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Summary of Achievement

Refereed Journal Papers

[k-asai-01:2014] Kazuto Asai. The group generated by the gamma functions $\Gamma(ax+1)$, and its subgroup of the elements converging to constants. *Kyushu Journal of Mathematics*, 68(2):307–313, 9 2014.

Let G be the multiplicative group generated by the gamma functions $\Gamma(ax+1)$ $(a = 1, 2, \ldots)$, and H be the subgroup of all elements of G that converge to non-zero constants as $x \to \infty$. The quotient group G/H is the group of equivalence classes of G, where f and g are equivalent $\iff f \sim Cg$ $(x \to \infty)$ for some $C \neq 0$. We show that $G/H \simeq \mathbf{Q}^+$. Similar consideration is possible for the case that the gamma functions $\Gamma(ax+1)$ with $a \in \mathbf{R}^+$ are concerned, and we show that $G/H \simeq \mathbf{Z} \times \mathbf{R} \times \mathbf{R}$. Also, several concrete examples of the elements of H are constructed, e.g. it holds that $\binom{18n}{12n,3n,3n} / \binom{18n}{9n,8n,n} \to \sqrt{\frac{2}{3}}$ $(n \to \infty)$, where $\binom{*}{*,\ldots,*}$ denotes a multinomial coefficient.

[kihara-01:2014] Hiroshi Kihara. Commutativity and cocommutativity of cogroups in the category of connected graded algebras. *Topology and its Applications*, pages 107–121, 2015.

Let ACGACG be the category of cogroups in the category AA of connected graded algebras over a fixed commutative ring R. We study the full subcategory View the MathML sourceACGco consisting of objects whose underlying algebras are graded commutative, together with the full subcategory AcoCGAcoCG consisting of cocommutative objects and the full subcategory View the MathML sourceACGco consisting of objects whose underlying coalgebras are graded cocommutative. We establish categorical equivalences of these full subcategories with categories of simpler algebraic objects, and obtain the inclusion relation of the full subcategories. Since H(Ω X;R)H(Ω X;R) is a cogroup in AA for a 1-connected co-H-group (under the assumption that R is a field), the algebraic results are applied to the theory of co-H -groups. We study when H(Ω X;R)H(Ω X;R) is in AcoCGAcoCG or View the MathML sourceACGco, and generalize a theorem of Kachi.

[m-honma-01:2014] Yutaka Utsuno, Takaharu Otsuka, Shuichiro Ebata, and Michio Honma. Photonuclear reactions of calcium isotopes calculated with the nuclear shell model. *Progress in Nuclear Energy*, page doi:10.1016/j.pnucene.2014.07.036, 2014.

Photoabsorption cross sections in calcium isotopes are investigated theoretically with the most advanced nuclear-structure calculations using the nu-

clear shell model. We show that the photoabsorption cross sections in ^{48}Ca dominated by a giant dipole resonance (GDR) are well reproduced with the shell model and predict that a pygmy dipole resonance (PDR) appears in ^{52}Ca in the low-energy tail of GDR. Excellent agreement with the experiment is achieved due to highly correlated many-body wave functions obtained by treating a huge matrix with the dimension of $\sim 10^{10}$

[m-honma-02:2014] Tomoaki Togashi, Noritaka Shimizu, Yutaka Utsuno, Takaharu Otsuka, and Michio Honma. Large-scale shell-model calculations for unnatural-parity high-spin states in neutron-rich Cr and Fe isotopes. *Phys. Rev. C*, 91:024320/1–12, 2015.

We investigate unnatural-parity high-spin states in neutron-rich Cr and Fe isotopes using large-scale shell-model calculations. These shell-model calculations are carried out within the model space of fp-shell+0g9/2+1d5/2 orbits with the truncation allowing $1\hbar\omega$ excitation of a neutron. The effective Hamiltonian consists of GXPF1Br for fp-shell orbits and VMU with a modification for the other parts. The present shell-model calculations can describe and predict the energy levels of both natural- and unnatural-parity states up to the high-spin states in Cr and Fe isotopes with $N \leq 35$. The total energy surfaces present prolate deformations on the whole and indicate that the excitation of one neutron into the 0g9/2 orbit plays the role of enhancing prolate deformation. For positive (unnatural)-parity states in odd-mass Cr and Fe isotopes, their energy levels and prolate deformations indicate the decoupling limit of the particle-plus-rotor model. The sharp drop of the 9/2+1 levels in going from N=29 to N=35 in odd-mass Cr, Fe, and Ni isotopes is explained by the Fermi surface approaching the ν0g9/2 orbit.

[t-maeda-01:2014] Shigeru Kanemoto T. Hayashi, T. Maeda and S. Matsufuji. Low-Peak-Facto Pseudo-White-Noise Sequence Set with Optimal Zero-Correlation Zone. *IEICE Trans. Fund.*, E97-A(12):23432351, December 2014.

The present paper introduces a novel method for the construction of sequences that have a zero-correlation zone. For the proposed sequence set, both the cross-correlation function and the side lobe of the autocorrelation function are zero for phase shifts within the zero-correlation zone. The proposed scheme can generate a set of sequences, each of length $16n^2$, from an arbitrary Hadamard matrix of order n and a set of $4n$ trigonometric function sequences of length $2n$. The proposed construction can generate an optimal

sequence set that satisfies, for a given zero-correlation zone and sequence period, the theoretical bound on the number of members. The peak factor of the proposed sequence set is equal to $\sqrt{2}$.

[t-watanb-01:2014] T. Watanabe. Escape rate for shift selfsimilar additive sequences. *J. Theoret. Probab.*, pages 1–25, 2015.

We characterized the law of iterated logarithm for shift selfsimilar additive sequences.

[tsuchiya-01:2014] Josef Teichmann Jiro Akahori, Yuji Hishida and Takahiro Tsuchiya. A Heat Kernel Approach to Interest Rate Models. *Japan Journal of Industrial and Applied Math*, 31(2):419–439, June 2014.

We construct default-free interest rate models in the spirit of the well-known Markov functional models: our focus is analytic tractability of the models and generality of the approach. We work in the setting of state price densities and construct models by means of the so called propagation property. The propagation property can be found implicitly in all of the popular state price density approaches, in particular heat kernels share the propagation property (wherefrom we deduced the name of the approach). As a related matter, an interesting property of heat kernels is presented, too.

[yamagami-01:2014] M. Yamagami and K. Matsuyanagi. Skyrme-RPA calculation for octupole vibrations on rotating superdeformed nuclei. *RIKEN Accel. Prog. Rep. 47*, page 60, 2014.

We developed a new computer code of a microscopic nuclear model (random phase approximation in rotating frame) for investigating rotational effects on vibrational excitations in radioactive atomic nuclei with large neutron excess. In the computer code, we used an up-to-date representation of the Skyrme-type local energy density functional that enables us to describe/predict static and dynamical properties across the nuclear chart.

[yamagami-02:2014] 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 in press, 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-03:2014] 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 in press, 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.

Refereed Proceeding Papers

[t-maeda-02:2014] Y. Watanabe T. Hayashi and T. Maeda. A Novel Class of Binary Zero-Correlation Zone Sequence Sets by using a Cyclic Difference Set. In *Proceedings of ISITA 2014*, pages 663–667, 2014.

The present paper introduces the construction of a binary sequence that has a zero-correlation zone (ZCZ). For the proposed sequence set, the cross-correlation function and the side-lobe of the autocorrelation function are zero for the phase shifts within the zero-correlation zone. The proposed ZCZ sequence set can be generated from an arbitrary binary sequence that has a two-value autocorrelation. In actual applications, the peak of the correlation function for the phase outside of the zerocorrelation zone is important. The absolute value of the out-ofphase correlation function of the proposed sequence of length m-th is less than or equal to $2^{m+1}(n+1)$, which is about half of the power (the inner product) $2^{m+2}n$ of the sequence. The proposed sequence set can be used in a robust sensor/controller network. With the proposed sequence, we examine the performances of ultrasonic imaging.

[t-maeda-03:2014] S. Matsufuji T. Hayashi, Y. Watanabe and T. Maeda. A Novel Zero-Correlation Zone Sequence Set Having a Low-Peak Factor and a Flat Power Spectrum. In *Proceedings of ISITA 2014*, pages 668–672, 2014.

The present paper introduces a novel method for the construction 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 construction can generate an optimal 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 shift. The peak factor of the proposed sequence set is $\sqrt{2}$.

[t-maeda-04:2014] T. Maeda and T. Hayashi. Parameterization of High-Dimensional Perfect Sequences over a Composition Algebra over R. In *Proceedings of ISITA 2014*, pages 682–686, 2014.

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 such sequences. Transforms that are similar to discrete Fourier transforms (DFTs) are introduced for a set of sequences. We define the discrete cosine transform, the discrete sine transform, and the generalized discrete Fourier transform (GDFT) of the sequences, and we prove the fundamental properties of these transforms. We show that the GDFT is bijective and that there exists a relationship between these transforms and a convolution of sequences. By applying these properties to a set of perfect sequences, we obtain a parameterization theorem for the sequences. Using this theorem, we show the equivalence of the left and right perfectness.

Academic Activities

[sigeru-w-01:2014] S. Watanabe, 2014-2015.

Reviewer: Mathematical Reviews published by the American Mathematical Society

[tsuchiya-02:2014] Takahiro Tsuchiya, 25 Sep. 2014.

Title: A note on convergence rates for stability problems of SDEs under Nakao-Le Gall condition. Abstract: We consider the stability problems of one dimensional stochastic differential equations when the diffusion coefficients satisfy the so called Nakao-Le Gall condition. A bounded rate of strong convergence in the sense of L^1 are given by the Yamada-Watanabe method.

Ph.D and Others Theses

[a-fujitu-01:2014] Ryo Yaginuma. Graduation Thesis: The simulation program of motion of an object on the orbit drawn freely, University of Aizu, 2014.

Thesis Advisor: A. Fujitsu

[a-fujitu-02:2014] Takahiro Ogino. Graduation Thesis: Electric circuit simulation program for education, University of Aizu, 2014.

Thesis Advisor: A. Fujistu

[a-fujitu-03:2014] Yuta Komatsu. Graduation Thesis: Billiard program with Lorentz force, University of Aizu, 2014.

Thesis Advisor: A. Fujistu

[a-fujitu-04:2014] Takayuki Oe. Graduation Thesis: Improvement of academic ability by animation, University of Aizu, 2014.

Thesis Advisor: A. Fujistu

[m-honma-03:2014] Tsubasa Sato. Master Thesis: Stellar orbits in realistic Milky Way mass model, University of Aizu, 2015.

Thesis Advisor: M. Honma

[sigeru-w-02:2014] Yosuke Kojima. Master thesis, Graduate School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[sigeru-w-03:2014] Yuya Fujioka. Graduation thesis, School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[sigeru-w-04:2014] Yukihiro Matsumoto. Graduation thesis, School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[sigeru-w-05:2014] Shota Watanabe. Graduation thesis, School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[sigeru-w-06:2014] Masayoshi Shiraiwa. Graduation thesis, School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[sigeru-w-07:2014] Yasuhiro Imai. Graduation thesis, School of Computer Science and Engineering, March 2015.

Thesis Adviser: S. Watanabe

[yamagami-04:2014] Kazuki Inoue. Orbit's change of Dust tails by the repulsive force, School of Computer Science and Engineering, March 2015.

Thesis Advisor: M. Yamagami

[yamagami-05:2014] Shuto Suzuki. Acceleration of Satellites by Swing-by Effects, School of Computer Science and Engineering, March 2015.

Thesis Advisor: M. Yamagami

Others

[k-asai-02:2014] Kazuto Asai. Handouts (Texts for classes) in Japanese: Discrete Systems (85 pages), Linear Algebra (85 pages), Complex Analysis (67 pages), Applied Algebra (50 pages) Handouts (graduate school) in English: ALGEBRAIC SYSTEMS AND COMBINATORICS (43 pages) A GRADUATE TEXT FOR THE CORE COURSE: GRAPH THEORY (33 pages). pdf-files, 2014 (revised edition).

http://web-ext.u-aizu.ac.jp/ k-asai/classes/class-texts.html

[kihara-02:2014] Hiroshi Kihara. Groups of homotopy classes of phantom maps. Lecture at Conference on algebraic and geometric models of spaces, at Shinshuu University, September 2014.

In the lecture, I gave a sufficient condition that the set Ph(X,Y) of phantom maps has a natural group structure, and computed the groups Ph(X,Y) in the case where the generalizations of Millerś theorem can not be directly applied.