

Mathematics and Physics Laboratory Group



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Summary of Achievement

Refereed academic journal

[kihara-101-074-01:2017] Hiroshi Kihara. Groups of homotopy classes of phantom maps. *Algebraic & Geometric Topology*, 18(1):583–612, 2018.

We introduce a new approach to phantom maps which largely extends the rational-ization-completion approach developed by Meier and Zabrodsky. Our approach enables us to deal with the set $Ph(X, Y)$ of homotopy classes of phantom maps and the subset $SPh(X, Y)$ of homotopy classes of special phantom maps simultaneously. We give a sufficient condition for $Ph(X, Y)$ and $SPh(X, Y)$ to have natural group structures, which is much weaker than the conditions obtained by Meier and McGibbon. Previous calculations of $Ph(X, Y)$ have generally assumed that $[X, \Omega\hat{Y}]$ is trivial, in which case generalizations of Miller's theorem are directly applicable, and calculations of $SPh(X, Y)$ have rarely been reported. Here, we calculate not only $Ph(X, Y)$ but also $SPh(X, Y)$ in many important cases of nontrivial $[X, \Omega\hat{Y}]$.

[kihara-101-074-02:2017] Hiroshi Kihara. Groups of homotopy classes of phantom maps. *Algebraic & Geometric Topology*, 18(1):583–612, 2018.

We introduce a new approach to phantom maps which largely extends the rational-ization-completion approach developed by Meier and Zabrodsky. Our approach enables us to deal with the set $Ph(X, Y)$ of homotopy classes of phantom maps and the subset $SPh(X, Y)$ of homotopy classes of special phantom maps simultaneously. We give a sufficient condition for $Ph(X, Y)$ and $SPh(X, Y)$ to have natural group structures, which is much weaker than the conditions obtained by Meier and McGibbon. Previous calculations of $Ph(X, Y)$ have generally assumed that $[X, \Omega\hat{Y}]$ is trivial, in which case generalizations of Miller's theorem are directly applicable, and calculations of $SPh(X, Y)$ have rarely been reported. Here, we calculate not only $Ph(X, Y)$ but also $SPh(X, Y)$ in many important cases of nontrivial $[X, \Omega\hat{Y}]$.

[kihara-101-074-03:2017] Hiroshi Kihara. Groups of homotopy classes of phantom maps. *Algebraic & Geometric Topology*, 18(1):583–612, 2018.

We introduce a new approach to phantom maps which largely extends the rational-ization-completion approach developed by Meier and Zabrodsky. Our approach enables us to deal with the set $Ph(X, Y)$ of homotopy classes of phantom maps and the subset $SPh(X, Y)$ of homotopy classes of special phantom maps simultaneously. We give a sufficient condition for $Ph(X, Y)$ and $SPh(X, Y)$ to have natural group structures, which is much weaker than

the conditions obtained by Meier and McGibbon. Previous calculations of $Ph(X, Y)$ have generally assumed that $[X, \Omega\hat{Y}]$ is trivial, in which case generalizations of Miller's theorem are directly applicable, and calculations of $SPh(X, Y)$ have rarely been reported. Here, we calculate not only $Ph(X, Y)$ but also $SPh(X, Y)$ in many important cases of nontrivial $[X, \Omega\hat{Y}]$.

[m-honma-101-074-01:2017] Noritaka Shimizu, Takashi Abe, Michio Honma, Takaharu Otsuka, Tomoaki Togashi, Yusuke Tsunoda, Yutaka Utsuno, and Tooru Yoshida. Monte Carlo shell model studies with massively parallel supercomputers. *Physica Scripta*, 92:063001/1–19, 2017.

We present an overview of the advanced Monte Carlo shell model (MCSM), including its recent applications to no-core shell-model calculations and to large-scale shell-model calculations (LSSM) in the usual sense. For the *ab initio* no-core MCSM we show recent methodological developments, which include the evaluation of energy eigenvalues in an infinitely large model space by an extrapolation method. As an example of the application of the no-core MCSM, the cluster structure of Be isotopes is discussed. Regarding LSSM applications, the triple shape coexistence in ^{68}Ni and ^{70}Ni and the shape transition of Zr isotopes are clarified with the visualization of the intrinsic deformation of the MCSM wave function. General aspects of the code development of the MCSM on massively parallel computers are also briefly described.

[m-honma-101-074-02:2017] C. Wraith, X.F. Yang, L. Xie, C. Babcock, J. Bieroń, J. Billowes, M.L. Bissell, K. Blaum, B. Cheal, L. Filippin, R.F. Garcia Ruiz, W. Gins, L.K. Grob, G. Gaigalas, M. Godefroid, C. Gorges, H. Heylen, M. Honma, P. Jönsson, S. Kaufmann, M. Kowalska, J. Krämer, S. Malbrunot-Ettenauer, R. Neugart, G. Neyens, W. Nörtershäuser, F. Nowacki, T. Otsuka, J. Papuga, R. Sánchez, Y. Tsunoda, and D.T. Yordanov. Evolution of nuclear structure in neutron-rich odd-Zn isotopes and isomers. *Physics Letters B*, 771:385–391, 2017.

Collinear laser spectroscopy was performed on Zn ($Z=30$) isotopes at ISOLDE, CERN. The study of hyperfine spectra of nuclei across the Zn isotopic chain, $N=33-49$, allowed the measurement of nuclear spins for the ground and isomeric states in odd- A neutron-rich nuclei up to $N=50$. Exactly one long-lived (≥ 10 ms) isomeric state has been established in each $^{69-79}\text{Zn}$ isotope. The nuclear magnetic dipole moments and spectroscopic quadrupole moments are well reproduced by large-scale shellmodel calculations in the $f_5p_{g_9}$ and $fp_{g_9}d_5$ model spaces, thus establishing the dominant term in their wave function. The

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magnetic moment of the intruder $I^\pi = 1/2^+$ isomer in ^{79}Zn is reproduced only if the $\nu s_{1/2}$ orbital is added to the valence space, as realized in the recently developed PFSDG-U interaction. The spin and moments of the low-lying isomeric state in ^{73}Zn suggest a strong onset of deformation at $N=43$, while the progression towards ^{79}Zn points to the stability of the $Z=28$ and $N=50$ shell gaps, supporting the magicity of ^{78}Ni .

[m-honma-101-074-03:2017] M. Queiser, A. Vogt, M. Seidlitz, P. Reiter, T. Togashi, N. Shimizu, Y. Utsuno, T. Otsuka, M. Honma, P. Petkov, K. Arnswald, R. Altenkirch, B. Birkenbach, A. Blazhev, T. Braunroth, A. Dewald, J. Eberth, C. Fransen, B. Fu, H. Hess, R. Hetzenegger, R. Hirsch, J. Jolie, V. Karayonchev, L. Kaya, L. Lewandowski, C. Müller-Gatermann, J.-M. Régis, D. Rosiak, D. Schneiders, B. Siebeck, T. Steinbach, K. Wolf, and K.-O. Zell. Cross-shell excitations from the f p shell: Lifetime measurements in ^{61}Zn . *Phys. Rev. C*, 96:044313/1–13, 2017.

Lifetimes of excited states in the neutron-deficient nucleus ^{61}Zn were measured employing the recoil-distance Doppler-shift (RDDS) and the electronic fast-timing methods at the University of Cologne. The nucleus of interest was populated as an evaporation residue in $^{40}\text{Ca}(^{24}\text{Mg},n2p)^{61}\text{Zn}$ and $^{58}\text{Ni}(\alpha,n)^{61}\text{Zn}$ reactions at 67 and 19 MeV, respectively. Five lifetimes were measured for the first time, including the lifetime of the $5/2^-$ isomer at 124 keV. Short lifetimes from the RDDS analysis are corrected for Doppler-shift attenuation (DSA) in the target and stopper foils. Ambiguous observations in previous measurements were resolved. The obtained lifetimes are compared to predictions from different sets of shell-model calculations in the fp , $f_{5/2}pg_{9/2}$, and multishell $fp-g_{9/2}d_{5/2}$ model spaces. The band built on the $9/2^+$ state exhibits a prolate deformation with $\beta \approx 0.24$. Especially, the inclusion of cross-shell excitation into the $1d_{5/2}$ orbital is found to be decisive for the description of collectivity in the first excited positive-parity band.

[t-maeda-101-074-01:2017] Toshiaki MIYAZAKI Anh T. PHAM Takao MAEDA Shinya MATSUFUJI Takafumi HAYASHI, Yodai WATANABE. A Novel Class of Quadriphase Zero-Correlation Zone Sequence Sets. *IE-ICE Trans. Fundamentals*, E100-A(4):pp.953–960, April 2017.

The present paper introduces the construction of quadriphase sequences having a zero-correlation zone. For a zero-correlation zone sequence set of N sequences, each of length l , the cross-correlation function and the side lobe of the auto-correlation function of the proposed sequence set are zero for the phase shifts

within the zero-correlation zone z , such that $|\tau| \leq z$ ($\tau \neq 0$ for the auto-correlation function). The ratio $\frac{N(z+1)}{l}$ is theoretically limited to one. When $l = N(z + 1)$, the sequence set is called an optimal zero-correlation sequence set. The proposed zero-correlation zone sequence set can be generated from an arbitrary Hadamard matrix of order n . The length of the proposed sequence set can be extended by sequence interleaving, where m times interleaving can generate $4n$ sequences, each of length $2^{m+3}n$. The proposed sequence set is optimal for $m = 0, 1$ and almost optimal for $m > 1$.

[t-maeda-101-074-02:2017] Takao MAEDA Shinya MATSUFUJI Takafumi HAYASHI, Yodai WATANABE. A Novel Construction of Tree-Structured Zero-Correlation Zone Sequence Sets. *IEICE Trans. Fundamentals*, E100-A(10):pp.2187–2194, October 2017.

The present paper introduces a novel construction of structured ternary sequences having a zero-correlation zone (ZCZ) for both periodic and aperiodic correlation functions. The cross-correlation function and the side lobe of the auto-correlation function of the proposed sequence set are zero for phase shifts within the ZCZ. The proposed ZCZ sequence set can be generated from an arbitrary Hadamard matrix of order n . The sequence set of order 0 is identical to the r -th row of the Hadamard matrix. For $m \geq 0$, the sequence set of order $(m + 1)$ is constructed from the sequence set of order m by sequence concatenation and interleaving. The sequence set of order m has 2^m subsets of size n . The length of the sequence is equal to $n4^m + 2^{m+1}(2^m - 1)$; The phase shift of the ZCZ for the whole sequence set is from $-(2^m - 1)$ to $(2^m - 1)$. The sequence set of order 0 is coincident with the rows of the given Hadamard sequence with no ZCZ. The subsets can be associated with a perfect binary tree of height m with 2^m . The r -th sequence subset consists of from the nr -th sequence to the $((n + 1)r - 1)$ -th sequence. The r -th subset is assigned to the r -th leaf of the perfect binary tree. For a longer distance between the corresponding leaves to the r -th and s -th sequences, the ZCZ of the r -th and s -th sequences is wider. This tree-structured width of ZCZ of a pair of the proposed sequences enables flexible design in applications of the proposed sequence set. The proposed sequence is suitable for a heterogeneous wireless network, which is one of the candidates for the fifth generation of radio access networks.

[tsuchiya-101-074-01:2017] Hiroya Hashimoto and Takahiro Tsuchiya. Stability problems for Cantor stochastic differential equations. *Stochastic Processes and their Applications*, 128(1):211–232, January 2018.

We consider driftless stochastic differential equations and the diffusions starting

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from the positive half line. It is shown that the Feller test for explosions gives a necessary and sufficient condition to hold pathwise uniqueness for diffusion coefficients that are positive and monotonically increasing or decreasing on the positive half line and the value at the origin is zero. Then, stability problems are studied from the aspect of Holder-continuity and a generalized Nakao-Le Gall condition. Comparing the convergence rate of Holder-continuous case, the sharpness and stability of the Nakao-Le Gall condition on Cantor stochastic differential equations are confirmed. Furthermore, using the Malliavin calculus, we construct a smooth solution to degenerate second order Fokker-Planck equations under weak conditions on the coefficients.

[yamagami-101-074-01:2017] Yamagami M. and Matsuyanagi K. QRPA calculations with Skyrme energy density functional for rotating unstable nuclei. *RIKEN Accel. Prog. Rep. 50*, page 92, 2017.

The energy density functional (EDF) theory is the only tractable microscopic theory that can be applied across the entire table of nuclides. For studying collective dynamics in unstable atomic nuclei, we have developed a new computer code for the quasiparticle random phase approximation (QRPA) calculation with the Skyrme EDF. With this code, we investigated quadrupole excitations in neutron-rich ^{34}Mg and ^{36}Mg . The role of pairing correlations (superfluidity) and collective rotation (breaking of time-reversal invariance) on the excitation mode is clarified.

[yamagami-101-074-02:2017] Yamagami M. Enhancement of pairing fluctuation in neutron-rich Mg isotopes studied by Skyrme QRPA calculation. *RIKEN Accel. Prog. Rep. 51*, page in press, 2018.

We investigated isoscalar quadrupole excitations in neutron-rich Mg isotopes as a probe of dineutron correlation (a novel phase of superfluidity). By performing the quasiparticle random phase approximation (QRPA) calculation with the Skyrme energy density functional, we predicted the strong enhancement of pairing fluctuation by the coupling to continuum states in deformed, weakly-bound Mg isotopes around ^{40}Mg . This phenomenon suggests the presence of dineutron correlations. We also showed that the quadrupole transition strength contain indispensable information about the novel pairing properties.

Unrefereed proceedings of an academic conference

[tsuchiya-101-074-02:2017] Takahiro Tsuchiya. A SDE with locally Holder contin-

uous diffusion coefficients. In *Colloquium at Ritsumeikan University*, 30 December 2017.

Invited talk.

[tsuchiya-101-074-03:2017] Takahiro Tsuchiya. Cantor diffusion SDEs and its applications. In *The Probability Symposium 2017 in Tohoku Univ.*, 2017.

[tsuchiya-101-074-04:2017] Takahiro Tsuchiya. Stability problems for Cantor stochastic differential equations. In *Seminar of Probability in Fukuoka Univ.*, 2 November 2017.

Invited talk

Academic society activities

[m-honma-101-074-04:2017] M. Honma, November 2017.

Organizing committee member, Ito International Research Center (IIRC) symposium :Perspectives of the physics of nuclear structure

[m-honma-101-074-05:2017] M. Honma, 2018.

Outstanding Referee of the Physical Review journals

[sigeru-w-101-074-01:2017]

[sigeru-w-101-074-02:2017]

Advisor for undergraduate research and graduate research

[a-fujitu-101-074-01:2017] Kento Fukumitsu. Collision avoidance simulation of cars, University of Aizu, 2017.

Thesis Advisor: A. Fujitsu

[a-fujitu-101-074-02:2017] Syota Yanai. The Textbook about Black-body radiation, University of Aizu, 2017.

Thesis Advisor: A. Fujitsu

[a-fujitu-101-074-03:2017] Kazuma Nakai. Teaching materials of physics by using Mathematica, University of Aizu, 2017.

Thesis Advisor: A. Fujitsu

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[a-fujitu-101-074-04:2017] Shoya Furukawa. Simulation of collapsing building by earthquake, University of Aizu, 2017.

Thesis Advisor: A. Fujitsu

[m-honma-101-074-06:2017] Tomoyuki Takai. Graduation Thesis: A Monte Carlo approach to neutron transport, University of Aizu, September 2017.

Thesis Advisor: M. Honma

[m-honma-101-074-07:2017] Keisuke Mizuno. Graduation Thesis: Monte Carlo simulations of polymer chain conformations, University of Aizu, March 2018.

Thesis Advisor: M. Honma

[sigeru-w-101-074-03:2017]

[sigeru-w-101-074-04:2017]

[sigeru-w-101-074-05:2017]

[sigeru-w-101-074-06:2017]

[sigeru-w-101-074-07:2017]

[sigeru-w-101-074-08:2017]

[sigeru-w-101-074-09:2017]

Others

[k-asai-101-074-01:2017] Kazuto Asai. Bipartite Chebyshev polynomials and elliptic integrals expressible by elementary functions (revised). preprint, 2017.

Contributions related to syllabus preparation

[k-asai-101-074-02:2017] Prepare syllabi for the following classes: CSC07 Advanced Graph Theory (Graduate School) CSA13 Algebraic Systems and Combinatorics (Graduate School) M06 Complex Analysis F03 Discrete Systems (partial contribution) M01 Linear Algebra I (partial contribution) M08 Applied Algebra (partial contribution)

[kihara-101-074-04:2017] Differential Calculus I

[kihara-101-074-05:2017] Differential Calculus II

Preparation of course examination to measure comprehension

[k-asai-101-074-03:2017] Preparation for the examinations for the following classes:
Complex Analysis, Discrete Systems, Linear Algebra I, Linear Algebra I(TGU),
Applied Algebra.

[yamagami-101-074-03:2017] General admission test and Admission test based on recommendation [Math], Creation of exam problems

[yamagami-101-074-04:2017] General admission test and Admission test based on recommendation [Math], Selection of exam problems

[yamagami-101-074-05:2017] Admission test based on recommendation (Math), Scoring

[yamagami-101-074-06:2017] General admission test (Math), Scoring

[yamagami-101-074-07:2017] Transfer admission test (Physics), Creation of exam problems

[yamagami-101-074-08:2017] Transfer admission test (Physics), Scoring

Contribution related to the creation of the annual schedule

[k-asai-101-074-04:2017] A contribution to the preparation of the annual schedule of the committees concerning the entrance examinations.

Contribution related to the selection of library or textbook materials

[k-asai-101-074-05:2017] A contribution to the selection of the textbooks or reference books for the following classes: Complex Analysis, Discrete Systems, Linear Algebra, Applied Algebra.

Advisor of a student club or circle

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[k-asai-101-074-06:2017] Keion (music circle)

Contribution related to student management (for example, solution of a student-related problem)

[yamagami-101-074-09:2017] Mentor of class

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

[a-fujitu-101-074-05:2017] ISTC steering committee member

Contribution related to educational planning management

[yamagami-101-074-10:2017] Member of Academic Affair Committee

Contribution related to educational research technology and facility planning management

[yamagami-101-074-11:2017] Member of Working group for medium-term goal proposal and medium-term plans (Hyouka-shitsu working group)

Other significant contribution toward university planning, management, or administration

[k-asai-101-074-07:2017] Providing great amount of problems to the entrance examination in mathematics. (Approx. 56% of the general entrance examination for 2018) 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.