Mathematics and Physics Laboratory Group

Toshiro Watanabe
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Refereed academic journal

[m-honma-101-074-01:2015] C. J. Chiara, D. Weisshaar, R. V. F. Janssens, Y. Tsunoda, T. Otsuka, J. L. Harker, W. B. Walters, F. Recchia, M. Albers, M. Alcorta, V. M. Bader, T. Baugher, D. Bazin, J. S. Berryman, P. F. Bertone, C. M. Campbell, M. P. Carpenter, J. Chen, H. L. Crawford, H. M. David, D. T. Doherty, A. Gade, C. R. Hoffman, M. Honma, F. G. Kondev, A. Korichi, C. Langer, N. Larson, T. Lauritsen, S. N. Liddick, E. Lunderberg, A. O. Macchiavelli, S. Noji, C. Prokop, A. M. Rogers, D. Seweryniak, N. Shimizu, S. R. Stroberg, S. Suchyta, Y. Utsuno, S. J. Williams, K. Wimmer, and S. Zhu. Identification of deformed intruder states in semi-magic ^{70}Ni. *Phys. Rev. C*, 91:044309/1–10, 2015.

The structure of semi-magic $^{70}_{28}\mathrm{Ni}_{42}$ was investigated following complementary multinucleon-transfer and secondary fragmentation reactions. Changes to the higher-spin, presumed negative-parity states based on observed γ-ray coincidence relationships result in better agreement with shell-model calculations using effective interactions in the neutron $f_{5/2}pg_{9/2}$ model space. The second 2^+ and (4^+) states, however, can only be successfully described when proton excitations across the Z=28 shell gap are included. Monte Carlo shell-model calculations suggest that the latter two states are part of a prolate-deformed intruder sequence, establishing an instance of shape coexistence at low excitation energies similar to that observed recently in neighboring ^{68}Ni.

[m-honma-101-074-02:2015] Y. Fujita, H. Fujita, T. Adachi, G. Susoy, A. Algora, C. L. Bai, G. Colò, M. Csatlós, J. M. Deaven, E. Estevez-Aguado, C. J. Guess, J. Gulyás, K. Hatanaka, K. Hirota, M. Honma, D. Ishikawa, A. Krasznahorkay, H. Matsubara, R. Meharchand, F. Molina, H. Nakada, H. Okamura, H. J. Ong, T. Otsuka, G. Perdikakis, B. Rubio, H. Sagawa, P. Sarriguren, C. Scholl, Y. Shimbara, E. J. Stephenson, T. Suzuki, A. Tamii, J. H. Thies, K. Yoshida, R. G. T. Zegers, and J. Zenihiro. High-resolution study of Gamow-Teller excitations in the ^{42}Ca(^{3}He ,t)^{42}Sc reaction and the observation of a "low-energy super-Gamow-Teller state". *Phys. Rev. C*, 91:064316/1–15, 2015.

To study the Gamow-Teller (GT) transitions from the $T_z = +1$ nucleus ^{42}Ca to the $T_z = 0$ nucleus ^{42}Sc, where T_z is the z component of isospin T, we performed a (p, n)-type (^{3}He ,t) charge-exchange reaction at 140 MeV/nucleon and scattering angles around 0°. With an energy resolution of 29 keV, states ex-

cited by GT transitions (GT states) could be studied accurately. The reduced GT transition strengths B(GT) were derived up to the excitation energy of 13 MeV, assuming the proportionality between the cross sections at 0° and B(GT) values. The main part of the observed GT transition strength is concentrated in the lowest 0.611-MeV, $J^\pi = 1^+$ GT state. All the other states at higher energies are weakly excited. Shell-model calculations could reproduce the gross feature of the experimental B(GT) distribution, and random-phase-approximation calculations including an attractive isoscalar interaction showed that the 0.611-MeV state has a collective nature. It was found that this state has all of the properties of a "low-energy super-Gamow-Teller state". It is expected that low-lying $J^\pi = 1^+$ GT states have $T = 0$ in the $T_z = 0$ nucleus ^{42}Sc. However, $T = 1$ states are situated in a higher energy region. Assuming an isospin-analogous structure in $A = 42$ isobars, analogous $T = 1$, 1^+ states are also expected in ^{42}Ca. Comparing the ^{42}Ca(^{3}He, t)^{42}Sc and ^{42}Ca (p, p') spectra measured at 0°, candidates for $T = 1$ GT states could be found in the 10–12MeV region of ^{42}Sc. They were all weakly excited. The mass dependence of the GT strength distributions in Sc isotopes is also discussed.

[m-honma-101-074-03:2015] Y. Shiga, K. Yoneda, D. Steppenbeck, N. Aoi, P. Doornenbal, J. Lee, H. Liu, M. Matsushita, S. Takeuchi, H. Wang, H. Baba, P. Bednarczyk, Zs. Dombradi, Zs. Fulop, S. Go, T. Hashimoto, M. Honma, E. Ideguchi, K. Ieki, K. Kobayashi, Y. Kondo, R. Minakata, T. Motobayashi, D. Nishimura, T. Otsuka, H. Otsu, H. Sakurai, N. Shimizu, D. Sohler, Y. Sun, A. Tamii, R. Tanaka, Z. Tian, Y. Tsunoda, Zs. Vajta, T. Yamamoto, X. Yang, Z. Yang, Y. Ye, R. Yokoyama, and J. Zenihiro. Investigating nuclear shell structure in the vicinity of ^{78}Ni : Low-lying excited states in the neutron-rich isotopes ^{80,82}Zn. *Phys. Rev. C*, 93:024320/1–7, 2016.

The low-lying level structures of nuclei in the vicinity of ^{78}Ni were investigated using in-beam γ-ray spectroscopy to clarify the nature of the nuclear magic numbers Z=28 and N=50 in systems close to the neutron drip line. Nucleon knockout reactions were employed to populate excited states in ^{80}Zn and ^{82}Zn. A candidate for the 4_1^+ level in ^{80}Zn was identified at 1979(30) keV, and the lifetime of this state was estimated to be 136^{+92}_{-67} ps from a line-shape analysis. Moreover, the energy of the 2_1^+ state in ^{82}Zn is reported to lie at 621(11) keV. The large drop in the 2_1^+ energy at ^{82}Zn indicates the presence of a significant peak in the $E(2_1^+)$ systematics at N=50. Furthermore, the $E(4_1^+)/E(2_1^+)$ and $B(E2; 4_1^+ \rightarrow 2_1^+)/B(E2; 2_1^+ \rightarrow 0_{g.s.}^+)$ ratios in ^{80}Zn were deduced to be 1.32(3)

and 1.12^{+80}_{-60}, respectively. These results imply that ^{80}Zn can be described in terms of two-proton configurations with a ^{78}Ni core and are consistent with a robust N=50 magic number along the Zn isotopic chain. These observations, therefore, indicate a persistent N=50 shell closure in nuclei far from the line of β stability, which in turn suggests a doubly magic structure for ^{78}Ni.

[m-honma-101-074-04:2015] Y. Iwata, N. Shimizu, T. Otsuka, Y. Utsuno, J. Menéndez, M. Honma, and T. Abe. Large-Scale Shell-Model Analysis of the Neutrinoless $\beta\beta$ Decay of ^{48}Ca. *Phys. Rev. Lett.*, 116:112502/1–6, 2016.

We present the nuclear matrix element for the neutrinoless double-beta decay of ^{48}Ca based on large-scale shell-model calculations including two harmonic oscillator shells (*sd* and *pf* shells). The excitation spectra of ^{48}Ca and ^{48}Ti, and the two-neutrino double-beta decay of ^{48}Ca are reproduced in good agreement to the experimental data. We find that the neutrinoless double-beta decay nuclear matrix element is enhanced by about 30% compared to *pf*-shell calculations. This reduces the decay lifetime by almost a factor of 2. The matrix-element increase is mostly due to pairing correlations associated with cross-shell *sd-pf* excitations. We also investigate possible implications for heavier neutrinoless double-beta decay candidates.

[t-maeda-101-074-01:2015] Takao MAEDA, Takafumi HAYASHI, and Yodai WATANABE. Parameterization of High-Dimensional Perfect Sequences over a Composition Algebra over R. *IEICE Trans. Fund.*, E98-A(12):2439–2445, December 2015.

To analyze the structure of a set of high-dimensional perfect sequences over a composition algebra over R, we developed the theory of Fourier transforms of the set of such sequences. We define the discrete cosine transform and the discrete sine transform, and we show that there exists a relationship between these transforms and a convolution of sequences. By applying this property to a set of perfect sequences, we obtain a parameterization theorem. Using this theorem, we show the equivalence between the left perfectness and right perfectness of sequences. For sequences of real numbers, we obtain the parameterization without restrictions on the parameters.

[t-maeda-101-074-02:2015] Takafumi HAYASHI, Yodai WATANABE, Anh T. PHAM, Toshiaki MIYAZAKI, Shinya MATSUFUJI, and Takao MAEDA. A Novel Class of Zero-Correlation Zone Sequence Set Having

a Low Peak-Factor and a Flat Power Spectrum. *IEICE Trans. Fund.*, E98-A(12):2429–2438, December 2015.

The present paper introduces a novel method for the construction of a class of sequences that have a zero-correlation zone. For the proposed sequence set, both the cross-correlation function and the side lobe of the auto-correlation function are zero for phase shifts within the zero-correlation zone. The proposed scheme can generate a set of sequences of length $8n^2$ from an arbitrary Hadamard matrix of order n and a set of $2n$ trigonometric-like function sequences of length $4n$. The proposed sequence construction can generate an optimal zero-correlation zone sequence set that satisfies the theoretical bound on the number of members for the given zero-correlation zone and sequence period. The auto-correlation function of the proposed sequence is equal to zero for all nonzero phase shifts. The peak factor of the proposed sequence set is $\sqrt{2}$, and the peak factor of a single trigonometric function is equal to $\sqrt{2}$. Assigning the sequences of the proposed set to a synthetic aperture ultrasonic imaging system would improve the S/N of the obtained image. The proposed sequence set can also improve the performance of radar systems. The performance of the applications of the proposed sequence sets are evaluated.

[tsuchiya-101-074-01:2015] Takahiro Tsuchiya. A note of Newton's method on SDEs with unbounded coefficients. *The book of extended abstracts of the 47th ISCIE International Symposium on Stochastic Systems Theory and Its Applications*, (117-119), 12 2015.

We consider a Newton scheme of so called Lamperti's transformed CIR process defined on a sub-domain $D = (0, \infty)$. Firstly, we show that the Newton's approximation is well-defined on D using the comparison theorem. Then, it is shown that the scheme has a convergence in the sense of second order under a mild assumption.

[tsuchiya-101-074-02:2015] Hiroya Hashimoto and Takahiro Tsuchiya. Stability problems for Cantor stochastic differential equations. *2016*, to be announced.

The paper have been submited to a top quality jurnal namced Q1 of Scientific Journal Rankings (SJR) and it is under minor revision to be accepted.

[yamagami-101-074-01:2015] M. Yamagami and K. Matsuyanagi. Rotational Effect on Octupole Vibrations in Superdeformed Nuclei Studied by Cranked RPA Calculation with Skyrme Density Functional. *JPS Conf. Proc. 6*, page 030051 (4pages), 2015.

This is a first study that is perfromed by means of cranked RPA (random phase approximation) calculation using Skyrme energy density functional. Low-frequency octupole vibrations of rotating superdeformed states in ^{40}Ca and ^{44}Ti are analyzed by focusing on the convergence property of calculations.

[yamagami-101-074-02:2015] M. Yamagami and K. Matsuyanagi. Study of low-frequency negative-parity vibrational excitations of superdeformed rotational band in ^{40}Ca using cranked Skyrme-RPA calculations. *RIKEN Accel. Prog. Rep. 48*, page 85, 2015.

We investigate low-frequency octupole vibrations of superdeformed states in ^{40}Ca by means of cranked RPA (random phase approximation) calculation using Skyrme energy density functional. We predict that the excitation energy of 0^- pear-like vibrational state becomes lower from 4 to 0 MeV when the rotational frequency changes from $\omega_{rot} = 0$ to 1.6 MeV/$\hbar$. This may indicate instability from vibration to static reflection-asymmetric shape.

[yamagami-101-074-03:2015] M. Yamagami and K. Matsuyanagi. Soft negative-parity excitations of rotating super- and hyperdeformed states around ^{40}Ca studied by Skyrme-RPA calculations. *RIKEN Accel. Prog. Rep. 49*, page in press, 2016.

Soft mode connected to the violation of symmetries is one of the central issues in nuclear physics. We discussed soft modes emerging from the superdeformed (SD) states and the hyperdeformed (HD) states in ^{36}Ar, ^{40}Ca, and ^{44}Ti toward a non-axial reflection-asymmetric shape due to the collective-rotational effect. For this purpose, we performed systematic RPA calculations with the Skyrme energy density functional (Skyrme-EDF). We emphasized the role of rotational alignment of special high-j orbits, the [440]1/2 orbits in the SD states and the [550]1/2 orbits in the HD states for the emergence of the soft modes toward banana shape around ^{40}Ca.

Unrefereed academic journal

[k-asai-101-074-01:2015] Kazuto Asai. Bipartite Chebyshev polynomials and elliptic integrals expressible by elementary functions. *arXiv.org*, arXiv:1603.09622:1–7, 3 2016.

Academic society activities

[shimizu-101-074-01:2015] k.Shimizu, march 2016.

I gaved a presentation of proposal of gravitational energy momentum tensor.

[sigeru-w-101-074-01:2015] S. Watanabe, 2015-2016.

Reviewer: Mathematical Reviews published by the American Mathematical Society

[tsuchiya-101-074-03:2015] Takahiro Tsuchiya, 12 2015.

A presentation in the 47th ISCIE International Symposium on Stochastic Systems Theory and Its Applications, December 5-8, 2015, Hawaii, USA. Session: 3M1-2. Title: A note of Newton's method on SDEs with unbounded coefficients

[tsuchiya-101-074-04:2015] Takahiro Tsuchiya, 2016.

The presentation in The Mathematical Society of Japan (MSJ) Autumn Meeting 2016. The title is "A SDE with the Cantor diffusion coefficient and a generalized Nakao-Le Gall condition".

Advisor for undergraduate research and graduate research

[a-fujitu-101-074-01:2015] Masatomo Segawa. Graduation Thesis: Simulator for separation of smoking areas using fluid dynamics, University of Aizu, 2015.

Thesis Advisor: A. Fujitsu

[a-fujitu-101-074-02:2015] Katsuya Suzuki. Graduation Thesis: The Simulation Program for Large Electric Circuits, University of Aizu, 2015.

Thesis Advisor: A. Fujitsu

[a-fujitu-101-074-03:2015] Kohei Oshige. Graduation Thesis: The Simulation Program of Motion of an Object on the Orbit Effected by F riction, University of Aizu, 2015.

Thesis Advisor: A. Fujitsu

[m-honma-101-074-05:2015] Yoshinori Sugihara. Graduation Thesis: Molecular dynamics study on thermodynamical properties of two dimensional argon, University of Aizu, 2015.

Thesis Advisor: M. Honma

[sigeru-w-101-074-02:2015] Misato Sampei. Master thesis, Graduate School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-03:2015] Takahiro Oda. Master thesis, Graduate School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-04:2015] Hiromichi Ishigami. Graduation thesis, School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-05:2015] Masatoshi Aizawa. Graduation thesis, School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-06:2015] Akira Isobe. Graduation thesis, School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-07:2015] Yuma Aoyagi. Graduation thesis, School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[sigeru-w-101-074-08:2015] Sho Umeda. Graduation thesis, School of Computer Science and Engineering, 2016.

Thesis Adviser: S. Watanabe

[yamagami-101-074-04:2015] Takuya Hoshi. Using polytrope to examine structure of star, School of Computer Science and Engineering, September 2015.

Thesis Advisor: M. Yamagami

[yamagami-101-074-05:2015] Toshiki Sakuraoka. The Luminosity change in Meteors, School of Computer Science and Engineering, September 2015.

Thesis Advisor: M. Yamagami

[yamagami-101-074-06:2015] Kakeru Nemot. Polytropic model of the sun and planet in solar system, School of Computer Science and Engineering, March 2016.

Thesis Advisor: M. Yamagami

[yamagami-101-074-07:2015] Soichiro Kando. Difference of the cycle of simple pendulum and physical pendulum, School of Computer Science and Engineering, March 2016.

Thesis Advisor: M. Yamagami

[yamagami-101-074-08:2015] Toshiki Sakaue. The phenomenon which pumps a swing, School of Computer Science and Engineering, March 2016.

Thesis Advisor: M. Yamagami

Others

[k-asai-101-074-02:2015] Kazuto Asai. Textbooks for the classes:
A graduate text for the core course - Graph theory - (CSC07 Advanced graph theory)
Algebraic systems and combinatorics - Finite fields - (CSA13 Algebraic systems and combinatorics)
Handout for Discrete Systems (in Japanese) (Discrete Systems)
Handout for Linear Algebra (in Japanese) (Linear Algebra I)
Handout for Complex Analysis (in Japanese) (Complex Analysis)
Handout for Applied Algebra (in Japanese) (Applied Algebra).

Contributions related to syllabus preparation

[a-fujitu-101-074-04:2015] Literacy 1 syllabus

[a-fujitu-101-074-05:2015] Literacy 2 syllabus

[k-asai-101-074-03:2015] Syllabi for the following classes: CSC07 Advanced graph theory, CSA13 Algebraic systems and combinatorics, Discrete Systems, Complex Analysis, Linear Algebra I (partial support), Applied Algebra (partial support).

[shimizu-101-074-02:2015] I made syllabus of mechanics, electromagnetism and quantum mechanics.

Preparation of course examination to measure comprehension

[k-asai-101-074-04:2015] Examinations for the following classes: Discrete Systems, Linear Algebra I, Complex Analysis, Applied Algebra.

[yamagami-101-074-09:2015] General admission test and Admission test based on recommendation [Math], Creation of exam problems

[yamagami-101-074-10:2015] General admission test and Admission test based on recommendation [Math], Selection of exam problems

[yamagami-101-074-11:2015] General admission test and Admission test based on recommendation [Math], Scoring

[yamagami-101-074-12:2015] Transfer admission test [Physics], Creation of exam problems

Contribution related to the creation of the annual schedule

[k-asai-101-074-05:2015] Partially support to make a schedule for the creation and selection of the entrance examination.

Advisor of a student club or circle

[k-asai-101-074-06:2015] Advisor of

[shimizu-101-074-03:2015] I am a supervisor of ccc

Contribution related to the building or operation of the university computer system

[a-fujitu-101-074-06:2015] ISTC steering committee member

Other significant contribution toward university planning, management, or administration

[k-asai-101-074-07:2015] Participate in the committees for the creation and selection of the entrance examination, and also participate in marking of examination papers of the entrance examination.

[t-maeda-101-074-03:2015] A memeber of the steering comittee of PC Koshien, Personal Computer Concurs for High School Students, organized by Fukushima Prefectural Board of Education, Fukushima Prefecture and the University of Aizu.

Contributions related to regional education

[t-maeda-101-074-04:2015] To give a lecture of mathematics about the circular constant to students of Aizu Gakuho junior highschool

[t-maeda-101-074-05:2015] Advisor of SSH (super science highschool) of Aizu Gakuho highschool