Division of Computer Science

Mathematics and Physics Laboratory Group

Toshiro Watanabe
Professor

Michio Honma
Professor

Noriaki Kamiya
Professor

Hiroyuki Sagawa
Special Honorary Professor

Katsutaro Shimizu
Senior Associate Professor

Hiroshi Kihara
Senior Associate Professor

Takao Maeda
Senior Associate Professor

Kazuto Asai
Senior Associate Professor

Shigeru Watanabe
Senior Associate Professor

Akira Fujitsu
Senior Associate Professor

Masayuki Yamagami
Associate Professor

Takahiro Tuchiya
Associate Professor
Summary of Achievement

Refereed Journal Papers


Let $G$ be the multiplicative group generated by the gamma functions $\Gamma(ax + 1)$ ($a=1,2,\cdots$), and $H$ be the subgroup of all elements of $G$ that converge to nonzero constants as $x \to \infty$. The quotient group $G/H$ is the group of equivalence classes of $G$, where $f$ and $g$ are equivalent if $g(x \to \infty)$ for some $C \neq 0$. We show that $G/HQ^+$. A similar consideration is possible for the case that the gamma functions $\Gamma(ax + 1)$ with $a \in \mathbb{R}^+$ are concerned, and we show that $G/H \approx \mathbb{R} \times \mathbb{R}$. Also, several concrete examples of the elements of $H$ are constructed.


In order to study the Gamow-Teller (GT) transitions from the $T_z=+2$ nucleus $^{44}\text{Ca}$ to the $T_z=+1$ nucleus $^{44}\text{Sc}$, where $T_z$ is the $z$ component of isospin $T$, we performed the $(p,n)$-type ($^{3}\text{He},t$) charge-exchange (CE) reaction at 140 MeV/nucleon and the scattering angles $0^\circ$ and $2.5^\circ$. An energy resolution of 28 keV, that was realized by applying matching techniques to the magnetic spectrometer system, allowed the study of fragmented states. The GT transition strengths, $B(GT)$, were derived up to the excitation energy ($E_x$) of 13.7 MeV assuming the proportionality between cross sections and $B(GT)$ values. The total sum of $B(GT)$ values in discrete states was 3.7, which was obtained using the GXPF1J interaction could reproduce the gross features of the experimental $B(GT)$ distribution, but not the fragmentation of the strength.

Summary of Achievement

The internal-conversion and internal-pair-production decays of the first excited 0+ state in 68Ni are studied following the beta decay of 68Co. A novel experimental technique, in which the ions of 68Co were implanted into a planar germanium double-sided strip detector and which required digital pulse processing, is developed. New values for the energy of the first excited 0+ state and the electric monopole transition strength from the first excited 0+ state to the ground state in 68Ni are determined to be 1605(3) keV and 7.6(4) x 10^{-3}, respectively. Comparisons of the experimental results to Monte Carlo Shell Model calculations suggest the coexistence between a spherical ground state and an oblate first excited 0+ state in 68Ni.


Gamow-Teller (GT) transitions in atomic nuclei are sensitive to both nuclear shell structure and effective residual interactions. The nuclear GT excitations were studied for the mass number A=42, 46, 50, and 54 “f-shell” nuclei in (3He, t) charge-exchange reactions. In the 42Ca→42Sc reaction, most of the GT strength is concentrated in the lowest excited state at 0.6 MeV, suggesting the existence of a low-energy GT phonon excitation. As A increases, a high-energy GT phonon excitation develops in the 6-11 MeV region. In the 54Fe→54Co reaction, the high-energy GT phonon excitation mainly carries the GT strength. The existence of these two GT phonon excitations are attributed to the 2 fermionic degrees of freedom in nuclei


The shapes of neutron-rich exotic Ni isotopes are studied. Large-scale shell
model calculations are performed by the advanced Monte Carlo shell model (MCSM) for the pf-g9/2-d5/2 model space. Experimental energy levels are reproduced well by a single fixed Hamiltonian. Intrinsically shapes are analyzed for MCSM eigenstates. Intriguing interplays among spherical, oblate, prolate, and γ-unstable shapes are seen, including shape fluctuations, E(5)-like situations, the magicity of doubly magic 56,68,78Ni, and the coexistence of spherical and strongly deformed shapes. Regarding the last point, strong deformation and change of shell structure can take place simultaneously, being driven by the combination of the tensor force and changes of major configurations within the same nucleus.


Atomic nuclei are finite quantum systems composed of two distinct types of fermion—protons and neutrons. In a manner similar to that of electrons orbiting in an atom, protons and neutrons in a nucleus form shell structures. In the case of stable, naturally occurring nuclei, large energy gaps exist between shells that fill completely when the proton or neutron number is equal to 2, 8, 20, 28, 50, 82 or 126. Away from stability, however, these so-called ‘magic numbers’ are known to evolve in systems with a large imbalance of protons and neutrons. Although some of the standard shell closures can disappear, new ones are known to appear. Studies aiming to identify and understand such behaviour are of major importance in the field of experimental and theoretical nuclear physics. Here we report a spectroscopic study of the neutron-rich nucleus 54Ca (a bound system composed of 20 protons and 34 neutrons) using proton knockout reactions involving fast radioactive projectiles. The results highlight the doubly magic nature of 54Ca and provide direct experimental evidence for the onset of a sizable subshell closure at neutron number 34 in isotopes far from stability.


To analyze the structure of a set of perfect sequences over a composition
algebra of the real number field, transforms of a set of sequences similar to the discrete Fourier transform (DFT) are introduced. The discrete cosine transform, discrete sine transform, and generalized discrete Fourier transform (GDT) of the sequences are defined and the fundamental properties of these transforms are proved. We show that GDT is bijective and that there exists a relationship between these transforms and a convolution of sequences. Applying these properties to the set of perfect sequences, a parameterization theorem of such sequences is obtained.


In this paper, we consider Euler-Maruyama approximations for 1-dimensional stochastic differential equations (SDEs) driven by rotation invariant (i.e. symmetric) α-stable processes and discuss their rate of strong convergence by numerical simulations. We also study the relationship between the convergence rate and the index α of rotation invariant stable process and/or the exponent γ of the Hölder continuity of the diffusion coefficient.


We discuss the predictive power of our local energy density functional for pairing correlations in nuclei around the neutron drip line. An empirical relation among the parameters in the isoscalar part of pair-DF is extracted. The uncertainty of the isovector part is also examined by calculating the pairing gaps of neutron-rich and proton-rich nuclei in a wider region of of the nuclear chart.


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-
Summary of Achievement

type local energy density functional that enables us to describe/predict static
and dynamical properties across the nuclear chart.

Un refereed Papers

of stability problems of SDEs with (dis-)continuous coefficients. arXiv,
(1401.4542 [math.PR]), 2013.

We consider the stability problems of one dimensional SDEs when the diffusion
coefficients satisfy the so called Nakao-Le Gall condition. The explicit rate of
convergence of the stability problems are given by the Yamada-Watanabe method
without the drifts. We also discuss the convergence rate for the SDEs driven by
the symmetric $\alpha$ stable process. These stability rate problems are extended to
the case where the drift coefficients are bounded and in L1. It is shown that the
convergence rate is invariant under the removal of drift method for the SDEs
driven by the Wiener process.

Refereed Proceeding Papers

[t-maeda-02:2013] Takafumi Hayashi, Takao Maeda Shigeru Kanemoto, and
Shinya Matsufuji. Low-Peak Factor Optimal Zero-Correlation Zone Se-
quence Set and Its Applications. In Pingzhi Fan et al., editor, Proceed-
ings of the Sixth International Workshop on Signal Design and Its Ap-
plications in Communications (IWSDA’13), pages 72–75. IEEE, IEEE

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 sequence set can
be generated from an arbitrary Hadamard matrix of order $n$ and a set of $2^n$
trigonometric-like function sequences of length $4n$. 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 $\sqrt{2}$.

[tsuchiya-03:2013] Hiroya Hashimoto and Takahiro Tsuchiya. Euler and
Maruyama scheme and the convergence rate of SDEs driven by rota-

The rate of convergence of the Euler-Maruyama schemes to the solution was drawn primarily from the paper Deelstra and Delbaen in 1998. Their results has been sharpened and considerably generalized by Gyongy and Rasonyi in 2011. In the real world, these heavy tail behaviors are observed in various fields. Then, we are interested in how much effect the mathematical framework depend of the fat-tail driven process $Z$. 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 $L^1$ is given via the Yamada-Watanabe method. Using the extended Tanaka-Meyer formula, the result is extended to the SDEs driven by rotation invariant and $\alpha$-stable processes ($1 < \alpha < 2$) under the Belfadli-Ouknine’s condition.

**Academic Activities**


Reviewer: Mathematical Reviews published by the American Mathematical Society


He was the treasurer of IWSDA (the International Workshop on Signal Design and its Applications in Communications ) supported by IEEE.


A member of the Steering Committee of ACM International Collegeate Programming Contest, Asia Regional Contest, 2013, Aizu.


Analysis prize 2013

**Ph.D and Others Theses**


Thesis Advisor: A. Fujitsu
Summary of Achievement

   Thesis Advisor: A. Fujitsu

   Thesis Advisor: M. Honma

   Thesis Advisor: M. Honma

   Thesis Advisor: M. Honma

   Thesis Adviser: S. Watanabe

   Thesis Adviser: S. Watanabe

   Thesis Adviser: S. Watanabe

   Thesis Adviser: S. Watanabe

   Thesis Adviser: S. Watanabe
Summary of Achievement

Thesis Adviser: S. Watanabe

Thesis Adviser: S. Watanabe

Thesis Advisor: M. Yamagami

Thesis Advisor: M. Yamagami

Thesis Advisor: M. Yamagami

Others

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

A dissertation submitted in partial fulfilment of the requirements for the degree of philosophy in computer science and engineering