ANNUAL REPORT

2018-2019

November 2018 - March 2020

Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP), Osaka City University

NITEP
Nambu Yoichiro Institute of Theoretical and Experimental Physics

6 January 2021

Editors: Hiroshi Itoyama, Nobuyuki Kanda, and Takeshi Oota

PREFACE

Two years have passed since Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP) was founded and we present our annual report, summarizing scientific accomplishments made during the period of November 2018 through March 2020, namely 2018 and 2019 academic years since the foundation. The number of our research members is 35 and currently many of us are co-members from our physics department. During this period, we produced 134 research papers and 2 books. We organized and conducted 10 conferences/workshops among which 2 were unfortunately cancelled by COVID-19. Several lecture series were given at Umeda satellite of OCU where graduate as well as undergraduate students and young researchers from and outside our university attended. Two public symposia were delivered, ending with a lot of interesting questions from audience who include high-school students and retired citizens. A wide variety of research seminars and series of joint meetings from 14 research groups were actively given. We do hope that these activities have demonstrated the notion of "Be Borderless" in all fields in theoretical and experimental physics as much as we could at this moment in order to follow the spirit of Professor Nambu closely.

Our main scientific theme since the foundation is "Quest of Universality and Emergence in Physics led by Broken Symmetry" which lays down particle physics, nuclear physics, cosmology and condensed matter physics both in theory and experiment. The research carried out during this period certainly develops this notion vigorously. We are, however, in no sense satisfied with the accomplishments achieved so far. We will carry out several frontier research program more vigorously by the affiliation with international and domestic institutions from now on. We will continue to host international conferences and symposia which are vital to be held in Far East Asia and to organize interesting workshops and public lectures of our own. We will make every effort to inspire and promote young scientists who are needed for future breakthrough. We are determined to dedicate ourselves to the advances of NITEP toward a full-fledged research institute.

Hiroshi Itoyama, the director

Contents

1 ABOUT NITEP

Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP), Osaka City University was founded on Novermber 1, 2018.

Osaka City University (OCU) is known to be the only university in Japan where Yoichiro Nambu taught as professor before he left for the United States. Since then, our physics department has been recognized as a first-rate research institute in physics till today, emphasizing free spirit and imagination fostered by the group led by Professor Nambu in early fifties. In 2013, OCU awarded Professor Nambu a Special Emeritus Professor for his Novel prize in Physics in 2008. In 2018, the President Tetsuo Arakawa decided to open a new research institute in physics on our campus crowned under Nambu to promote our activities and foster human resources further, aiming at the formation of an international center where scientists both from abroad and inside Japan gather regularly. International presence of our university has thus been strengthened.

2 NEWS

1. Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP) was founded. (1 November 2018)

2. NITEP has become one of the supporting institutions of the journal, Progress of Theoretical and Experimental Physics (PTEP). (20 January 2020)

3. KAGRA, a gravitational wave observation project with the participation of Nobuyuki Kanda (Deputy Director of NITEP) and Yousuke Itoh, has started its observations. (25 February 2020)

3 AWARDS

1. **Makoto Tsubota** was selected as a winner of the **2019 Fluid Science Research Award** on 2 August 2019.

2. **Hiromitsu Takeuchi** and **Koichi Sato** have been selected as recipients of the **2019 Yoichiro Nambu Memorial Encouragement Award for Young Scientists** on 24 October 2019.

3. **Masako Iwasaki** was chosen as a winner of the **2019 Osaka City University Special Award for Female Researchers** [**Okamura Prize**] on 25 December 2019.

4 INTERNATIONAL COLLABORATION

NITEP has been putting forward international collaborations in several directions strongly since its foundation.

In high energy experiments, Y. Seiya and K. Yamamaoto have been working at the long baseline neutrino oscillation experiment T2K, concluding that the angle δ_{CP} may be around the $-\pi/2$. They are also working at the DeeMe experiment in preparation to search for the charged lepton flavor violating process, μ-e conversion. M. Iwasaki and E. Nakano have been working on the international B factory experiments of Belle and Belle II. M. Iwasaki has also been working for the future ILC experiment on the SiD R&D and physics feasibility studies.

In high energy theory, N. Maru has been working with N. Okada and S. Okada on the collider physics and the dark matter physics related to the Higgs sector in the standard model. M. Yamanaka has collaborated with people at Laboratoire Univers et Particules de Montpellier (LUPM) on muon-electron conversion in nuclei. In quantum field theory and string theory, H. Itoyama has continued to collaborate with A. Mironov and A. Morozov, the two renowned Russian scientists at ITEP, Moscow and produced three papers on tensor models and their algebraic properties. S. Moriyama collaborates intermittently with Heng-Yu Chen at National Taiwan University on various aspects of conformal field theories.

In gravitational wave observations, N. Kanda, Y. Itoh, and T. Sawada are the members of the KAGRA collaboration, which consists of more than 400 researchers from more than 110 institutions in 15 countries and regions around the world (as of August 2020). Kanda serves as an executive office member of the KAGRA collaboration, Itoh is a liaison member of several LIGO-Virgo-KAGRA joint committees from the KAGRA collaboration, and Sawada is a coordinator of the LIGO-Virgo-KAGRA observing runs. In cosmic ray observations, S. Ogio and Y. Tsunesada are principal researchers of the Telescope Array experiment, the largest cosmic ray observatory in the northern hemisphere. Ogio is the spokesperson, and Tsunesada serves as the analysis coordinator leading the science team of this Japan-US-Korea-Russian collaboration

In theory of gravitation and astrophysics, K. Nakao has been in contact with P. S. Joshi Charotar University of Science and Technology (CHARUSAT) on strong gravity.

In strongly correlated electron systems, A. Oguri and Y. Nishikawa have collaborated with people at (i) CNRS, Univ. Paris-Sud, Universite Paris Saclay, France, and (ii) Imperial College London. The collaborations involve not only theorists but also experimentalists. In low temperature physics, in particular, turbulence at Bose gases and liquid helium, M. Tsubota conducted the joint research of low temperature physics with the scientists of Yale University, Florida State University, USA, University of Cambridge, UK, National Taiwan Normal University, Taiwan, and University of Konstanz, Germany, publishing five papers. H. Takeuchi collaborated with people at Seoul National University, Antwerp University, National Changhua University of Education, Newcastle University, and University of Otago, publishing four papers.

5 RESEARCH HIGHLIGHTS

5.1 Unitary matrix model, supersymmetric gauge theory, and Painlevé system

Takeshi Oota

In the papers [1,2], three of us, H. Itoyama, T. Oota and K. Yano, have argued that certain unitary one matrix model is closely related to the $\mathcal{N}=2$ supersymmetric $SU(2)$ gauge theory with two matter hypermultiplets. This is an example of the gauge theory/matrix model correspondence.

The partition function of the unitary matrix model takes the form

$$Z = \int [\mathrm{d}U] \exp\left(\mathrm{Tr}\, W(U)\right),$$

where U is an $N \times N$ unitary matrix, $[\mathrm{d}U]$ denotes the integration measure for the unitary group $U(N)$, and $W(U)$ is the potential given by

$$W(z) = -\frac{1}{2g}(z + z^{-1}) + M \log z.$$

Here g and M are coupling constants of the matrix model. The $M = 0$ case is the famous unitary theory, called the Gross-Witten-Wadia model which exhibits the third-order phase transition in the large N limit.

The spectral curve of this matrix model is isomorphic to the Seiberg-Witten curve of the corresponding gauge theory. Furthermore, the partition function Z can be identified with a finite analog of the Fourier transformation of the instanton partition function of the gauge theory.

In addition to the gauge theory/matrix model correspondence, this system is related to the Painlevé equation. The Painlevé equations are certain non-linear second-order ordinary differential equations (ODEs). The partition function Z of the matrix model is the tau function of the underlying Painlevé equation, the Painlevé III$'$. The Painlevé equations are the Hamiltonian systems. For $\mathrm{P}_{\mathrm{III}'}$,

$$\frac{\mathrm{d}q}{\mathrm{d}t} = \frac{\partial H}{\partial p}, \qquad \frac{\mathrm{d}p}{\mathrm{d}t} = -\frac{\partial H}{\partial q},$$

where the Hamiltonian is given by

$$H = \frac{1}{t}\left[q^2p^2 - (q^2 + v_2 q - t)p + \frac{1}{2}(v_1 + v_2)q\right].$$

Here v_1 and v_2 are parameters related to those of the matrix model by $v_1 = M + N$, $v_2 = -M + N$. The time variable t is identified with $1/(4g^2)$. The tau function τ of $\mathrm{P}_{\mathrm{III}'}$ is defined by

$$H = \frac{\mathrm{d}}{\mathrm{d}t} \log \tau.$$

The relation between the tau function of $\mathrm{P}_{\mathrm{III}'}$ and the partition function of the matrix model is given by

$$\tau = t^{(1/2)MN} Z.$$

We remark that the Bäcklund transformations of the $\mathrm{P}_{\mathrm{III}'}$ generate the discrete Painlevé equation, and are isomorphic to the Weyl group of the $(2A_1)^{(1)}$ root system. The discrete Painlevé equation is also closely related to a rational surface of type $D_6^{(1)}$, hence it is denoted by d-P$((2A_1)^{(1)}/D_6^{(1)})$.

We can consider the double scaling limit to the critical point of the unitary matrix model. This limit corresponds to the limit to the infrared superconformal fixed point of the gauge theory, called the Argyres-Douglas point. Also, the discrete Painlevé equation d-P($(2A_1)^{(1)}/D_6^{(1)}$) turns into the (continuous) Painlevé II equation in this limit.

The Argyres-Douglas theory (AD theory) is the superconformal low energy effective theory of the $\mathcal{N}=2$ supersymmetric gauge theory on the Coulomb branch. The AD theory does not have the Lagrangian description because of the existence of mutually non-local massless states. The double scaling limit of the unitary matrix model captures the critical behavior of the 4D $\mathcal{N}=2$ supersymmetric $SU(2)$ gauge theory with $N_f=2$ around its Argyres-Douglas superconformal point of type $H_1=(A_1,A_3)$.

In [3], we have generalized the above gauge theory/matrix model correspondence to more general case. It is the correspondence between certain unitary matrix model and the 4D $\mathcal{N}=2$ gauge theory called the $\hat{A}_{2k,2k}$ theory. The $\hat{A}_{2k,2k}$ theory is the $SU(2)$ gauge theory coupled to two AD theories of type D_{2k}.

We have shown that this unitary matrix model at the k-th multicritical point corresponds to the (A_1,A_{4k-1}) AD point of the $\hat{A}_{2k,2k}$ theory. We also derived a system of two ODEs for the scaling functions to the free energy by taking the double scaling limit in the $k=2$ case.

[1] H. Itoyama, T. Oota and K. Yano, "Discrete Painlevé system and the double scaling limit of the matrix model for irregular conformal block and gauge theory," Phys. Lett. B **789**, 605-609 (2019) [arXiv:1805.05057 [hep-th]].

[2] H. Itoyama, T. Oota and K. Yano, "Discrete Painlevé system for the partition function of $N_f=2$ $SU(2)$ supersymmetric gauge theory and its double scaling limit," J. Phys. A **52**, no.41, 415401 (2019) [arXiv:1812.00811 [hep-th]] (NITEP preprint #1).

[3] H. Itoyama, T. Oota and K. Yano, "Multicritical points of unitary matrix model with logarithmic potential identified with Argyres-Douglas points," Int. J. Mod. Phys. A**35**, 2050146 [12 pages] (2020) [arXiv:1909.10770 [hep-th]] (NITEP preprint #33).

[4] T. Oota, "Matrix model, CFT and SUSY gauge theory," The 3rd Intensive Lecture for KEK Theory Center Project "From Strings to Higgs/Flavors", High Energy Accelerator Research Organization (KEK) , Ibaraki, 19-21 November 2018.

[5] T. Oota, "Matrix model, supersymmetric gauge theory, and discrete Painleve equation," International Symposium in Honor of Professor Nambu for the 10th Anniversary of his Nobel Prize in Physics, Osaka City University, Osaka, Japan, 13 December 2018.

[6] T. Oota, "Matrix model, supersymmetric gauge theory and Painleve equation," The 1st NITEP Lecture Series, Osaka City University (Umeda Satellite), Osaka, 17 and 19 January 2019.

[7] T. Oota, "Matrix models, supersymmetric gauge theories and Painleve equations," The 2nd Workshop on "Mathematics and Physics in General Relativity", Setsunan University, Osaka, 23 March 2019.

[8] T. Oota, "Unitary matrix model, supersymmetric gauge theory, and Painleve system," International Workshop "New Trends in Integrable Systems 2019", Osaka City University, Osaka, Japan, 12 September 2019.

5.2 A journey to search for the origin of ultra-high-energy cosmic rays at the OCU

Jihyun Kim

From October 1, 2018, to August 31, 2020, I have been working on the search for the nature and origin of ultra-high-energy cosmic rays (UHECRs) as a postdoctoral researcher of the cosmic ray physics laboratory at the Osaka City University, which is one of the most active research groups for cosmic rays in Japan.

The UHECRs are extremely energetic particles that originated from outer space that impinge on Earth's atmosphere, such as protons or nuclei, which have energies greater than 10^{18} eV. These particles are very rare so that a gigantic observatory is necessary for capturing these rare events effectively. To this end, the Telescope Array (TA) project, an international consortium of US, Japanese, Korean, Russian and European scientists, has deployed sophisticated detectors over thousands of square kilometers of desert in the USA to determine the energy, composition and source direction of UHECRs. Our cosmic ray physics laboratory has played a leading role in the TA project. My contributions to the collaboration have focused on studying the arrival direction of UHECRs to search for the origin of UHECRs by using simulations and statistical test methods.

In 2014, the TA experiment identified an intermediate scale of anisotropy in the arrival directions of UHECRs Those clustered UHECR events, so-called the hotspot, are expected to give us a clue to their origin. However, it remains unanswered because there is no prominent source candidate behind the hotspot. To understand the sky distribution of TA events, we investigated the structures of galaxies around the hotspot region in the local universe. We found that there are filaments of galaxies, connected to the Virgo cluster, and a correlation of statistical significance between the galaxy filaments and TA events. With 5-year TA data, we found 19 out of 72 events were correlated with filaments at 3.4° , while 4.2 events were expected from the isotropy simulation. By Monte-Carlo simulation, the probability that such correlated events observed by chance is estimated to be around 5.1σ level. Based on this finding, we suggested a model for the origin of TA hotspot events. We assume that UHECRs are produced at a source or sources inside the Virgo cluster. They roam around for a while in the cluster, confined by the magnetic fields. Then, some of them escape through connected filaments and are scattered at turbulent magnetic fields in filaments, shown in Fig. 1. This model constrains magnetic fields' strength in filament to be $\gtrsim$ 20nG, which needs to be confirmed in future observations. This work was presented at the International Conference on UHECRs, Paris, France, in 2018. Also, it was published in Science Advances and covered by Newsweek on January 2, 2019 [1, 2].

To examine our model's feasibility for the origin of the hotspot, we generated the model universes through numerical simulations for the large scale structure formation. A cosmological hydrodynamics code, assuming a Λ CDM cosmological model, were used. We injected a hundred thousand of protons with 6×10^{19} eV at random positions within the cluster core region toward random directions. Then, we traced their propagation trajectories with the relativistic equation of motions. The fraction of the UHE protons confined within clusters during the GZK time and the fraction which escapes from clusters to filaments were studied. The preliminary results of this work show that the ratio of particles that directly escape from the cluster to voids to particles that escape to the filaments a bit different but almost similar, 50 to 50. The results confirm that it is possible for a UHE proton produced from a source in a galaxy cluster to escape through connected filaments, which supports the model we suggested for the origin of TA hotspot. However, it is shown that the details are very sensitive to the configuration and strength of magnetic fields. For the more realistic simulation to reproduce the TA hotspot events with the Virgo cluster and its filaments, we need to know the exact configuration of the magnetic field in those regions. As of now, however, the magnetic fields in the cosmic web are not well known. Therefore, to do that, it needs future projects for the exploration of intergalactic magnetic fields. This work was presented at the spring meeting of the Korean Physical Society, Daejeon, Korea, and the International Cosmic Ray Conference, Madison, USA, in 2019 [3].

Also, we reported the updated analysis result of the correlation between TA UHECRs and the filaments of galaxies connected to the Virgo cluster at the 75th annual meeting of the Physical Society of Japan. In the published paper, we used TA 5-year data, which was an identical dataset used for the hotspot identification, but more data is now available owing to the TA collaboration's continued efforts. Using 11-year data recorded by the TA experiment, we confirmed that there is still a significant correlation between UHECRs and the filaments of galaxies. The probability that such correlation observed by chance is estimated to be around 4.4σ level.

My research activities have been engaged not only in work related to the conference or publication but also in observations and maintenance, which are essential to collect data. In two years while I was in OCU, I went to Utah twice, around two months in total, as a leader of observation shift to run our facilities at nighttime and to train students who first participate in observation. Also, when TA collaboration tested the remote observation in Japan, OCU managed two-month observations, and I took a shift and trained our students. Most of our students had no experience with the observation; therefore, I tried to teach them carefully and encourage them to become independent.

My area of expertise was slightly different from that of our laboratory in some senses; however, my advisor, Ogio-san, has given me lots of freedom to explore my research independently. In addition, he and Tsunesada-san have provided new perspectives in researches, and we were able to have productive discussions, which were very helpful for me to extend the research ability and to develop me to work as an independent researcher. Also, I have had a goal that I would do my best to communicate with our students to help them to study basic concepts from the beginning based on my background. Though we had some language barriers, it didn't matter, and it was a great time for me to interact with our students. The research experience at OCU was an excellent opportunity for me to exchange valuable ideas and have constructive discussions. After leaving OCU, I believe we can continue discussions wherever I am. Thank you, and good luck to you!

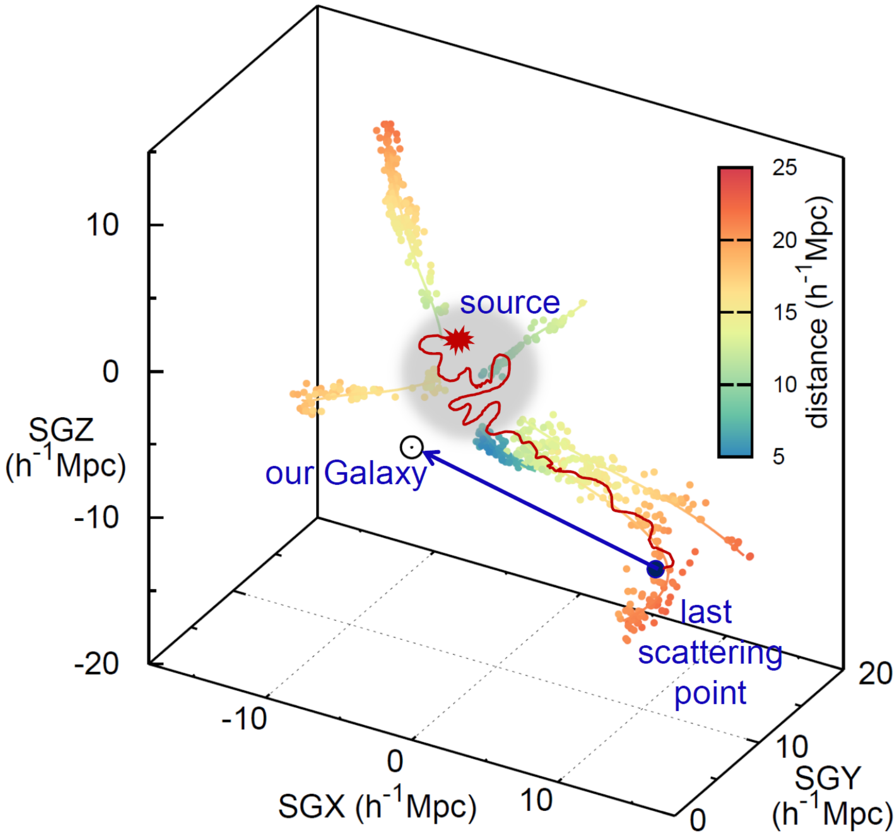


Figure 1: Schematic drawing of a model for the origin of TA hotspot events. The model assumes UHECRs are produced at a source or sources inside the Virgo Cluster, which are represented in the gray sphere at the center of the box. They roam around for a while confined by cluster magnetic fields, then some of them escape to the filaments of galaxies, which are shown with bullets of color, connected to the cluster. The solid lines with color show galaxies' string-like filamentary structure. By the turbulent magnetic fields in the filaments of galaxies, some of UHECRs would be scattered out to the void region and may come to our Galaxy. If this real, the arrival direction of UHECRs would show a correlation with the distribution of filaments of galaxies in the sky; that is, more data would be detected towards the filaments, which can give us a clue to the origin of TA hotspot. Adopted from [1].

[1] J. Kim, D. Ryu, H. Kang, S. Kim, and S. Rey, "Filaments of Galaxies as a Clue to the Origin of Ultra-High-Energy Cosmic Rays," Science Advances 5, eaau8227, Jan., 2019

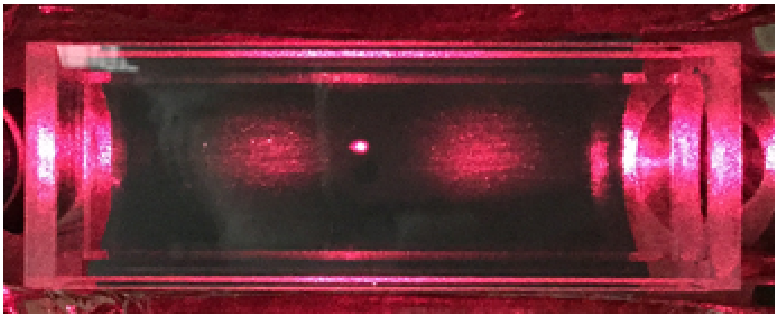
[2] https://www.newsweek.com/ultra-high-energy-cosmic-rays-galaxy-filament-virgo-cluster-space-universe-1277159

[3] J. Kim, D. Ryu, S. Roh, J. Ha, and H. Kang, "Propagation of Ultra-High-Energy Cosmic Rays in the Magnetized Cosmic Web," PoS(ICRC2019)315 (The 36th International Cosmic Ray Conference in Madison, U.S.A)

5.3 Ultracold Fermi atomic gases are shining in NITEP

Munekazu Horikoshi

An experimental apparatus for ultracold Fermi gases using ^{6}Li atoms has been developed in NITEP. We have achieved magneto-optical trapping (MOT) of ^{6}Li atoms as shown in the picture. The gas in the MOT is already so cold in the order of mK. After further cooling of the gas below μ K in a process of evaporative cooling, we can explore quantum worlds where the de Broglie wavelength exceeds the mean interparticle distance. Since ultracold ^{6}Li atoms possess a great feature of "tunable attractive interactions between fermions" through the Feshbach resonances, the atomic system can work as great quantum simulator for interacting fermions. Actually, our previous work showed the equation of state (EOS) of dilute neutron matter in neutron stars by cold atom experiment [1,2].



In NITEP, we have progressed projects about the universal viscosity coefficients in the unitary regime, novel three-body force in a Feshbach molecular gas, quantum simulator for negative sign problems in Fermi systems, optical control of Feshbach resonances, programable superfluid circuit, precision spectroscopy of molecules, and coherent control of polyatomic molecules, and so on. Especially, the spectroscopic study of Feschbach molecules has made great progress last year. This result is a big step towards quantitative measurement of Feshbach molecular gases, coherent control of Feschbach molecules or Efimov trimers, and application to quantum chemistry.

[1] Munekazu Horikoshi, Masato Koashi, Hiroyuki Tajima, Yoji Ohashi, and Makoto Kuwata-Gonokami, "Ground-state thermodynamic quantities of homogeneous spin-1/2 fermions from the BCS region to the unitarity limit", Phys. Rev. X 7, 041004 (2017).

[2] Munekazu Horikoshi and Makoto Kuwata-Gonokami, "Cold atom quantum simulator for dilute neutron matter", International Journal of Modern Physics E Vol. 28, No. 1, 1930001 (2019).

5.4 Exotic Spontaneous Symmetry breaking in nematic-spin superfluids

Hiromitsu Takeuchi

Spontaneous symmetry breaking is a universal concept applied to different physical systems, high energy physics, nuclear physics, cosmology, and condensed matter physics. In this article, I would like to introduce an exotic example of spontaneous symmetry breaking in quantum fluids from condensed matter physics.

Prof. Nambu came up with the idea of spontaneous symmetry breaking that leads to the Nobel prize while working in superconductivity, superfluidity of electron flow. Superconductivity and superfluidity are fundamental to understand the macroscopic behavior of quantum fluids at very low temperatures. In these systems, Fermi-Dirac and Bose-Einstein statistics of quantum statistical mechanics govern the many-body behaviors of Bose and Fermi particles. In bosonic quantum fluids, Bose-Einstein statistics causes Bose-Einstein condensation, in which a large fraction of bosons occupy the lowest quantum state described by a *macroscopic* wave function ψ. In fermionic systems, pairs of two fermions, called the Cooper pairs, behaves like bosons and form Bose-Einstein condensates (BECs). Since the wave function is originated by quantum mechanics, such quantum fluids exhibit quantum mechanical behaviors macroscopically, called the macroscopic quantum effect, such as superfluidity and superconductivity, "frictionless" and "resistantless" flows of neutral and charged particles. The appearance of a macroscopic wave function implies that the phases of wave functions of macroscopic number of particles takes a certain value although the phase of wave function of each particle can be arbitrary without taking account of correlation between particles. This is just a manifestation of spontaneous symmetry breaking associated with the phase $\phi = \arg \psi$, the orientation in the complex plane $(\mathrm{Re}\psi, \mathrm{Im}\psi)$.

When the spin degrees of freedom of condensed particles become important, a variety of macroscopic quantum effects occur due to the spontaneous symmetry breaking associated with the orientation of *macroscopic* spin $\boldsymbol{s}$ in addition to that of ϕ of the macroscopic wave function. Such quantum fluids called spinful superfluids and have been studied extensively after realizations of spin-triplet p-wave superfluid ^{3}He and spinor BECs of ^{87}Rb and ^{23}Na atoms. Spinful superfluids are classified into two types according to the magnetic properties, ferromagnetic and anti-ferromagnetic superfluids. The symmetry breaking in the former superfluids is described by the orientation of the vector field $\boldsymbol{s}$ while that in the latter by a different vector field $\boldsymbol{d}$, which characterizes the anti-ferromagnetic properties. Anti-ferromagnetic superfluids may be called as spin-nematic or nematic-spin superfluids because of their behavior like the uniaxial nematic liquid crystal, in which the orientation of the rod-shaped molecules is parallel to a vector field $\tilde{\boldsymbol{n}}$ called the *director*. The liquid crystal is familiar to us by being applied to liquid-crystal displays. In the liquid crystal, a state of $\tilde{\boldsymbol{n}}$ is macroscopically identical to that of $-\tilde{\boldsymbol{n}}$. This property can be mimicked by combing the degrees of freedom of $\boldsymbol{d}$ with that of the macroscopic phase ϕ.

Recently, the manifestation of the nematic-spin property has been directly detected for the first time by observing an exotic topological defect, called the wall-vortex composite defect (see Fig. 1) [1]. Quantum vortex is known as a fundamental topological defect, whose circulation is quantized by $\kappa = \frac{h}{M}$ with the Planck constant h and the mass M of the carrier particles. The quantization of the circulation comes from the physical requirement that the macroscopic wave function must be a single-valued function; the phase ϕ changes by $2\pi n$ with integer n around a vortex. However, the observed wall-vortex defect is composed by a half quantum vortex, whose circulation is a half of κ. The whole wave function is single-valued when the phase rotates by π and the pseudo-director $\boldsymbol{d}$ turns to the opposite direction as shown in Fig. 1. This sort of exotic topological objects have been also discussed in superfluid ^{3}He related to a cosmological scenario in which similar objects are nucleated via spontaneous symmetry breaking phase transition in the early universe [2], but little is known about them. Further experimental and theoretical investigations of the composite topological defects will

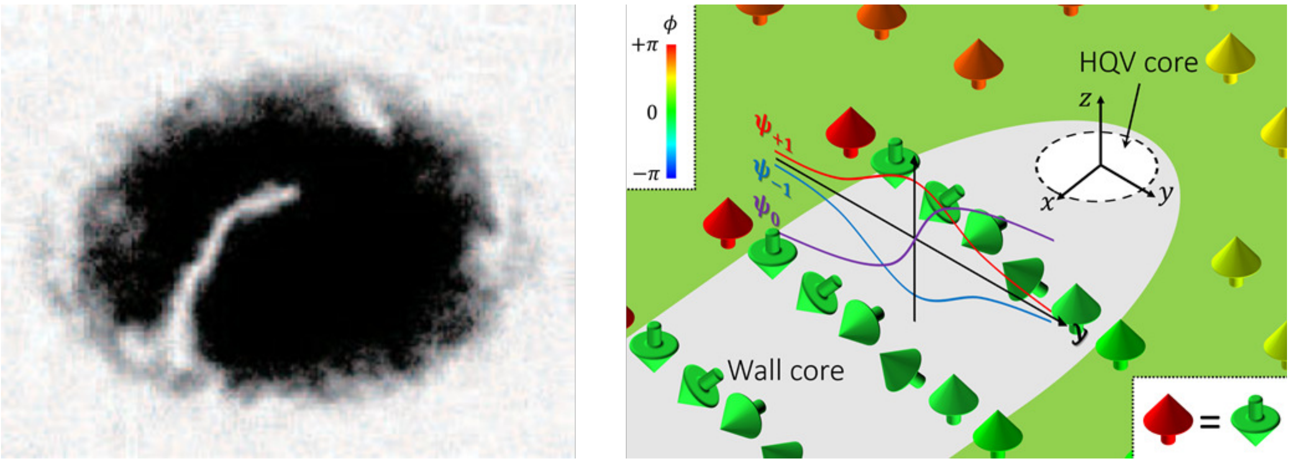


Figure 1: (Left) The wall-vortex composite defect observed in a atomic cloud of spin-1 Bose-Einstein condensates. The dark area shows a region with higher density in a spin component (ψ_0). A linear object corresponds to a domain wall. The wall terminate on a half quantum vortex (HQV). (Right) The schematic of the core structure of a half quantum vortex (HQV) terminated by a domain wall. The macroscopic wave function ψ_0 has a phase different π across the domain wall. The direction and color of the arrows show the direction of the pseudo-director field and the phase of the macroscopic wave function. The left panel is extracted from Fig. 2 in Ref. [1].

shed light on unexplored new phenomena of spontaneous symmetry breaking.

[1] Seji Kang, Sang Won Seo, Hiromitsu Takeuchi, and Y. Shin, Phys. Rev. Lett. **122**, 095301 (2019).

[2] J. T. Mäkinen, V. V. Dmitriev, J. Nissinen, J. Rysti, G. E. Volovik, A. N. Yudin, K. Zhang, and V. B. Eltsov, Nat. Commun. **10**, 237 (2019).

6 CONFERENCES & WORKSHOPS

6.1 Conferences/Symposia/Workshops organized by NITEP

1. International Symposium in Honor of Professor Nambu for the 10th Anniversary of his Nobel Prize in Physics, 12-13 December 2018, Media Center, Osaka City University.

2. Shanghai University (SHU)-Osaka City University (OCU) Symposium on Physics, 27 December 2018, Osaka City University.

3. NITEP One-day Workshop "Recent advances in nuclear cluster physics", 5 March 2019, 5th Lecture Room (F212) of Science Faculties General Experiment, Osaka City University.

4. NITEP workshop "Scattering Observables and Nuclear Structure Connected by Microscopic Theory", 28 March 2019, 3rd Lecture Room (104) of Umeda Satellite, Osaka City University.

5. Workshop "Turbulence of all kinds", 25-26 April 2019, Umeda Satellite, Osaka City University.

6. Flavor Physics Workshop 2019, 19-22 November 2019, Kanpo no Yado Tondabayashi (Tondabayashi, Osaka). (Co-organized by RCNP (Osaka University) and NITEP).

7. "Elementary Particle Phenomenology Workshop 2019", 23-25 November 2019, Media Center, Osaka City University.

8. NITEP one year anniversary conference/workshop series: "Turbulence of all kinds", 7-9 January 2020, Media Center, Osaka City University.

9. The workshop "Black Hole Magnetosphere 2020", 3-5 March 2020, 8th Lecture Room (F216) of Science Faculties General Experiment Building, Osaka City University. (Cancelled due to the Coronavirus (COVID-19)).

10. NITEP one year anniversary conference/workshop series: Randomness, Integrability and Representation Theory in Quantum Field Theory, 26-28 March 2020, Media Center, Osaka City University. (Support: Osaka City University Advanced Mathematical Institute: MEXT Joint Usage/Research Center on Mathematics and Theoretical Physics). (Cancelled due to the Coronavirus (COVID-19)).

6.2 Conferences/Symposia/Workshops supported by NITEP

1. The international workshop "TAUP 2019 in Toyama," 9-13 September, 2019, Toyama.

2. The international workshop "New Trends in Integrable Systems 2019," 9-20 September 2019, Media Center, Osaka City University.

3. One day workshop "GR in AdS," 16 January 2020, Rikkyo University.

7 MEETINGS & SEMINARS

7.1 Lectures

1. 1st NITEP Lecture Series: Takeshi Oota (NITEP), Matrix model, supersymmetric gauge theory and Painlevé equation. 17 January 2019, 16:30-; 19 January 2019, 10:00-12:00, Large Seminar Room of Umeda Satellite, Osaka City University.

2. 2nd NITEP Lecture Series: Yuki Yokokura (RIKEN), A Self-consistent Model of Evaporating Black Holes. 29 March 2019, 16:00-, Large Seminar Room of Umeda Satellite, Osaka City University.

3. 3rd NITEP Lecture Series: Nobuyoshi Ohta (Kindai University), Introduction to asymptotic safety. 16-17 April 2019, 16:00-, Large Seminar Room of Umeda Satellite, Osaka City University.

4. 4th NITEP Lecture Series: Kazuyuki Ogata (RCNP, Osaka U.), Introduction to Nuclear Reaction Theory. 6 and 12 June 2019, 16:00-19:50, Large Seminar Room of Umeda Satellite, Osaka City University.

5. The 19th Chushiro Hayashi Memorial Lecture (supported by NITEP): Takahiro Tanaka (Kyoto University), Cosmic Image Revealed by Gravitational Waves; Fumitaka Sato (Professor Emeritus, Kyoto University), Dr. Hayashi's Youth: Yoichiro Nambu and Chushiro Hayashi. 29 October 2019, 15:15-, the auditorium on the 10th floor of Media Center, Osaka City University.

6. V. P. Nair (The City College of New York), Lectures on the Frontiers of Quantum Field Theory, 24-25 March 2020, Large Seminar Room of Umeda Satellite, Osaka City University. (Support: Osaka City University Advanced Mathematical Institute: MEXT Joint Usage/Research Center on Mathematics and Theoretical Physics). (Cancelled due to the Coronavirus (COVID-19)).

7.2 Seminars

1. NITEP Astrophysics Seminar: Peter Tinyakov (Universite Libre de Bruxelles, Belgium), Solar mass black holes and dark matter; Igor Tkachev (Russian Academy of Sciences), Axion stars: from birth to death. 22 May 2019, 13:30-15:45, Meeting Room of the Faculty of Science.

2. NITEP Seminar: Nguyen Tri Toan Phuc (VNUHCM-University of Science, Ho Chi Minh City, Vietnam Institute for Nuclear Science and Technology, VINATOM, Vietnam), Multistep alpha transfer in elastic ^{16}O+^{12}C scattering. 19 June 2019, 15:15-, B105 room on the ground floor on the Building No. 12 (Faculty of Science) at Sugimoto campus of Osaka City University.

7.3 Joint Monthly Meetings of Nuclear Theory Lab. and Ultracold Quantum Gas Lab.

1. 1st Meeting: Yohei Chiba gave a basic explanation on the importance of clusters in nuclei. (26 June 2019, 14:30-16:30, Room B105).

2. 2nd Meeting: Munekazu Horikoshi discussed the Feschbach resonances and Efimov states in cooled atoms, comparing phase transition phenomena in cooled atoms and nuclei. (17 July 2019, 10:00-12:30, Room B105).

3. 3rd Meeting: Kazuyuki Ogata, The Feschbach resonance of ^{11}Li (and the Fano resonance of ^{22}C). (23 August 2019, 13:00-15:00, Room B105).

4. 4th Meeting: Munekazu Horikoshi, Photoexcitation of Feschbach molecules. (6 November 2019, 13:00-15:00, Room B105).

5. 5th Meeting: Koichi Sato, Spontaneous Symmetry Breaking in Nuclei -Superfluidity and Deformation-. (11 December 2019, 13:00-15:00, Room B105).

6. 6th Meeting: Shin Inouye, Scattering of cooled atoms. (29 January 2020, 13:00-15:00, Room F202).

7.4 NITEP Joint Seminar of Mathematical Physics and Particle Physics

1. Masato Yamanaka (NITEP), Search for charged lepton flavor violation using nucleus, 14 May 2019, 16:30-, 2nd Lecture Room (F203).

2. Naoki Sakakura (YITP, Kyoto U.), Space-time concept of the canonical tensor model depicted by mathematical methods of data analysis, 21 May 2019, 16:30-, 2nd Lecture Room (F203).

3. Katsuya Hashino (Osaka University), Verification of the extended Higgs model by gravitational wave observation and accelerator experiments, 4 June 2019, 16:30-, 4th Lecture Room (F205).

4. Yuki Sato (Nagoya University), How to "cool down" Ising model on 2d dynamical triangulations, 18 June 2019, 16:30-, 4th Lecture Room (F205).

5. Ryo Nagai (University of Tokyo), (Extended) Higgs Field Effective Theory and its Applications, 25 June 2019, 16:30-, 4th Lecture Room (F205).

6. Gi-Chol Cho (Ochanomizu University), Lepton-flavor violation via four-Fermi contact interactions at e^+e^- linear collider, 16 July 2019, 16:30-, 4th Lecture Room (F205).

7. Satoshi Tsuchida (Osaka City University), Dark Matter Signals on a Laser Interferometer, 1 October 2019, 16:30-, 4th Lecture Room (F205).

8. Reona Arai (Tokyo Institute of Technology), Finite N corrections to the superconformal index from D3-brane analysis in AdS_5/CFT_4, 15 October 2019, 16:30-, 4th Lecture Room (F205).

9. Yutaka Ookochi (Kyushu University), Catalytic Creation of Baby Bubble Universe with Small Positive Cosmological Constant, 12 November 2019, 16:30-, 4th Lecture Room (F205).

10. Yasuyuki Hikida (YITP, Kyoto U.), Matrix-valued higher spin holography, 26 November 2019, 16:30-, 4th Lecture Room (F205).

7.5 NITEP Colloquium

1. 1st NITEP Colloquium: Daisuke Yonetoku (Kanazawa University), Gamma-Ray Bursts and Gravitational Wave Astronomy. 19 December 2018, 16:30-17:30, E108 Meeting Room of the Faculty of Science.

2. 2nd NITEP Colloquium: Masao Kuriki (Hiroshima University), Design Concept of the Linear Collider Accelerator. 9 January 2019, 16:30-17:30, E108 Meeting Room of the Faculty of Science.

3. 3rd NITEP Colloquium: Three lectures were given by new faculty members. Koichi Sato, Large-amplitude collective motion of atomic nuclei and its microscopic descrition; Kim Jihyun, Ultra-high-energy cosmic rays and a clue to their origin; Munekazu Horikoshi, Ultracold atoms and molecules converting into various quantum systems. 27 June 2019, 13:00-17:00, the Room for Cultural Exchange of the Media Center.

4. 4th NITEP Colloquium: Tomohiro Harada (Rikkyo University), Primordial black hole formation in the matter-dominated phase of the Universe: recent results. 2 September 2019, 15:30-, E108 Meeting Room of the Faculty of Science.

5. 5th NITEP Colloquium: Takuya Hirano (Gakushuin University), Dissipation-Assisted Coherent Formation in a Spinor BEC; Kosuke Shibata (Gakushuin University), Development of a high-sensitive BEC magnetometer. 7 October 2019, 15:30-17:00, 9th Lecture Room (E101).

6. 6th NITEP Colloquium: Yasuhiro Asano (Hokkaido University), Andreev bound states without dispersion and odd-frequency Cooper pairs. 16 October 2019, 16:00-, E108 Meeting Room of the Faculty of Science.

7. 7th NITEP Colloquium: Hidetoshi Kubo (Kyoto University), High-Energy Universe as Seen with Gamma Rays. 19 December 2019, 15:15-16:55, E108 Meeting Room of the Faculty of Science.

8. 8th NITEP Colloquium: Akihiro Yoshimi (Okayama University), Study of very low energy excitation levels in laser-excitable ^{229}Th nuclei and their applications. 15 January 2020, 15:30-18:00, 4th Lecture Room (F205).

7.6 Public Symposium

1. Special Seminar for Citizens 2018 "The Key to Unlocking the Mysteries of the Universe: What Prof. Nambu Found" was held on December 16, with three lectures by NITEP members Hiroshi Itoyama, Yoshihiro Seiya, and Makoto Tsubota. 16 December 2018, 13:00-17:00, the large lecture theater of Tanaka Memorial Hall, Osaka City University.

2. The public symposium "Photographed! Captured! The Black Hole" (co-organized by NITEP and Osaka Branch of The Physical Society of Japan). 21 December 2019, 12:55-16:45, the auditorium on the 10th floor of Media Center, Osaka City University.

8 PUBLICATIONS

8.1 Books

1. Yoshiki Tsunesada (Chap. 3), “Observations of the Universe III [2nd Edition] – High Energy Astronomy,” (Series: Modern Astronomy, 17), Hajime Inoue et al. (eds.), Nippon Hyoron Sha Co., Ltd (2019), ISBN 978-4-535-60767-5.

2. Nobuyuki Kanda (Sec. 5.5.3) and Shoichi Ogio (Sec. 4.8.6, Sec. 5.4.4 and Sec. 5.4.5), “Handbook of Astrophysics,” Fumio Takahara et al. (eds.), Asakura Publishing Co., Ltd (2020), ISBN978-4-254-13127-7.

8.2 Research Papers

1. Hiroshi Itoyama, Takeshi Oota, Katsuya Yano, “Discrete Painleve system for the partition function of $N_f = 2$ $SU(2)$ supersymmetric gauge theory and its double scaling limit,” J. Phys. A: Math. Theor. **52**, 415401 [49 pages] (2019), `http://dx.doi.org/10.1088/1751-8121/ab3f4f`.

2. Hideki Ishihara, Tatsuya Ogawa, “Perfect Charge Screening of Extended Sources in an Abelian-Higgs Model,” arXiv:1811.10848 [hep-th].

3. Hideki Ishihara, Tatsuya Ogawa, “Charge-screened nontopological solitons in a spontaneously broken $U(1)$ gauge theory,” Prog. Theor. Exp. Phys. **2019**, Issue 2, 021B01 [8 pages] (2019),

   `http://dx.doi.org/10.1093/ptep/ptz005`.

4. Chul-Moon Yoo, Ken-ichi Nakao, “Constant-mean-curvature slicing of the Swiss-cheese universe,” Gen. Relativ. Gravit. **51**, no.9, 114 [14 pages] (2019),

   `http://dx.doi.org/10.1007/s10714-019-2596-0`.

5. Tomohiro Furukawa, Sanefumi Moriyama, “ABJM matrix model and 2D Toda lattice hierarchy,” JHEP **1903**, 197 [31 pages] (2019), `http://dx.doi.org/10.1007/JHEP03(2019)197`.

6. Junsik Han and Makoto Tsubota, “Phase separation of quantized vortices in two-component miscible Bose-Einstein condensates in a two-dimensional box potential,” Phys. Rev. A **99**, 033607 [8 pages] (2019), `http://dx.doi.org/10.1103/PhysRevA.99.033607`.

7. Hideki Ishihara, Tatsuya Ogawa, “Homogeneous balls in a spontaneously broken $U(1)$ gauge theory,” Phys. Rev. D **99**, 056019 [9 pages] (2019),

   `https://doi.org/10.1103/PhysRevD.99.056019`.

8. Mengjiao Lyu, Kazuki Yoshida, Yoshiko Kanada-En’yo, Kazuyuki Ogata, “Direct probing of the cluster structure in 12Be via α-knockout reaction,” Phys. Rev. C **99**, 064610 [9 pages] (2019),

   `http://dx.doi.org/10.1103/PhysRevC.99.064610`.

9. Hiroshi Itoyama, Reiji Yoshioka, “Generalized cut operation associated with higher order variation in tensor models,” Nuclear Physics B **945**, 114681 [13 pages] (2019),

   `http://dx.doi.org/10.1016/j.nuclphysb.2019.114681`.

10. Nobuhito Maru, Yoshiki Yatagai, “Fermion mass hierarchy in grand gauge-Higgs unification,” Prog. Theor. Exp. Phys. **2019**, Issue 8, 083B03 [24 pages] (2019),

    `http://dx.doi.org/10.1093/ptep/ptz083`.

11. Yoshiko Kanada-En'yo, Kazuyuki Ogata, "α scattering cross sections on ^{12}C with a microscopic coupled-channels calculation," Phys. Rev. C **99**, 064601 [13 pages] (2019),

http://dx.doi.org/10.1103/PhysRevC.99.064601.

12. Katsuichi Kanemoto, Shuto Hatanaka, Takayuki Suzuki, "Correlation between bias-dependent ESR signals and magnetic field effects in organic light emitting diodes," Journal of Applied Physics, vol. **125**, 125501 [7 pages] (2019), https://doi.org/10.1063/1.5084216.

13. Nir Navon, Christoph Eigen, Jinyi Zhang, Raphael Lopes, Alexander L. Gaunt, Kazuya Fujimoto, Makoto Tsubota, Robert P. Smith, Zoran Hadzibabic, "Synthetic dissipation and cascade fluxes in a turbulent quantum gas," Science **366**, Issue 6463, 382-385 (2019),

http://dx.doi.org/10.1126/science.aau6103.

14. Sosuke Inui, Makoto Tsubota, Peter Moroshkin, Paul Leiderer, Kimitoshi Kono, "Dynamics of Fine Particles Due to Quantized Vortices on the Surface of Superfluid ^{4}He," J. Low Temp. Phys. **196**, Issue 1-2, 190-196 (2019), http://dx.doi.org/10.1007/s10909-018-02116-z.

15. P. Moroshkin, P. Leiderer, K. Kono, S. Inui, M. Tsubota, "Dynamics of the Vortex-Particle Complexes Bound to the Free Surface of Superfluid Helium," Phys. Rev. Lett. **122**, 174502 [5 pages] (2019), http://dx.doi.org/10.1103/PhysRevLett.122.174502.

16. Takahisa Igata, Hideki Ishihara, Yu Yasunishi, "Observability of spherical photon orbits in near-extremal Kerr black holes," Phys. Rev. D **100**, 044058 [6 pages] (2019),

http://dx.doi.org/10.1103/PhysRevD.100.044058.

17. Yoshiko Kanada-En'yo, Kazuyuki Ogata, "First microscopic coupled-channels calculation of cross sections for inelastic α scattering off ^{16}O," Phys. Rev. C **99**, 064608 [10 pages] (2019),

http://dx.doi.org/10.1103/PhysRevC.99.064608.

18. Takuya Hirose, Nobuhito Maru, "Cancellation of one-loop corrections to scalar masses in Yang-Mills theory with flux compactification," JHEP **1908**, 54 [19 pages] (2019),

http://dx.doi.org/10.1007/JHEP08(2019)054.

19. Koichi Sato, Takenori Furumoto, Yuma Kikuchi, Kazuyuki Ogata, Yukinori Sakuragi, "Large-amplitude quadrupole shape mixing probed by the (p, p') reaction : A model analysis," Prog. Theor. Exp. Phys. **2019**, 101D01 [10 pages] (2019), https://doi.org/10.1093/ptep/ptz095.

20. Yoshitaka Kuno, Joe Sato, Toru Sato, Yuichi Uesaka, Masato Yamanaka, "Momentum distribution of the electron pair from the charged lepton flavor violating process $\mu^- e^- \to e^- e^-$ in muonic atoms with a polarized muon," Phys. Rev. D **100**, 075012 [11 pages] (2019),

http://dx.doi.org/10.1103/PhysRevD.100.075012.

21. H. Itoyama, Sota Nakajima, "Exponentially suppressed cosmological constant with enhanced gauge symmetry in heterotic interpolating models," Prog. Theor. Exp. Phys. **2019**, Issue 12, 123B01 [21 pages] (2019), http://dx.doi.org/10.1093/ptep/ptz123.

22. Kazuki Yoshida, Yohei Chiba, Masaaki Kimura, Yasutaka Taniguchi, Yoshiko Kanada-En'yo, Kazuyuki Ogata, "Quantitative description of the ^{20}Ne$(p, p\alpha)^{16}$O reaction as a means of probing the surface α amplitude," Phys. Rev. C **100**, 044601 [6 pages] (2019),

http://dx.doi.org/10.1103/PhysRevC.100.044601.

23. Naotaka Kubo, Sanefumi Moriyama, "Hanany-Witten transition in quantum curves," JHEP **1912**, 101 [49 pages] (2019), `http://dx.doi.org/10.1007/JHEP12(2019)101`.

24. Nguyen Tri Toan Phuc, Kazuki Yoshida, Kazuyuki Ogata, "Toward a reliable description of (p, pN) reactions in the distorted-wave impulse approximation," Phys. Rev. C **100**, 064604 [8 pages] (2019), `http://dx.doi.org/10.1103/PhysRevC.100.064604`.

25. Yoshiko Kanada-En'yo, Kazuyuki Ogata, "Microscopic calculation of inelastic proton scattering off ^{18}O, ^{10}Be, ^{12}Be, and ^{16}C to study neutron excitation in neutron-rich nuclei," Phys. Rev. C **100**, 064616 [13 pages] (2019), `http://dx.doi.org/10.1103/PhysRevC.100.064616`.

26. Tomohiro Furukawa, Sanefumi Moriyama, Yuji Sugimoto, "Quantum mirror map for del Pezzo geometries," J. Phys. A: Math. Theor. **53**, 385401 (2020), `https://doi.org/10.1088/1751-8121/ab93fe`.

27. Hirotaka Yoshino, Kazuma Takahashi, Ken-ichi Nakao, "How does a collapsing star look?," Phys. Rev. D **100**, 084062 [27 pages] (2019), `http://dx.doi.org/10.1103/PhysRevD.100.084062`.

28. Satoshi Tsuchida, Nobuyuki Kanda, Yousuke Itoh, Masaki Mori, "Dark matter signals on a laser interferometer," Phys. Rev. D **101**, 023005 [8 pages] (2020), `http://dx.doi.org/10.1103/PhysRevD.101.023005`.

29. H. Itoyama, A. Mironov, A. Morozov, "Tensorial generalization of characters," JHEP **2019**, 127 [33 pages] (2019), `http://dx.doi.org/10.1007/JHEP12(2019)127`.

30. Yuen Sim Neoh, Mengjiao Lyu, Yoshiki Chazono, Kazuyuki Ogata, "Effect of the repulsive core in the proton-neutron potential on deuteron elastic breakup cross sections," Phys. Rev. C **101**, 054606 [6 pages] (2020), `https://doi.org/10.1103/PhysRevC.101.054606`.

31. Toshiaki Kanai, Wei Guo, Makoto Tsubota, Dafei Jin, "Torque and Angular-Momentum Transfer in Merging Rotating Bose-Einstein Condensates," Phys. Rev. Lett. **124**, 105302 [7 pages] (2020), `http://dx.doi.org/10.1103/PhysRevLett.124.105302`.

32. Yoshiko Kanada-En'yo, Kazuyuki Ogata, "Cluster structures and monopole transitions of ^{14}C," Phys. Rev. C **101**, 014317 [9 pages] (2020), `http://dx.doi.org/10.1103/PhysRevC.101.014317`.

33. H. Itoyama, T. Oota, Katsuya Yano, "Multicritical points of unitary matrix model with logarithmic potential identified with Argyres-Douglas points," Int. J. Mod. Phys. A **35**, 2050146 [12 pages] (2020), `https://doi.org/10.1142/S0217751X20501468`.

34. H. Itoyama, A. Mironov, A. Morozov, "Complete solution to Gaussian tensor model and its integrable properties," Phys. Lett. B **802**, 135237 [8 pages] (2020), `http://dx.doi.org/10.1016/j.physletb.2020.135237`.

35. Yohei Chiba, Yoshiko Kanada-En'yo, Yuki Shikata, "Cluster correlation and nuclear vorticity in low-lying 1- states of ^{24}Mg," arXiv:1911.08734 [nucl-th].

36. The T2K Collaboration (including Y. Seiya and K. Yamamoto), "Constraint on the matter-antimatter symmetry-violating phase in neutrino oscillations," Nature **580**, 339–344 (2020), `https://doi.org/10.1038/s41586-020-2177-0`.

37. N. Amburg, H. Itoyama, A. Mironov, A. Morozov, D. Vasiliev, R. Yoshioka, "Correspondence between Feynman diagrams and operators in quantum field theory that emerges from tensor model," Eur. Phys. J. C **80**, 471 [5 pages] (2020),

https://doi.org/10.1140/epjc/s10052-020-8013-8.

38. K. Abe et al. (T2K Collaboration), including Y. Seiya and K. Yamamoto, "Measurement of neutrino and antineutrino neutral-current quasielasticlike interactions on oxygen by detecting nuclear deexcitation γ rays," Phys. Rev. D **100**, 112009 [19 pages] (2019),

http://dx.doi.org/10.1103/PhysRevD.100.112009.

39. Nobuhito Maru, Yoshiki Yatagai, "Improving fermion mass hierarchy in grand gauge-Higgs unification with localized gauge kinetic terms," Eur. Phys. J. C **80**, 933 [15 pages] (2020), https://doi.org/10.1140/epjc/s10052-020-08485-8.

40. Yuki Adachi, Nobuhito Maru, "Strong first order electroweak phase transition in gauge-Higgs unification at finite temperature," Phys. Rev. D **101**, 036013 [6 pages] (2020),

http://dx.doi.org/10.1103/PhysRevD.101.036013.

41. Satoshi Yui, Hiromichi Kobayashi, Makoto Tsubota, Wei Guo, "Fully Coupled Two-Fluid Dynamics in Superfluid ^{4}He: Anomalous Anisotropic Velocity Fluctuations in Counterflow," Phys. Rev. Lett. **124**, 155301 [6 pages] (2020), https://doi.org/10.1103/PhysRevLett.124.155301.

42. Kousuke Iwamoto, Yuto Hayakawa, Shuto Hatanaka, Takayuki Suzuki, Katsuichi Kanemoto, "Electron–Hole Pairs Generated in the Crystalline Phase of Polymer Diodes Studied by Electrically Detected Magnetic Resonance Techniques," Journal of Physical Chemistry C **123**, 26116-26123 (2019), https://doi.org/10.1021/acs.jpcc.9b07796.

43. N. Teshima, "Status of the DeeMe Experiment, an Experimental Search for $\mu-e$ Conversion at J-PARC MLF," PoS(NuFact2019)082 [5 pages] (2020), https://doi.org/10.22323/1.369.0082.

44. Yoshimichi Teratani, Rui Sakano, Akira Oguri, "Fermi Liquid Theory for Nonlinear Transport through a Multilevel Anderson Impurity," Phys. Rev. Lett. **125**, 216801 [6 pages] (2020),

https://doi.org/10.1103/PhysRevLett.125.216801.

45. Kazuyuki Ogata, Carlos A. Bertulani, "Nuclear medium effect on neutron capture reactions during neutron star mergers," J. Phys. G: Nucl. Part. Phys. **47**, 095101,

https://doi.org/10.1088/1361-6471/ab9d06.

46. Kazuyuki Ogata, Yohei Chiba, Yukinori Sakuragi, "Correspondence between α inelastic cross sections off ^{24}Mg and isoscalar monopole strengths," arXiv:2001.09627 [nucl-th].

47. R. U. Abbasi, et al. (Telescope Array Collaboration), including S. Ogio and Y. Tsunesada, "Constraints on the diffuse photon flux with energies above 10^{18} eV using the surface detector of the Telescope Array experiment," Astropart. Phys. **110**, 8-14 (2019),

https://doi.org/10.1016/j.astropartphys.2019.03.003.

48. Jihyun Kim, Dongsu Ryu, Hyesung Kang, Suk Kim, Soo-Chang Rey, "Filaments of galaxies as a clue to the origin of ultrahigh-energy cosmic rays," Science Advances **5**, eaau8227 [7 pages] (2019), http://dx.doi.org/10.1126/sciadv.aau8227.

49. O. Adriani et al. (CALET Collaboration), including Y. Tsunesada, "Direct Measurement of the Cosmic-Ray Proton Spectrum from 50 GeV to 10 TeV with the Calorimetric Electron Telescope on the International Space Station," Phys. Rev. Lett. **122**, 181102 [8 pages] (2019), `http://dx.doi.org/10.1103/PhysRevLett.122.181102`.

50. Shoichi Ogio for the Telescope Array collaboration, "Telescope Array Experiment," EPJ Web of Conferences **208**, 08002 [6 pages] (2019), `https://doi.org/10.1051/epjconf/201920808002`.

51. S. Ogio On behalf of the Telescope Array collaboration, "Highlights from the Telescope Array experiment," PoS(ICRC2019)013 [2 pages] (2019), `https://pos.sissa.it/358/013/`.

52. D. Bergman, J.F. Krizmanic, K. Nakai, Y. Omura, Y. Tsunesada, for the Telescope Array Collaboration, "First Results from NICHE and the NICHE-TALE Hybrid Detector," PoS(ICRC2019)189 [7 pages] (2019), `https://pos.sissa.it/358/189/`.

53. K. Kawata et al. for the Telescope Array Collaboration (including S. Ogio), "Updated Results on the UHECR Hotspot Observed by the Telescope Array Experiment," PoS(ICRC2019)310 [5 pages] (2019), `https://pos.sissa.it/358/310/`.

54. Jihyun Kim, Dongsu Soonyoung Roh, Jihoon Ha, Hyesung Kang, "Propagation of ultra-high-energy cosmic rays in the magnetized cosmic web," PoS(ICRC2019)315 [8 pages] (2019), `https://pos.sissa.it/358/315/`.

55. R. Mayta Palacios, Y. Tsunesada, S. Ogio, for the Telescope Array Collaboration, "Time structure analysis of extensive air showers using the Telescope Array Data," PoS(ICRC2019)347 [8 pages] (2019), `https://pos.sissa.it/358/347/`.

56. T. Nonaka, R. Cady, R. Fujiwara, E. Kido, J. Matthews, S. Ogio, T. Okuda, H. Sagawaa, N. Sakaki, S. Thomas, K. Yada, "Long distance network link for TAx4 expansion," PoS(ICRC2019)372 [8 pages] (2019), `https://pos.sissa.it/358/372/`.

57. S. Ogio, for the Telescope Array collaboration, "Telescope Array Low energy Extension(TALE) Hybrid," PoS(ICRC2019)375 [8 pages] (2019), `https://pos.sissa.it/358/375/`.

58. Y. Omura, K. Nakai, Y. Tsunesada, D. R Bergman, J. F Krizmanic, "NICHE detector and operations," PoS(ICRC2019)379 [7 pages] (2019), `https://pos.sissa.it/358/379/`.

59. T. Sako, et al. (including S. Ogio and Y. Tsunesada), "ALPACA air shower array to explore 100TeV gamma-ray sky in Bolivia," PoS(ICRC2019)779 [8 pages] (2019), `https://pos.sissa.it/358/779/`.

60. H. Kojima, et al. (including S. Ogio), "Correlation between Cosmic Ray Intensity Variations Observed by the Large Acceptance GRAPES-3 Muon Telescope and Interplanetary Magnetic Field," PoS(ICRC2019)1151 [7 pages] (2019), `https://pos.sissa.it/358/1151/`.

61. Yoshiko Kanada-En'yo, Kazuyuki Ogata, "Transition properties of low-lying states in ^{28}Si probed via inelastic proton and alpha scattering," Phys. Rev. C **101**, 064607 [13 pages] (2020), `https://doi.org/10.1103/PhysRevC.101.064607`.

62. Tomo Nakagawa, Sosuke Inui, Makoto Tsubota, Hideo Yano, "Statistical laws and self-similarity of vortex rings emitted from a localized vortex tangle in superfluid ^{4}He," Phys. Rev. B **101**, 184515 [8 pages] (2020), `https://doi.org/10.1103/PhysRevB.101.184515`.

63. H. Itoyama, Sota Nakajima, “Stability, enhanced gauge symmetry and suppressed cosmological constant in 9D heterotic interpolating models,” Nucl. Phys. B **958**, 115111 [24 pages] (2020), `https://doi.org/10.1016/j.nuclphysb.2020.115111`.

64. Kazumasa Okabayashi, Nobuyuki Asaka, Ken-ichi Nakao, “Do black hole shadows merge?,” Phys. Rev. D **102**, 044011 [11 pages] (2020),
`https://doi.org/10.1103/PhysRevD.102.044011`.

65. Yoshiko Kanada-En'yo, Kazuyuki Ogata, “Properties of $K^\pi = 0^+_1$, $K^\pi = 2^-$, and $K^\pi = 0^-_1$ bands of ^{20}Ne probed via proton and alpha inelastic scattering,” Phys. Rev. C **101**, 064308 [12 pages] (2020), `https://doi.org/10.1103/PhysRevC.101.064308`.

66. Yoshimichi Teratani, Rui Sakano, Tokuro Hata, Tomonori Arakawa, Meydi Ferrier, Kensuke Kobayashi, Akira Oguri, “Field-induced $SU(4)$ to $SU(2)$ Kondo crossover in a half-filling nanotube dot: Spectral and finite-temperature properties,” Phys. Rev. B **102**, 165106 [23 pages] (2020), `https://doi.org/10.1103/PhysRevB.102.165106`.

67. C. Matsuoka, K. Nishihara and T. Sano, “Nonlinear interfacial motion in magnetohydrodynamic flows,” High Energy Density Phys. **31**, 19-23 (2019),
`https://doi.org/10.1016/j.hedp.2019.02.002`.

68. C. Matsuoka, “Nonlinear interaction between bulk vortices and the interface in the incompressible Richtmyer-Meshkov instability, ” High Energy Density Phys. **36**, 100834 [5 pages] (2020), `https://doi.org/10.1016/j.hedp.2020.100834`.

69. C. Matsuoka and K. Nishihara, “Nonlinear interaction between bulk point vortices and an unstable interface with nonuniform velocity shear such as Richtmyer-Meshkov instability,” Phys. Plasmas **27**, 052305 [11 pages] (2020), `https://doi.org/10.1063/1.5131701`.

70. Satoshi Tsuchida, Nobuyuki Kanda, Yousuke Itoh, Masaki Mori, “Dark matter signals on a laser interferometer,” Phys. Rev. D **101**, 023005 [8 pages] (2020),
`https://doi.org/10.1103/PhysRevD.101.023005`.

71. KAGRA collaboration, “First cryogenic test operation of underground km-scale gravitational-wave observatory KAGRA,” Class. Quant. Grav. **36**, Issue 16, 165008 (2019),
`https://doi.org/10.1088/1361-6382/ab28a9`.

72. KAGRA Collaboration (Y. Akiyama et al.), “Vibration isolation system with a compact damping system for power recycling mirrors of KAGRA,” Class. Quant. Grav. **36**, Number 9, 095015 (2019), `https://doi.org/10.1088/1361-6382/ab0fcb`.

73. KAGRA collaboration, “KAGRA: 2.5 generation interferometric gravitational wave detector,” Nature Astronomy **3**, 35-40 (2019), `https://doi.org/10.1038/s41550-018-0658-y`.

74. T. Akutsu et al. (KAGRA Collaboration), “An arm length stabilization system for KAGRA and future gravitational-wave detectors,” Class. Quant. Grav. **37**, 035004 (2020),
`https://doi.org/10.1088/1361-6382/ab5c95`.

75. T. Akutsu et al. (KAGRA Collaboration), “Application of independent component analysis to the iKAGRA data,” Prog. Theor. Exp. Phys. **2020**, Issue 5, 053F01 [19 pages] (2020),
`https://doi.org/10.1093/ptep/ptaa056`.

76. T. Akutsu et al. (KAGRA Collaboration), "Overview of KAGRA: Detector design and construction history," Prog. Theor. Exp. Phys. **2020**, ptaa125 [24 pages] (2020), `https://doi.org/10.1093/ptep/ptaa125`.

77. T. Akutsu et al.(KAGRA Collaboration), "Overview of KAGRA: KAGRA science," Prog. Theor. Exp. Phys. **2020**, ptaa120 [68 pages] (2020), `https://doi.org/10.1093/ptep/ptaa120`.

78. B. P. Abbott et al. (KAGRA Collaboration, LIGO Scientific Collaboration and Virgo Collaboration), "Prospects for observing and localizing gravitational-wave transients with Advanced LIGO, Advanced Virgo and KAGRA," Living Rev. Relativ. **23**, Article number: 3 [69 pages] (2020), `https://doi.org/10.1007/s41114-020-00026-9`.

79. T. Akutsu et al.(KAGRA Collaboration), "The status of KAGRA underground cryogenic gravitational wave telescope," Journal of Physics: Conference Series **1342**, 012014 [7 pages] (2020), `https://doi.org/10.1088/1742-6596/1342/1/012014`.

80. Akira Watanabe, Takahiro Sawada, Mei Huang, "Extraction of gluon distributions from structure functions at small x in holographic QCD," Phys. Lett. B **805**, 135470 [6 pages] (2020), `https://doi.org/10.1016/j.physletb.2020.135470`.

81. Wen-Chen Chang, Jen-Chieh Peng, Stephane Platchkov, Takahiro Sawada, "Constraining gluon density of pions at large x by pion-induced J/ψ production," Phys. Rev. D **102**, 054024 [19 pages] (2020), `https://doi.org/10.1103/PhysRevD.102.054024`.

82. J. Dove et al. (SeaQuest Collaboration), "The Asymmetry of Antimatter in the Proton," Nature, accepted for publication.

83. Satoshi Tsuchida, Hiroshi Kuratsuji, "Random motion theory of an optical vortex in nonlinear birefringent media," Phys. Rev. E **102**, 032204 [7 pages] (2020), `https://doi.org/10.1103/PhysRevE.102.032204`.

84. M. Gelb *et al.* (Belle collaboration including M. Iwasaki), "Search for the rare decay of $B^+ \to \ell^+\nu_\ell\gamma$ with improved hadronic tagging," Phys. Rev. D **98**, no. 11, 112016 [13 pages] (2018), `https://doi.org/10.1103/PhysRevD.98.112016`.

85. S. Jia *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Observation of $e^+e^- \to \gamma\chi_{c1}$ and search for $e^+e^- \to \gamma\chi_{c0}, \gamma\chi_{c2}$, and $\gamma\eta_c$ at $\sqrt{s}$ near 10.6 GeV at Belle," Phys. Rev. D **98**, no. 9, 092015 [8 pages] (2018), `https://doi.org/10.1103/PhysRevD.98.092015`.

86. B. Pal *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Measurement of the branching fraction and time-dependent CP asymmetry for $B^0 \to J/\psi\pi^0$ decays," Phys. Rev. D **98**, no. 11, 112008 [8 pages] (2018), `https://doi.org/10.1103/PhysRevD.98.112008`.

87. B. G. Fulsom *et al.* (Belle collaboration including M. Iwasaki), "Observation of $\Upsilon(2S) \to \gamma\eta_b(1S)$ Decay," Phys. Rev. Lett. **121**, no. 23, 232001 [8 pages] (2018), `https://doi.org/10.1103/PhysRevLett.121.232001`.

88. Y. B. Li *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Evidence of a structure in $\bar{K}^0\Lambda_c^+$ consistent with a charged $\Xi_c(2930)^+$, and updated measurement of $\bar{B}^0 \to \bar{K}^0\Lambda_c^+\bar{\Lambda}_c^-$ at Belle," Eur. Phys. J. C **78**, issue 11, Article number: 928 [8 pages] (2018) `https://doi.org/10.1140/epjc/s10052-018-6425-5`.

89. J. H. Yin *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Observation of $e^+e^- \to \pi^+\pi^-\pi^0\chi_{b1,2}(1P)$ and search for $e^+e^- \to \phi\chi_{b1,2}(1P)$ at $\sqrt{s} = 10.96$—11.05 GeV," Phys. Rev. D **98**, no. 9, 091102(R) [9 pages] (2018),
`https://doi.org/10.1103/PhysRevD.98.091102`.

90. I. Adachi *et al.* (BaBar and Belle collaboration in cluding M. Iwasaki and E. Nakano), "Measurement of $\cos 2\beta$ in $B^0 \to D^{(*)}h^0$ with $D \to K^0_S\pi^+\pi^-$ decays by a combined time-dependent Dalitz plot analysis of BaBar and Belle data," Phys. Rev. D **98**, no. 11, 112012 [29 pages] (2018) `https://doi.org/10.1103/PhysRevD.98.112012`.

91. I. Adachi *et al.* (BaBar and Belle collaboration in cluding M. Iwasaki and E. Nakano), "First Evidence for $\cos 2\beta > 0$ and Resolution of the Cabibbo-Kobayashi-Maskawa Quark-Mixing Unitarity Triangle Ambiguity," Phys. Rev. Lett. **121**, no. 26, 261801 [11 pages] (2018)
`https://doi.org/10.1103/PhysRevLett.121.261801`.

92. M. Berger *et al.* (Belle collaboration including M. Iwasaki), "Measurement of the decays $\Lambda_c \to \Sigma\pi\pi$ at Belle," Phys. Rev. D **98**, no. 11, 112006 [10 pages] (2018),
`https://doi.org/10.1103/PhysRevD.98.112006`.

93. A. Abdesselam *et al.* (Belle collaboration including M. Iwasaki), "Measurement of the D^{*-} polarization in the decay $B^0 \to D^{*-}\tau^+\nu_\tau$," arXiv:1903.03102 [hep-ex].

94. A. Abdesselam *et al.* (Belle collaboration including M. Iwasaki), "Test of lepton flavor universality in $B \to K^*\ell^+\ell^-$ decays at Belle," arXiv:1904.02440 [hep-ex].

95. A. Abdesselam *et al.* (Belle collaboration including M. Iwasaki), "Measurement of $\mathcal{R}(D)$ and $\mathcal{R}(D^*)$ with a semileptonic tagging method," arXiv:1904.08794 [hep-ex].

96. A. Abdesselam *et al.* (Belle collaboration including M. Iwasaki), "Test of lepton flavor universality in $B \to K\ell^+\ell^-$ decays," arXiv:1908.01848 [hep-ex].

97. K. Tanida *et al.* (Belle collaboration including M. Iwasaki), "Experimental determination of the isospin of $\Lambda_c(2765)^+/\Sigma_c(2765)^+$," arXiv:1908.06235 [hep-ex].

98. Y. Li *et al.* (Belle collaboration including M. Iwasaki), "Measurements of the branching fractions $B(B^- \to \bar{\Lambda}_c^-\Xi_c'^0)$, $B(B^- \to \bar{\Lambda}_c^-\Xi_c(2645)^0)$ and $B(B^- \to \bar{\Lambda}_c^-\Xi_c(2790)^0)$," Phys. Rev. D **100**, no. 11, 112010 [8 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.112010`.

99. S. Jia *et al.* (Belle collaboration including M. Iwasaki), "Observation of a vector charmoniumlike state in $e^+e^- \to D_s^+D_{s1}(2536)^- + c.c.$," Phys. Rev. D **100**, no. 11, 111103 [8 pages] (2019),
`https://doi.org/10.1103/PhysRevD.100.111103`.

100. H. Li *et al.* (Belle collaboration including M. Iwasaki), "Azimuthal asymmetries of back-to-back $\pi^\pm - (\pi^0, \eta, \pi^\pm)$ pairs in e^+e^- annihilation," Phys. Rev. D **100**, no. 9, 092008 [26 pages] (2019),
`https://doi.org/10.1103/PhysRevD.100.092008`.

101. P. K. Resmi *et al.* (Belle collaboration including M. Iwasaki), "First measurement of the CKM angle ϕ_3 with $B^\pm \to D(K^0_S\pi^+\pi^-\pi^0)K^\pm$ decays," JHEP **10**, 178 [31 pages] (2019),
`https://doi.org/10.1007/JHEP10(2019)178`.

102. Y. Jin *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Observation of $\tau^- \to \pi^-\nu_\tau e^+e^-$ and search for $\tau^- \to \pi^-\nu_\tau\mu^+\mu^-$," Phys. Rev. D **100**, no. 7, 071101(R) [9 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.071101`.

103. S. Jia *et al.* (Belle collaboration including M. Iwasaki), "Search for $\Omega(2012) \to K\Xi(1530) \to K\pi\Xi$ at Belle," Phys. Rev. D **100**, no. 3, 032006 [11 pages] (2019) ,

`https://doi.org/10.1103/PhysRevD.100.032006`.

104. P. C. Chou *et al.* (Belle collaboration including M. Iwasaki), "Search for $B^0 \to X(3872)\gamma$," Phys. Rev. D **100**, no. 1, 012002 [8 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.012002`.

105. K. Chilikin *et al.* (Belle collaboration including M. Iwasaki), "Evidence for $B^+ \to h_c K^+$ and observation of $\eta_c(2S) \to p\bar{p}\pi^+\pi^-$," Phys. Rev. D **100**, no. 1, 012001 [16 pages] (2019),

`https://doi.org/10.1103/PhysRevD.100.012001`.

106. R. Mizuk *et al.* (Belle collaboration including M. Iwasaki), "Observation of a new structure near 10.75 GeV in the energy dependence of the e$^+$e$^-$→ Υ (nS)$\pi^+\pi^-$ ($n = 1, 2, 3$) cross sections," JHEP **10**, 220 [30 pages] (2019), `https://doi.org/10.1007/JHEP10(2019)220`.

107. Y. B. Li *et al.* (Belle collaboration including M. Iwasaki), "First measurements of absolute branching fractions of the Ξ_c^+ baryon at Belle," Phys. Rev. D **100**, no. 3, 031101(R) [8 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.031101`.

108. T. V. Dong, S. Uno, M. Uchida, H. Ozaki, N. Taniguchi, E. Nakano and K. Trabelsi, "Calibration and alignment of the Belle II central drift chamber," Nucl. Instrum. Meth. A **930**, 132-141 (2019), `https://doi.org/10.1016/j.nima.2019.03.072`.

109. V. Bhardwaj *et al.* (Belle collaboration including M. Iwasaki), "Search for $X(3872)$ and $X(3915)$ decay into $\chi_{c1}\pi^0$ in B decays at Belle," Phys. Rev. D **99**, no. 11, 111101(R) [8 pages] (2019),

`https://doi.org/10.1103/PhysRevD.99.111101`.

110. Y. T. Lai *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Measurement of branching fraction and final-state asymmetry for the $\bar{B}^0 \to K_S^0 K^\mp \pi^\pm$ decay," Phys. Rev. D **100**, no. 1, 011101(R) [9 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.011101`.

111. B. Pal *et al.* (Belle collaboration including M. Iwasaki), "Evidence for the decay $B^0 \to p\bar{p}\pi^0$," Phys. Rev. D **99**, no. 9, 091104(R) [8 pages] (2019),

`https://doi.org/10.1103/PhysRevD.99.091104`.

112. R. Seidl *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Transverse momentum dependent production cross sections of charged pions, kaons and protons produced in inclusive e^+e^- annihilation at $\sqrt{s} = 10.58$ GeV," Phys. Rev. D **99**, no. 11, 112006 [15 pages] (2019),

`https://doi.org/10.1103/PhysRevD.99.112006`.

113. R. Garg *et al.* (Belle collaboration including M. Iwasaki), "Search for the $B \to Y(4260)K$, $Y(4260) \to J/\psi\pi^+\pi^-$ decays," Phys. Rev. D **99**, no. 7, 071102(R) [8 pages] (2019),

`https://doi.org/10.1103/PhysRevD.99.071102`.

114. A. B. Kaliyar *et al.* (Belle collaboration including M. Iwasaki), "Measurements of branching fraction and direct CP asymmetry in $B^\pm \to K_S^0 K_S^0 K^\pm$ and a search for $B^\pm \to K_S^0 K_S^0 \pi^\pm$," Phys. Rev. D **99**, no. 3, 031102(R) [9 pages] (2019),

`https://doi.org/10.1103/PhysRevD.99.031102`.

115. Y. B. Li *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "First Measurements of Absolute Branching Fractions of the Ξ_c^0 Baryon at Belle," Phys. Rev. Lett. **122**, no. 8, 082001 [7 pages] (2019), `https://doi.org/10.1103/PhysRevLett.122.082001`.

116. M. Sumihama *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Observation of $\Xi(1620)^0$ and Evidence for $\Xi(1690)^0$ in $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ Decays," Phys. Rev. Lett. **122**,no. 7, 072501 [7 pages] (2019), `https://doi.org/10.1103/PhysRevLett.122.072501`.

117. J. B. Kim *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Search for CP violation with kinematic asymmetries in the $D^0 \to K^+K^-\pi^+\pi^-$ decay," Phys. Rev. D **99**, no. 1, 011104(R) [7 pages] (2019), `https://doi.org/10.1103/PhysRevD.99.011104`.

118. Y. Yusa *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Measurement of time-dependent CP violation in $B^0 \to K_S^0\pi^0\pi^0$ decays," Phys. Rev. D **99**, no. 1, 011102(R) [7 pages] (2019), `https://doi.org/10.1103/PhysRevD.99.011102`.

119. I. S. Seong *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Search for a Light CP-odd Higgs Boson and Low-Mass Dark Matter at the Belle Experiment," Phys. Rev. Lett. **122**, no. 1, 011801 [8 pages] (2019), `https://doi.org/10.1103/PhysRevLett.122.011801`.

120. E. Waheed *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Measurement of the CKM matrix element $|V_{cb}|$ from $B^0 \to D^{*-}\ell^+\nu_\ell$ at Belle," Phys. Rev. D **100**, no. 5, 052007 [32 pages] (2019), `https://doi.org/10.1103/PhysRevD.100.052007`.

121. E. Kou *et al.* (Belle-II collaboration including M. Iwasaki), "The Belle II Physics Book," PTEP **2019**, no. 12, 123C01 [654 pages] (2019), [erratum: PTEP **2020**, no. 2, 029201 (2020)], `https://doi.org/10.1093/ptep/ptz106`, `https://doi.org/10.1093/ptep/ptaa008` (erratum).

122. Y. Guan *et al.* (Belle collaboration including M. Iwasaki), "Observation of Transverse $\Lambda/\bar{\Lambda}$ Hyperon Polarization in e^+e^- Annihilation at Belle," Phys. Rev. Lett. **122**, no. 4, 042001 [8 pages] (2019), `https://doi.org/10.1103/PhysRevLett.122.042001`.

123. P. C. Lu *et al.* (Belle collaboration including M. Iwasaki), "Observation of $B^+ \to p\bar{\Lambda}K^+K^-$ and $B^+ \to \bar{p}\Lambda K^+K^+$," Phys. Rev. D **99**, no. 3, 032003 [9 pages] (2019), `https://doi.org/10.1103/PhysRevD.99.032003`.

124. S. Watanuki *et al.* (Belle collaboration including M. Iwasaki), "Measurements of isospin asymmetry and difference of direct CP asymmetries in inclusive $B \to X_s\gamma$ decays," Phys. Rev. D **99**, no. 3, 032012 [13 pages] (2019), `https://doi.org/10.1103/PhysRevD.99.032012`.

125. K. Chilikin *et al.* (Belle collaboration including M. Iwasaki), "First search for the $\eta_{c2}(1D)$ in B decays at Belle," JHEP **05**, 034 [26 pages] (2020), `https://doi.org/10.1007/JHEP05(2020)034`.

126. R. Seidl *et al.* (Belle collaboration including M. Iwasaki), "Update of inclusive cross sections of single and pairs of identified light charged hadrons," Phys. Rev. D **101**, no. 9, 092004 [13 pages] (2020), `https://doi.org/10.1103/PhysRevD.101.092004`.

127. M. T. Prim *et al.* (Belle collaboration including M. Iwasaki), "Search for $B^+ \to \mu^+\,\nu_\mu$ and $B^+ \to \mu^+\,N$ with inclusive tagging," Phys. Rev. D **101**, no. 3, 032007 [20 pages] (2020), `https://doi.org/10.1103/PhysRevD.101.032007`.

128. K. Chu *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Study of $B \to p\bar{p}\pi\pi$," Phys. Rev. D **101**, no. 5, 052012 [8 pages] (2020), `https://doi.org/10.1103/PhysRevD.101.052012`.

129. P. Katrenko *et al.* (Belle collaboration including M. Iwasaki and E. Nakano), "Observation of the Radiative Decays of $\Upsilon(1S)$ to χ_{c1}," Phys. Rev. Lett. **124**, no. 12, 122001 [7 pages] (2020), `https://doi.org/10.1103/PhysRevLett.124.122001`.

130. F. Abudinén *et al.* (Belle-II collaboration including M. Iwasaki and E. Nakano), "Measurement of the integrated luminosity of the Phase 2 data of the Belle II experiment," Chin. Phys. C **44**, No. 2, 021001 [12 pages] (2020), `https://doi.org/10.1088/1674-1137/44/2/021001`.

131. J. Kobayashi, A. Ogino, S. Inouye, "Measurement of the variation of electron-to-proton mass ratio using ultracold molecules produced from laser-cooled atoms," Nature Communications **10**, 3771 [5 pages] (2020), `https://doi.org/10.1038/s41467-019-11761-1`.

132. H. Yano, K. Hamazaki, N. Koizumi, K. Sato, K. Obara, O. Ishikawa, "Size Distribution of Emission Vortex Rings in Turbulence Induced by Vibrating Wire in Superfluid ^{4}He," J. Low Temp. Phys. **201**, 18-24 (2020), `https://doi.org/10.1007/s10909-019-02285-5`.

133. H. Yano , K. Sato, K. Hamazaki, R. Mushiake, K. Obara , O. Ishikawa, "Vortex Emission from Quantum Turbulence Generated by Vibrating Wire in Superfluid ^{4}He," J. Low Temp. Phys. **196**, 184-189 (2019), `https://doi.org/10.1007/s10909-019-02143-4`.

134. I. Matsumura, K. Ohyama, K. Sato, K. Obara , H. Yano , O. Ishikawa, "Observation of Second Sound Attenuation Across a Superfluid Suction Vortex," J. Low Temp. Phys. **196**, 204-210 (2019), `https://doi.org/10.1007/s10909-019-02164-z`.

9 MEMBERS

Director

Hiroshi Itoyama, Graduate School of Science, Professor

Deputy Director

Nobuyuki Kanda, Graduate School of Science, Professor

Researchers

Masaki Arima, Graduate School of Science, Associate Professor
Yohei Chiba, Graduate School of Science, Assistant Professor with term
Hiromotsu Hamabata, Graduate School of Science, Associate Professor
Shin Inouye, Graduate School of Science, Professor
Hideki Ishihara, Graduate School of Science, Professor
Osamu Ishikawa, Graduate School of Science, Professor
Yousuke Itoh, Graduate School of Science, Associate Professor
Hiroshi Itoyama, Graduate School of Science, Professor (Director)
Masako Iwasaki, Graduate School of Science, Associate Professor
Nobuyuki Kanda, Graduate School of Science, Professor (Deputy Director)
Katsuichi Kanemoto, Graduate School of Science, Associate Professor
Nobuhito Maru, Graduate School of Science, Associate Professor
Sanefumi Moriyama, Graduate School of Science, Associate Professor
Eiichi Nakano, Graduate School of Science, Associate Professor
Ken-ichi Nakao, Graduate School of Science, Professor
Yuunori Nishikawa, Graduate School of Science, Lecturer
Ken Obara, Graduate School of Science, Lecturer
Kazuyuki Ogata, Graduate School of Science, Associate Professor
(Cross appointment with Research Center for Nuclear Physics, Osaka University)
Shoichi Ogio, Graduate School of Science, Professor
Akira Oguri, Graduate School of Science, Professor
Takeshi Oota, Graduate School of Science, Associate Professor with term
Koichi Sato, Graduate School of Science, Lecturer with term
Yoshihiro Seiya, Graduate School of Science, Professor
Mitsuru Sugisaki, Graduate School of Science, Associate Professor
Hiromitsu Takeuchi, Graduate School of Science, Lecturer
Natsuki Teshima, Graduate School of Science, Assistant Professor with term
Makoto Tsubota, Graduate School of Science, Professor
Yoshiki Tsunesada, Graduate School of Science, Associate Professor
Kazuhiro Yamamoto, Graduate School of Science, Associate Professor
Masato Yamanaka, Graduate School of Science, Assistant Professor with term
Hideo Yano, Graduate School of Science, Associate Professor

Endowed Course: Laser Cooled Atom Lab

Shin Inouye, Graduate School of Science, Professor
(Concurrent with the NITEP researcher)
Munekazu Horikoshi, Graduate School of Science, Associate Professor with term
Kohei Kato, Graduate School of Science, Assistant Professor with term

Concurrent Post Researchers

Hiroyuki Sakuragi, Vice President (Graduate School of Science)
Chihiro Matsuoka, Graduate School of Engineering, Professor

Special Researchers

Hidetoshi Awata, Graduate School of Mathematics, Nagoya University
Keitaro Fujita, Graduate School of Science
Hiroyuki Kanno, Graduate School of Mathematics, Nagoya University
Reiji Yoshioka, Osaka City Advanced Mathematical Institute

Nambu Yoichiro Institute of Theoretical and Experimental Physics (NITEP),
Osaka City University,
3-3-138, Sugimoto, Sumiyoshi-ku, Osaka, 558-8585, Japan

https://www.nitep.osaka-cu.ac.jp/en/index.html