zheng, S. Goto, F. Tokanai

Jour. Phys. Soc. Jpn. 73 (2004) 1738

11. Status of superheavy element research using GARIS, RIKEN

K. Morita, K. Morimoto, D. Kaji, S. Goto, H. Haba, E. Ideguchi, R. Kanungo, K. Katori, H. Koura, H. Kudo, T. Ohnishi, A. Ozawa, J.C.Peter, T. Suda, K. Sueki, I. Tanihata, F. Tokanai, H. Xu, A.V. Yeremin, A. Yoneda, A. Yoshida, Y.-L. Zhao and T. Zheng

Nucl. Phys. A 734 (2004) 101

12. One neutron halo structure in ^{15}C

D.Q. Fang, T. Yamaguchi, T. Zheng, A. Ozawa, M. Chiba, R. Kanungo, T. Kato, K. Morimoto, T. Ohnishi, T. Suda, Y. Yamaguchi, A. Yoshida, K. Yoshida, and I. Tanihata

Phys. Rev. C. 69 (2004) 034613

13. Possibility of a two-proton halo in ^{17}Ne

R. Kanungo, M. Chiba, S. Adhikari, D. Fang, N. Iwasa, K. Kimura, K. Maeda, S. Nishimura, Y. Ogawa, T. Ohnishi, A. Ozawa, C. Samanta, T. Suda, T. Suzuki, Q. Wang, C. Wu, Y. Yamaguchi, K. Yamada, A. Yoshida, T. Zheng, I. Tanihata

Phys. Lett. B. 571 (2003) 21

14. Halo and skin nuclei.

Isao Tanihata and Rituparna Kanungo

C.R. Physique 4 (2003) 437

15. Experimental evidence for ^{7}H and for a specific structure of ^{8}He.

A.A. Korshennikov, E.Yu. Nikolskii, E.A. Kuzmin, A. Ozawa, K. Morimoto, F. Tokanai, R. Kanungo, I. Tanihata, N.K. Timofeyuk, M.S. Golovkov, A.S. Fomichev, A.M. Rodin, M.L.

Chelnokov, G.M. Ter-Akopian, W. Mittig, P. Roussel-Chomaz, H. Savajols, E. Pollacco, A.A. Ogloblin, M.V. Zhukov

Phys. Rev. Lett. 90 (2003) 082501

16. Nuclear shell changes at the limit of stability

    Rituparna Kanungo

    Nucl. Phys. A 722 (2003) 30c

17. Measurement of one- and two-neutron transfers in reaction of 6He+9Be at 25 MeV/u

    Y.-C.Ge, Y.-L. Ye, T. Zheng, Q.-J. Wang, Z.-H. Li, X.-Q. Li, D.-X.Jiang, A. Ozawa, Y. Yamaguchi, C. Wu, R. Kanungo, D. Fang and I. Tanihata

    Chin. Phys. Lett. 20(2003) 1034

18. Reply to Comment on : Experimental evidence of core modification in the near drip-line nucleus ^{23}O.

    Rituparna Kanungo, Masami Chiba, Naohito Iwasa, Shunji Nishimura, Akira Ozawa, Chhanda Samanta, Toshimi Suda, Takeshi Suzuki, Takayuki Yamaguchi, Tao Zheng, Isao Tanihata

    Phys. Rev. Lett 90 (2003) 159202

19. Momentum distribution of ^{14}C and ^{15}C fragments from ^{16}C breakup.

    T. Yamaguchi, T. Zheng, A. Ozawa, M. Chiba, R. Kanungo, T. Kato, K. Morimoto, T. Ohnishi, T. Suda, Y.Yamaguchi, A. Yoshida, K. Yoshida, I. Tanihata

    Nucl. Phys. A 724 (2003) 3

20. Search for ^{21}B.

    A. Ozawa, Y. Yamaguchi, M. Chiba, R. Kanungo, K. Kimura, S. Momota, T. Suda, T. Suzuki, I. Tanihata, T. Zheng, S. Watanabe, T. Yamaguchi, and K. Yoshida

    Phys. Rev. C 47 (2003) 014610

21. Production of neutron rich isotopes by fragmentation of 80MeV/nucleon ^{59}Co beam.

    Le Hong Khiem, T. Kato, K. Morimoto, M. Notani, A. Ozawa, R. Kanungo, I. Tanihata, A. Yoshida

    Phys. Rev. C 722 (2003) 484c.

22. Study of halo stru-3cture of ^{16}C from reaction cross section measurement.

    T. Zheng, T. Yamaguchi, A. Ozawa, M. Chiba, R. Kanungo, T. Kato, K. Katori, K. Morimoto, T. Ohnishi, T. Suda, I. Tanihata, Y. Yamaguchi, A. Yoshida, K. Yoshida, H. Toki, N. Nakajima

    Nucl. Phys. A 709 (2002) 103

23. Momentum distribution of ^{15}B fragments from the breakup of ^{17}B.

T. Suzuki, Y. Ogawa, M. Chiba, M. Fukuda, N. Iwasa, T. Izumikawa, R. Kanungo, Y. Kawamura, A. Ozawa, T. Suda, I. Tanihata, S. Watanabe, T. Yamaguchi, Y. Yamaguchi

Phys. Rev. Lett 89 (2002) 012501

24. Experimental evidence of core modification in the near drip-line nucleus ^{23}O.

Rituparna Kanungo, Masami Chiba, Naohito Iwasa, Shunji Nishimura, Akira Ozawa, Chhanda Samanta, Toshimi Suda, Takeshi Suzuki, Takayuki Yamaguchi, Tao Zheng, Isao Tanihata

Phys. Rev. Lett 88 (2002) 142502

25. Modification of shell structure in unstable nuclei.

Rituparna Kanungo,

Prog. in Theo. Phys. 146 (2002) 422.

26. Halo structure in ^{19}C

Rituparna Kanungo, I. Tanihata, Y. Ogawa, H. Toki, A. Ozawa

Nucl. Phys. A 701 (2002) 378c

27. Observation of new proton and neutron magic numbers

Rituparna Kanungo, I. Tanihata, A. Ozawa

Phys. Lett. B 528 (2002) 58

28. Observation of new proton and neutron magic numbers.

Rituparna Kanungo, I. Tanihata, A. Ozawa

Nuclear Physics in the 21st century, Int. Nucl. Phys. Conf. INPC 2001.AIP Proceedings, 2001, p.741

29. Breakup of 72MeV ^{7}Li projectiles in the fields of ^{12}C and ^{197}Au nuclei

D.Gupta, C.Samanta, R.Kanungo, P.Basu, S.Roy, S.Kailas, A.Chatterjee, B.J.Roy, K.Mahata, A.Samant, and A.Shrivastava

Pramana 57 (2001) 209

30. Possibility of enlarged core structure of N=15 neutron rich nuclei

Rituparna Kanungo, I. Tanihata, A. Ozawa

Phys. Lett. B 512 (2001) 261.

31. Halo structure in ^{19}C : a Glauber model analysis

Rituparna Kanungo, I. Tanihata, Y. Ogawa, H. Toki and A. Ozawa
Nucl. Phys. A 677(2000) 171.

32. Inverse proton scattering from unstable nuclei with halo
Rituparna Kanungo
Proceedings of the RCNP-TMU Symposium, Spins in Nuclear and Hadronic Reactions, World Scientific, 2000, p.183.

33. Effect of smeared ^{4}He-core in ^{6}He+p scattering
D.Gupta, C.Samanta, R.Kanungo
Acta Phys.Pol. B31, (2000) 471

34. Consistent Analysis of Proton Elastic Scattering from ^{4,6,8}He and ^{6,7,9,11}Li in the Energy Range of 25-75A MeV
D.Gupta, C.Samanta, R.Kanungo
Nucl.Phys. A674, (2000) 77