Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet003 PI: UTSUNO Yutaka

1	Title of research		Microscopic understanding of nuclear collectivity through collaboration of experiment and theory
2	List of Participants (Name and affiliation)		Yutaka Utsuno (Advanced Science Research Center, Japan Atomic Energy Agency)
			Eiji Ideguchi (RCNP, Osaka University)
			Rudrajyoti Palit (Tata Institute of Fundamental Research)
			Nori Aoi (RCNP, Osaka University)
3	Period of research		From September/2019 to March/2021
4	Main location of collaboration implementation		RCNP, Osaka University
5	Publication list (Please include DOI if available)	Articles	S. Go et al., "High-spin states in 35S", Phys. Rev. C 103, 034327 (2021), https://doi.org/10.1103/PhysRevC.103.034327. https://doi.org/10.1103/PhysRevC.103.034327.
			A. Kundu et al., New lifetime measurement for the 2+1 level in 112Sn by the Doppler-shift attenuation method, Phys. Rev. C 103, 034315 (2021), https://doi.org/10.1103/PhysRevC.103.034315.
			Md. S. R. Laskar et al., “Structure of the 11/2− isomeric state in 133La”, Phys. Rev. C 101, 034315 (2020), https://doi.org/10.1103/PhysRevC.101.034315.
		Talks	E. Ideguchi et al., “Shape coexistence in mass 40 region studied via E0 and gamma transitions", HIAS2019 conference, Sep. 7-15, 2019, Canberra, Australia.
			R. Palit et al., "Structure and isomers odd-A isotopes in A~130 region", XXIII International School on Nuclear Physics and Applications, Varna, Bulgaria, Sep. 22-29, 2019.
			Md. S. R. Laskar et al., "Nuclear moment measurements in Lanthanum (La) isotopes", 3-day theme meeting on Nuclear Reactions Involving Weakly Bound Stable and Radioactive Ion Beams, Anushaktinagar, India, Dec. 1-3, 2019.
			E. Ideguchi et al., Electric monopole transition from the superdeformed band in 40Ca, 5th Topical Workshop on Modern Aspects in Nuclear Structure, Bormio, Italy, Feb. 3-9, 2020.
			Md. S. R. Laskar et al., "Nuclear moment measurements in Lanthanum (La) isotopes", 5th Topical Workshop on Modern Aspects in Nuclear Structure, Bormio, Italy, Feb. 3-9, 2020.
			E. Ideguchi et al., "E0 transitions in superdeformed state in 40Ca", The 75th Annual Meeting of the Physical Society of Japan, Mar. 16-20, 2020.
			Y. Utsuno et al., "Large-scale shell-model calculations of the E0 transitions in 40Ca and their interpretation", The 75th Annual Meeting of the Physical Society of Japan, Mar. 16-20, 2020.
		Theses	
6	Description of the results and outputs		We carried out collaborations between nuclear theorists and nuclear experimentalist concerning nuclear structure in the A~40 and A~130 regions. The main goal for the A~40 region is to better understand the nature of collective states that arise by exciting nucleons across the N=Z=20 shell gap. We picked up two subjects: (1) E0 transition from the superdeformed state to the ground state in 40Ca and (2) high-spin states in 35S. For (1), we have clarified the origin of an ordinary small E0 matrix elements. What is unique in 40Ca is that there are three different deformations coexisting in the low excitation energy: spherical, normal deformed, and superdeformed states. They are mixed with one another as the eigenstates. These mixing contributes to cancel the E0 matrix elements, thus accounting for the very hindered E0 matrix element. For (2), we have clarified that two different excitations coexist in the high-spin state in 35S. While most of the positive-parity high-spin yrast levels are dominated by two-neutron excitations across the N=20 shell gap, the yrast 17/2+ level is interpreted as proton-neutron excitation by comparing shell-model calculations and experimental excitation energies and the decay properties. The main goal for A~130 region is to understand the interplay of single-particle states and collectivity. For this purpose, we concentrated on the determination of single-particle configurations in isomeric states in 137,138La from nuclear moments and lifetimes. For 137La, we analyzed the magnetic and quadrupole moments in the 11/2- state. Its large g factor and quadrupole moment are interpreted as a proton in the h11/2 orbit is coupled to a deformed core. For 138La, we have determined the dominant configurations of the yrast high-spin states by utilizing the half-lives of isomeric states. For instance, the yrast 7- and 8- states are dominated by unpaired proton in the d5/2 and g7/2 states, respectively, thus causing a moderate B(M1) value.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet004 PI: NAKAMURA Atsushi

1	Title of research		Theoretical and numerical study of QCD phase
2	List of Participants (Name and affiliation)		Vladimir Goy, Far Eastern Federal University
			Gerasimeniuk Nikolai, Far Eastern Federal University
			Masayuki Wakayama,Pukyong National University
			Atsushi Nakamura,RCNP, Osaka University
3	Period of research		Aug/2019 - March/2021
4	Main location of collaboration implementation		
5	Publication list (Please include DOI if available)	Articles	N. Yamanaka, H. Iida, A. Nakamura and M. Wakayama Physics Letters, B813, 10, (2021) 136056 https://doi.org/10.1016/j.physletb.2020.136056
			M. Wakayama and A. Hosaka, Physics Letters B795, 10 (2019), 548 DOI: 10.1016/j.physletb.2019.07.006
			M.N. Chernodu, H. Erbin, I.V. Grishmanovskii, V.A. Goy and A.V. Molochkov, Phys. Rev. Res. 2 033375 (2020) https://doi.org/10.1103/PhysRevResearch.2.033375
		Talks	S.i. Nam, ``QCD phase diagram via the canonical method in the PNJL model with complex quark chemical potential", 2020 Korea Physical Society meeting on Apr. 2020
			M. Wakayama, S. Nam, A. Hosaka, ``Study of QCD phase diagram from the PNJL model with the canonical method" The Physical Society of Japan 75th Spring Meeting, Nagoya University, Mar. 2020.
			V.G. Bornyakov, D. Boyda, V.A. Goy, A. Molochkov, A. Nakamura, ``Canonical partition functions in lattice QCD at finite density and temperature", LATTICE 2019
		Theses	
6	Description of the results and outputs		The project is intended to reveal the phase structure of QCD by making use of numerical analysis of the lattice QCD {\bf and} theoretical models. Although the lattice QCD simulation is the first principle calculation, there are the limication because of the finite size, finite spacing and finite quark mass. It is based on the Eucledian formulation and has less powerful for dynamical reactions. In addition, the lattice QCD simulations at finite baryon density suffer from the `sign problem'. We have beaten the sign problem by the canonical approach. In the paper by Wakayama and Hosaka, N-JL (Nambu-Jona-Lasinio)model and the Polyakov model at finite temperature and density are formulated in the framework of the canonical approach. In the paper by Wakayama et al. (Physics Letters B793), Lee-Yang zeros behavior at finite temperature and density are studied for studying the QCD phase structure by avoiding the sign problem. The number densities, are calculated at the pure imaginary chemical potential, where no sign problem occurs. Then, the canonical partition functions, Z_C, are estimated through fitting theoretically motivated functions,which are used to compute the Lee-Yang zeros. We study the temperature dependence of the distributions of the Lee- Yang zeros around the pseudo-critical temperature. In the paper by Boyda et al., it is demonstrated that the sign problem is overcome by our new cannonical approach, where the RHIC energy scan data are compared with lattice QCD results. In this project, we visited quite often to other institutes as S. Nam, A. Molochkov, V. Goy and N. Gerasimenyuk visited RCNP, Osaka. D. Boyda, A. Hosaka, M. Wakayama and A. Nakamura visited Pukyong National Univ., Pusan A. Hosaka visited FEFU, Vladivostok. It was very valuable to promote the project.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet006 PI: HAGINO Kouichi

1	Title of research		Quantum dynamics for superheavy elements
2	List of Participants (Name and affiliation)		Kouichi Hagino (Kyoto Univ.),Masaaki Tokieda (Tohoku Univ.),
			Kouhei Washiyama (Kyushu Univ.), Kazuyuki Ogata (RCNP)
			Tatsushi Shima (RCNP), Yasuhisa Abe (RCNP)
3	Period of research		From September, 2019 to March, 2021
4	Main location of collaboration implementation		RCNP
5	Publication list (Please include DOI if available)	Articles	M. Tokieda and K. Hagino, “A new approach for open quantum systems based on a phonon number representation of a harmonic oscillator bath”, Ann. of Phys. 412 (2020) 168005. doi.org/10.1016/j.aop.2019.168005
			M. Tokieda and K. Hagino, “Time-dependent approaches to open quantum systems”, Front. In Phys. 8 (2020) 8. doi.org/10.3389/fphy.2020.00008
			Y. Abe, D. Boilley, Q. Hourdille, and C. Shen, “A dynamical study of fusion hindrance with the Nakajima-Zwanzig projection method”, Prog. Theo. Exp. Phys. 2021 (2021) 021D01. doi.org/10.1093/ptep/ptab005
		Talks	K. Hagino, “Towards a microscopic understanding of compound nucleus reactions” (Online workshop on nuclear reactions as an evolution of time hierarchy of quantum systems, online, October 8, 2020).
			K. Hagino, “Recent progress and future perspectives of fusion and fission dynamics: from nuclear astrophysics to superheavy nuclei” (A3F program joint annual meeting, online, November 18, 2020).
			K. Hagino, “Role of quantum mechanics in a diffusion process for superheavy elements” (The virtual superheavy elements seminars, online, December 8, 2020).
			K. Hagino, “Quantum many-body dynamics in nuclear reactions” (KEK joint colloquium, online, March 30, 2021).
			M. Tokieda, “Effects of energy dissipation on fusion reactions around the Coulomb barrier” (Online workshop on nuclear reactions as an evolution of time hierarchy of quantum systems, online, October 8, 2020).
			M. Tokieda, “Effects of energy dissipation on fusion reactions around the Coulomb barrier” (The 76th JPS annual meeting, online, March 15, 2021).
			K. Ogata, “Spatial decoherence and quantum-classical transition in nuclear reactions” (Online workshop on nuclear reactions as an evolution of time hierarchy of quantum systems, online, October 8, 2020).
			T. Shima, “Quantum correlation in multi-step nuclear reactions” (Online workshop on nuclear reactions as an evolution of time hierarchy of quantum systems, online, October 8, 2020).
			T. Shima, “Quantum multi-step processes in neutron optics” (The 76th JPS annual meeting, online, March 15, 2021).
		Theses	M. Tokieda, "Studies of open quantum systems with applications to dissipative barrier transmission in heavy-ion fusion reactions", March 2021, Tohoku University.
6	Description of the results and outputs		Because of the covid19 pandemic, we did not have a discussion meeting this year with the whole members. Instead, we had continued discussions within two subgroups. Hagino, Tokieda, Washiyama, and Abe had discussions on the role of quantum effects on heavy-ion fusion reactions. This has resulted in a development of a novel approach for open quantum systems, with which a quantum mechanical Hamiltonian with couplings to environment can be solved exactly for a short term evolution. If one applies this method to the well known Caldeira-Leggett Hamiltonian, this is equivalence to a quantum Langevin method, since the classical Langevin equation can be derived from the Caldeira-Leggett Hamiltonian. Tokieda and Hagino applied this method to the 16O+208Pb fusion reaction and pointed out that the dissipation may play an important role already in such a relatively light system. Washiyama has been trying to apply a similar method to heavy-ion fusion reactions for superheavy elements in order to clarify the quantum effects on evaporation residue cross sections at low energies. In connection to fusion for superheavy elements, another important outcome of the present CoreNet project is that Abe developed a new method for heavy-ion fusion reactions based on the Nakajima-Zwanzig projection operator method for non-equilibrium statistical mechanics. This method was shown to provide a clear picture of the injection point for an initial condition of the Langevin equation. The other subgroup consists of Hagino, Ogata, and Shima. This group has continuously discussed the dynamics of decoherence in nuclear reactions, from a novel point of view of an evolution of time hierarchy of quantum systems. In this point of view, direct reactions, pre-equilibrium reactions, and compound nucleus formation reactions are regarded as different time hierarchies, and the differences observed in these reactions can be uniformly understood in terms of a temporal evolution of quantum systems. Based on this idea, Ogata applied the semi-classical distorted wave model to a one dimensional system and clarified how the spatial decoherence is realized as a consequence of multistep processes. As a part of the present CoreNet project, Ogata, Hagino, and Shima organized an online workshop on nuclear reactions as an evolution of time hierarchy of quantum systems, which was held on October 8, 2020. The workshop was attended by about 50 participants, with many lively discussions during the workshop. Ogata, Hagino, and Shima also organized a similar symposium in the 76th JPS annual meeting. With the success of these workshops, an importance of the direction of physics which we have been discussing in the present CoreNet project was clearly demonstrated.

COREnet010 PI: KATO Yuji

1	Title of research		Elucidation of heavy hadrons in B-factory by collaboration of experimentalists and theorists
2	List of Participants (Name and affiliation)		Yuji Kato, KMI Nagoya University
			Atsushi Hosaka, RCNP Osaka University
			Hikari Hirata, Nagoya University
			Kenkichi Miyabayashi, Nara Women's University
			Kiyoshi Tanida, Japan Atomic Energy Agency
			Makoto Takizawa, Showa Pharmaceutical University
			Makoto Oka, Japan Atomic Energy Agency
			Masayuki Niiyama, Kyoto Sangyo University
			Mizuki Sumihama, Gifu university/RCNP Osaka University
			Shigehiro Yasui, Keio University
			Tomoaki Hotta, RCNP Osaka University
			Yasuhiro Yamaguchi,Nishina Center, RIKEN
3	Period of research		2019 July - 2021 March
4	Main location of collaboration implementation		Nagoya University and virtual meeting room (zoom)
5	Publication list (Please include DOI if available)	Articles	T. J. Moon, K. Tanida, Y. Kato, First Determination of the Spin and Parity of a Charmed-Strange Baryon, Ξc(2970)+, submitted to Physical Review D (arXiv:2007.14700)
			J. Y. Lee, K. Tanida, Y. Kato, and et. al., Measurement of branching fractions of Λ+ c → ηΛπ +, ηΣ0π +, Λ(1670)π +, and ηΣ(1385) +, Physical Review D 103 052005 2021, https://doi.org/10.1103/PhysRevD.103.052005
			Yonghee Kim, Emiko Hiyama, Makoto Oka, Kei Suzuki, Spectrum of singly heavy baryons from a chiral effective theory of diquarks, Physical Review D 102 2020 014004-1-9, 10.1103/PhysRevD.102.014004
			Pc pentaquarks with chiral tensor and quark dynamics, Yasuhiro Yamaguchi, Hugo Garcia-Tecocoatzi, Alessandro Giachino, Atsushi Hosaka, Elena Santopinto, Sachiko Takeuchi, Makoto Takizawa, Phys. Rev. D 101 (2020) 091502 pp.1-7, https://doi.org/10.1103/PhysRevD.101.091502
			Heavy hadronic molecules with pion exchange and quark core couplings: a guide for practitioners [Authors] Yasuhiro Yamaguchi, Atsushi Hosaka, Sachiko Takeuchi, Makoto Takizawa [Journal] J. Phys. G: Nucl. Part. Physx.47(2020)053001 pp. 1-67 [arXiv:1908.08790 [hep-ph] pp.1-72]. [DOI] https://doi.org/10.1088/1361-6471/ab72b0
			Photoproduction of Dbar0 Lambda_c^+ within the Regge-plus-resonance model [Authors] D. Skoupil, Y. Yamaguchi [Journal] Phys. Rev. D 102, 074009 (2020). [DOI] https://doi.org/10.1103/PhysRevD.102.074009
			A. J. Arifi, H. Nagahiro, A. Hosaka, and K. Tanida, Roper-like resonances with various flavor contents and their two-pion emission decays, Phys. Rev. D 101, 111502(R) (2020).
			A. J. Arifi, H. Nagahiro, A. Hosaka, and K. Tanida, Three-body decay of Lambda_c(2765) and determination of its spin-parity, Phys. Rev. D 101, 094023 (2020).
		Talks	Charm hadron spectroscopy at Belle, The 8th Asia-Pacific conference on Few-Body problems in Physics (APFB2020), March 2, 2021
			Prospect of hadron spectroscopy at Belle II, Hadron in Nucleus 2020, March 9, 2020
			「擬スカラーチャーモニウムへの輻射崩壊による新ハドロンの探索」 宮林謙吉（奈良女子大学） 新学術領域研究「量子クラスターで読み解く物質の階層構造」領域研究会での講演 2019年5月31日
			「Belle II実験におけるB0→ηc γ K± π∓の研究」西川愛（奈良女子大学）Flavor Physics Workshop 2019でのポスター発表 2019年11月20日
			「Belle II実験におけるB0→ηc γ K± π∓の研究」 西川愛（奈良女子大学） Flavor Physics Workshop 2020（オンライン開催）での講演 2020年11月26日
			「Belle II実験におけるB0→ηc γ K± π∓崩壊の探索感度」 西川愛、宮林謙吉（奈良女子大学）他 Belle II colalboration 日本物理学会第 76回年次大会（オンライン開催）一般講演 2021年3月15日
			5クオーク状態との結合を伴うハドロン分子としての Pcペンタクォーク状態 (9/15), 山口康宏, 保坂淳, 竹内幸子, 瀧澤誠, 日本物理学会 2020年秋季大会 9/14-17 2020
			Pcペンタクォーク状態におけるパイオン交換力とコンパクト状態への結合 (11/5) [Authors] 山口康宏 [Conference] ELPH 研究会 C029「様々なフレーバー領域で探るクォーク・ハドロン多体系の分光と構造」 11/4-5 2020
			(Invited) Heavy hadronic molecules coupled with multiquark states (3/3) [Authors] Yasuhiro Yamaguchi (JAEA) [Conference] Yamada Conference LXXII: The 8th Asia-Pacific Conference on Few-Body Problems in Physics (APFB2020), Kanazawa, Japan 1-5 March 2021
			(Invited) Heavy hadronic molecules with pion exchange and coupling to multiquarks (3/9) [Authors] Yasuhiro Yamaguchi (JAEA) [Conference] Hadron in Nucleus 2020 (HIN20), Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan 8-10 March 2021
			K. Tanida: Charm baryons at Belle and Belle II, invited talk at Workshop on Physics of heavy-quark and exotic hadrons 2021 (online, Feb. 15-17, 2021)
			K. Tanida for Belle II collaboration: Belle II: Charmonium, Lambda_c, and X(3872) Family, Invited talk at 19th International Conference on B-Physics at Frontier Machines (Beauty2020) (Online, Sep. 21-24, 2020).
			K. Tanida for the Belle collaboration: Λc →Ληπ+崩壊による分岐比と Λ(1670) の測定, (2020年9月14-17日日本物理学会 2020年秋季大会)
			谷田聖他(Belle collaboration):Λ c(2765) の量子数の決定 (2019年9月17-20日 日本物理学会 2019年秋季大会 @山形大学)
			X(3872) in the hybrid model of charmonium and hadronic molecule (4/12), Yasuhiro Yamaguchi, Sachiko Takeuchi, Makoto Takizawa, Atsushi Hosaka, Experimental and theoretical status of and perspectives for XYZ states, Germany 12-15 Apr. 2021
			Makoto Oka, Diquark effectove theory for heavy baryons, KEK J-PARC Branch Workshop on Physics of Heavy Quark Hadron, 2020/1/28, KEK東海分室
		Theses	「Belle II実験におけるB0→ηc γ K± π∓崩壊の探索」西川愛，奈良女子大学大学院人間文化総合科学研究科博士前期課程数物科学専攻 2020年度修士論文
6	Description of the results and outputs		https://drive.google.com/open?id=1NbYvvZV_RH9rJj6cWus8CSCRQS94R1aB&authuser=sakiyama%40rcnp.osaka-u.ac.jp&usp=drive_fs

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet012 PI: HAGIWARA Yoshikazu

1	Title of research		Promoting and improving the NLOAccess program for the nuclear physics community
2	List of Participants (Name and affiliation)		Yoshikazu Hagiwara, Shandong University, Qindao, postdoc
			Nodoka Yamanaka, University of Massachusetts Amherst, postdoc
			Hiroyuki Noumi, Research Center for Nuclear Physics, Professor
			Jean-Philippe Lansberg, Institut de Physique Nucléaire Orsay, permanent CNRS re-searcher
			Carlo Flore, Institut de Physique Nucléaire Orsay, Contractuel ITA
3	Period of research		08/2019 to 04/2021
4	Main location of collaboration implementation		Research Center for Nuclear Physics, Osaka University, Osaka, Japan Institut de Physique Nucléaire Orsay, Université Paris-Sud, Orsay, France
5	Publication list (Please include DOI if available)	Articles	
		Talks	
		Theses	
6	Description of the results and outputs		In order to carry out this project, Dr. Carlo Flore from France needed to come to Japan for setting up our main program (NLOAcess) in the computer system of RCNP. However, from last year, COVID-19 spread all over the world including Japan and Europe. Europe was especially affected by the pandemic, and im-portant restrictions such as the lockdown were set. This made difficult the members to travel and to carry out this project. Regarding Dr. Hagiwara, he be-longs to a research institute in China, and it was almost impossible to travel to Japan due to the very strict border control on both sides due to the COVID-19 pandemic. Due to the security issue, it was also difficult to work remotely by connecting to the RCNP server. For this entirely unexpected and unfortunate reason, it was impossible to proceed with this project last year.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet013 PI: ZHOU Bo

1	Title of research		Study of α condensation in 20Ne within the THSR wave function
2	List of Participants (Name and affiliation)		Bo Zhou (contact), Hokkaido Univ., (moved to Fudan University)
			Yasuro Funaki,Kanto-gakuin Univ.
			Hisashi Horiuchi, Osaka Univ.
			Akihiro Tohsaki, Osaka Univ.
3	Period of research		2019.9~2021.3
4	Main location of collaboration implementation		RCNP, Hokudai, Fudan University
5	Publication list (Please include DOI if available)	Articles	
		Talks	B.Zhou, Alpha-particle condensation in 20Ne, JPS Antum meeting, September, 2020.
			B. Zhou, Container Picture for Cluster Structure in Nuclei, Yamada Conference LXXII: The 8th Asia-Pacific conference on Few-Body problems in Physics (APFB2020), March, 2021.
		Theses	
6	Description of the results and outputs		Quite recently, a new experiment performed by one group of Osaka University shows some clues for the α condensation state in 20Ne. The THSR wave function is particularly designed for describing the α condensation state and it is considered as one suitable tool for searching for the α condensation state in 20Ne at present. By using the one-beta and two-beta spherical size parameters THSR wave function, we performed the GCM calculations for 5alpha structure. It is found some 0+ state above the threshold is the possible candidate of five alpha condensate, which is confirmed further from the calculations of reduced width aplitude. In particularly, we found there is a very large amplitude between the 4alpha condensate state and one 0+ excited state of 20Ne. The results will be submitted soon.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet018 PI: KAWASAKI Shinsuke

1	Title of research		Neutron Electric Dipole Moment Search using Ultra-Cold Neutrons
2	List of Participants (Name and affiliation)		KEK
			RCNP
			University of Winnipeg
			TRIUMF
3	Period of research		May 1, 2020 – March 31, 2022
4	Main location of collaboration implementation		KEK
5	Publication list (Please include DOI if available)	Articles	"Optimizing neutron moderators for a spallation-driven ultracold-neutron source at TRIUMF" W. Schreyer, C. A. Davis, S. Kawasaki, T. Kikawa, C. Marshall, K. Mishima, T. Okamura, R. Picker Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 959, 163525 (2020) https://doi.org/10.1016/j.nima.2020.163525
			"Development of a Helium-3 Cryostat for Ultra-Cold Neutron Source", S. Kawasaki and T. Okamura, IOP Conference Series Materials Science and Engineering 755, 012140 (2020), https://doi.org/10.1088/1757-899X/755/1/012140
		Talks	川崎真介, and TUCAN collaboration, "中性子電気双極子モーメント探索による時間反転対称性の検証 ", 日本物理学会2020年秋季大会、Web開催、2020年9月14日-17日
			樋口嵩, TUCAN collaboration, 中性子EDM実験のための磁場関連実験要素の開発 日本物理学会2020年秋季大会、Web開催、2020年9月14日-17日
			今城想平, 関義親, and TUCAN collaboration, "中性子EDM実験に使用する中性子輸送ガイド管の性能評価 ", 日本物理学会2020年秋季大会、Web開催、2020年9月14日-17日
			S. Kawasaki, the TUCAN collaboration, "Development of a Helium-3 Cryostat for the TRIUMF Ultra-Cold Advanced ", International Workshop on Searches for a Neutron Electric Dipole Moment (nEDM2021), Les Houches School of Physics, France, 14-19 February. 2021.
			Takashi Higuchi, the TUCAN collaboration, "Prospects towards a neutron EDM measurement with an advanced ultracold neutron source at TRIUMF" International Workshop on Searches for a Neutron Electric Dipole Moment (nEDM2021) Les Houches School of Physics, France, 14-19 February. 2021.
			S. Imajo, "Performance measurement of ultracold neutron guides at J-PARC for a neutron EDM experiment in TRIUMF", International Workshop on Searches for a Neutron Electric Dipole Moment (nEDM2021) Les Houches School of Physics, France, 14-19 February. 2021.
			川崎真介, "大強度超冷中性子源による 中性子電気双極子モーメント探索 ", 日本物理学会第76回年次大会、東京大学 (オンライン)、2021年3月12日-15日
			樋口嵩, TUCAN collaboration TRIUMFにおける中性子EDM測定のための磁場関連実験要素の開発状況 日本物理学会第76回年次大会 2021年3月12日
			今城想平, TUCAN collaboration, "TRIUMF での中性子EDM 実験に向けた J-PARC/MLF BL05 での中性子ガイド管の性能測定 ", 日本物理学会第76回年次大会、東京大学 (オンライン)、2021年3月12日-15日
		Theses	
6	Description of the results and outputs		In view of the epidemic of covid-19, we did not make overseas business trips in FY2020. However, we have been managed our collaboration by holding weekly Japanese group meetings and international group meetings online. On a domestic business trip, we conducted the commissioning of a helium-3 cryostat, which is used for the upgrade of the UCN source at TRIUMF, at KEK, and evaluate its performance. We discussed deeply in-person meeting. An Ambient Magnetic Compensation (AMC) system has been developed in Japan. The AMC is a pair of coils that compensates large ambient magnetic fields produced by the cyclotron magnet so that mu-metal used for a magnetic shield is not saturated. Through online discussion with the collaboration, we decided requirements for the AMC system and detailed design which accommodates the magnetic shield room has been started. We had an online collaboration meeting in January 2021. The current status of the development of every sub-system of the neutron EDM measurement was reported.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet014		PI: BRACCO Angela
1	Title of research	Gamma-Decay from Pygmy and Giant Dipole Resonances
2	List of Participants (Name and affiliation)	A. Bracco*, Professor, Univ. of Milano/INFN, Angela.Bracco@mi.infn.it F. Camera, Professor, Univ. of Milano/INFN, Franco.Camera @mi.infn.it F. Crespi, Researcher, Univ. of Milano/INFN, Fabio.Crespi@mi.infn.it P. von Neumann-Cosel, Professor, TU-Darmstadt, vnc@ikp.tu-darmstadt.de A. Tamii, Associate Professor, RCNP, tamii@rcnp.osaka-u.ac.jp N. Kobayashi, Assistant Professor, RCNP, kobayash@rcnp.osaka-u.ac.jp
3	Period of research	July 2019 to March 2021
4	Main location of collaboration implementation	
5	Publication list (Please include DOI if available)	Articles
		Talks
		Theses
6	Description of the results and outputs	
7	Amount of budget implemented (for internal use only)	0
8	Requests or comments for improvement of the COREnet program (for internal use only)	

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet022 PI: ITO Makoto

1	Title of research		Studies of resonant reaction in nuclear astrophysics and alpha cluster structure
2	List of Participants (Name and affiliation)		M. Ito, Department of Pure and Applied Physics, Kansai University
			H. Yamaguchi, Center for Nuclear Study (CNS), the university of Tokyo
			I. H. Kevin and D. Kim, Institute for Basic Science (IBS), Center for exotic nuclear studies
3	Period of research		Apr. 2020 – Mar. 2021
4	Main location of collaboration implementation		Remote
5	Publication list (Please include DOI if available)	Articles	nothing
		Talks	See description of the results and outputs
		Theses	See description of the results and outputs
6	Description of the results and outputs		The main subject was the analysis of the resonant reaction, which plays important roles in the astrophysical phenomena. The reaction mainly discussed here is the resonant reaction induced by the slow RI beam with the α taeget, which has been recently achieved by the development of the experimental technique. The example of such the resonant reaction by the RI beam is 15O + α, 22Ne+α and so on. In the period of research, unfortunately, it was impossible to have an on-site and pragmatic collaboration because of COVID-19 calamity. Instead, we had the collaboration meeting by zoom on 11, December 2020. In this meeting, we exchanged information about the experimental and theoretical studies in Korean and Japanese groups. Moreover, we had a plan of mini workshop relevant to the resonant scattering by RI beam in collaboration with CNS the university of Tokyo, IBS research center for exotic nuclear studies and Kansai university. The mimi workshop was held on 22 February, 2021. The tiltle of mini workshop is “Physics in resonant reaction induced by low-energy RI beam”. There are 11 talkers and about 40 participants in this mini workshop. We had the exciting and fruitful discussion about the resonant reaction by the RI beam, and the workshop becomes a basic step to advance the international collaborations in this research field. The workshoip program and the presentation slides are opened in the following web-site: https://www.cns.s.u-tokyo.ac.jp/crib/PRR2021/miniWS.htm with the user name and the password of user: slides pass: resonant2021 Finally, I have a comment on the member in the COREnet program. Since we could not have pragmatic collaborations in this research period, Prof. P. Descouvement at Free university of Brussels, who was an original member in the program, was not involved in the research activity.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet019 PI: PELLEGRI Luna

1	Title of research		Electric Dipole Response of Nuclei for the Study of Extra-Galactic Propagation of Ultra High-Energy Cosmic Rays (PANDORA project)
2	List of Participants (Name and affiliation)		L. Pellegri, iThemba LABS and University of the Witwatersrand (South Africa)
			R. Neveling, iThemba LABS (South Africa)
			A. Tamii, RCNP (Japan)
			P-A Söderström, ELI-NP (Romania)
			Theory supports: D. Allard (Laboratoire Astroparticule et Cosmologie, France), E. Khan, (IPN Orsay, France), S. Nagataki (RIKEN, Japan), M. Kimura (Hokkaido Univ., Japan)
3	Period of research		From May 2020 to March 2022
4	Main location of collaboration implementation		iThemba LABS (South Africa)
5	Publication list (Please include DOI if available)	Articles	N/A
		Talks	N/A
		Theses	N/A
6	Description of the results and outputs		The PANDORA (Photo-Absorption of Nuclei and Decay Observation for Reactions in Astrophysics) project aims at systematic measurements of the electric dipole excitation strengths and decay properties of stable nuclei below the mass of A=56. The first experiment of the project was approved by the PAC of iThemba LABS in December 2019. The aim is to study the electric dipole response and decays of 12C and 27Al using proton scattering. Due to the global pandemic the experimented couldn't be performed so far and it is now scheduled for September/October 2021. A second proposal to study additional nuclei (10-11B, 12-12C, 24-26Mg and 27Al) was submitted to the RCNP PAC in December 2020. The proposal was approved and we expect to perform the experiment in 2022. The theoretical groups involved in the project are developing and improving the nuclear models available to predict the electric dipole response and the branching ratios for particle emission in the nuclei of interest. In particular, Dr T. Inakura is calculating the photo-absorption cross section of several relevant nuclei while the corresponding particle decays are calculated by Prof M. Kimura's group using the Antisymmetric Molecular Dynamics (AMD) model. These results will be used by Dr S. Nagataki and collaborators as inputs in the astrophysics calculations for the propagation of the UHECRs. Prediction of the electric dipole response calculated with the AMD model are also being performed by Prof M. Kimura and collaborators. A collaboration with Prof Y. Utsuno and Prof N. Shimizu was established to implement the calculations obtained using the large-scale shell model in the PANDORA project. The predictability of these models will be verified by comparing the results obtain with the experimental data extracted from the proposed measurements. The first PANDORA workshop was organized in July 2020 in order to discuss within the collaboration the key points of the project and the updates of the work performed. The workshop was held virtually via the Zoom platform. Forty (40) participants attended the workshop. A second workshop will be organised this year.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet020 PI: FUKUDA Yuji

1	Title of research		Development of scintillator-based detection system for laser-accelerated GeV proton
2	List of Participants (Name and affiliation)		Yuji Fukuda (Kansai Photon Science Institute, QST)
			Yasuhiro Kuramitsu (Graduate School of Engineering, Osaka University)
			Atsushi Tokiyasu (ELPH, Tohoku University)
			Hideki Kohri (RCNP, Osaka University)
3	Period of research		June 2020 to March 2022
4	Main location of collaboration implementation		Kansai Photon Science Institute, QST
5	Publication list (Please include DOI if available)	Articles	
		Talks	Title 'Detection of high energy particles in nuclear physics experiments ' 13pB1-9 Speaker : Hideki Kohri Conference : JPS meeting held on the 13th of March in 2021
			Title 'Astrophysics and laser-accelerated ions' 13pB1-2 Speaker : Yasuhiro Kuramitsu Conference : JPS meeting held on the 13th of March in 2021
		Theses	
6	Description of the results and outputs		Our research subject is laser driven ion acceleration. Techniques used in nuclear physics experiments are quite useful for identifying particles and measuring energies of them. We carried out an experiment using proton beams with energies of 100 and 230 MeV at HIMAC in September 2020. Energy measurements with a good linearity were performed by using a calorimeter and a reasonable time resolution of 240 ps was obtained for TOF using two plastic scintillators. We installed the same detectors in the J-KAREN experiment at Kansai Photon Science Institute in November 2020. However, huge electron background disturbed precise measurements. Kuramitsu and Kohri reported these results in the JPS meeting held in March 2021, and Tokiyasu will report in the HEDS international conference to be held in April 2021. After replacing the plastic scintillators with smaller ones and making thicker shields, we will try to measure the energies of laser-accelerated ions in 2021 or 2022.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet025 PI: HIYAMA Emiko

1	Title of research		Structure of neutron-rich hydrogen nucleus (7H) and neutron-rich He (8He) nucleus
2	List of Participants (Name and affiliation)		Emiko Hiyama, Tohoku University,Kazuyuki Ogata, Osaka University,
			Kazuki Yoshida, JAEA, Jaume Carbonell, Orsely,Rimantas Lazauskas, Strasbourg
3	Period of research		From June 12, 2020 to Mar. 31st, 2022
4	Main location of collaboration implementation		Online (Due to pandemic of COVID-19)
5	Publication list (Please include DOI if available)	Articles	
		Talks	Emiko Hiyama, March 15. 2021, Symposium in JPS meeting, "Hierarchical structure from view point of few-body problem"
		Theses	
6	Description of the results and outputs		In 2020, I focused on making code to calculate the resonant state of 7H within the framework of t+4n five-body model. The key is t-n potential to reproduce the t-n scattering data. Lazauskas provided t-n potential with pure Gaussian-form. The potential reproduces the scattering t-n data. However, the potential does not reproduce the observed resonance of 5H. Then, we introduced a phenomenological t-n-n three-body force and tuned the strength of three-body force so as to reproduce the data of 5H. The three-body force is applied to the calculation of 7H. Currently, without three-body force, we found the resonant state, 1/2+, by about 15 MeV above t-4n threshold. In the next financial year, with three-body force to reproduce the observed resonance, we obtain resonance of 7H. In addition, we will make a code of 8He(α+4n model) and calculate energy spectra of this nucleus.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet026 PI: IINUMA Masataka

1	Title of research		Development and applications of polarized targets for fundamental physics researches
2	List of Participants (Name and affiliation)		Masataka IINUMA(Hiroshima Univ.), Hiroki HOTTA(Nagoya Univ.), Ikuo IDE(Nagoya Univ.)
			Kohei ISHIZAKI(Nagoya Univ.), Yuki ITO(Nagoya Univ.), Hideki KOHRI(RCNP)
			Masaaki KITAGUCHI(Nagoya Univ.), Yoshiyuki MIYACHI(Yamagata Univ.)
			Hirohiko SHIMIZU(Nagoya Univ.), Masaru YOSOI(RCNP)
3	Period of research		1/April/2021 - 31/March/2022
4	Main location of collaboration implementation		Remote only or Mixing of remote and on-site implementation at RCNP or Yamagata Univ.
5	Publication list (Please include DOI if available)	Articles	K.Ishizaki,et.,al., Polarized Lanthanum Target for the T-violation Search in Slow Neutron Transmission, Proceeding of The 18th international Workshop on Polarized Sources, Targets, and Polarimetry - PoS (PSTP2019) Vol. 379, 061, 2020, DOI: https://doi.org/10.22323/1.379.0061
		Talks	K. Ishizaki, et.,al, Formation without twinning in LaAlO3 crystals and investigation on an evaluation method of twinning structure by neutron transmission imaging, JSNS 2020, online(Sendai), 9/Nov/2020
			M. Iinuma, Solid polarized target, invited in the domestic workshop on spin physics "Prospects of spin physics in Japan", online(Matsue), 23/Feb/2021-24/Feb/2021
			I.Ide,et.,al,Present status of development of nuclear polarized La targets for the experiments of T-violation searches, Experimental Nuclear Physics in 76th Annual meeting 2021, the Physical Society of Japan, online, 12/Mar to 15/Mar
		Theses	I.Ide, Studies on the DNP characteristics of target material LaAlO3 crystals toward the NOPTREX experiment, Master thesis FY2020 in Nagoya University
			Y.Ito, Crystal growth of target material Nd3+:LaAlO3 crystal for a search of violation in time reversal invariance, Graduation thesis Fy2020 in Nagoya University
6	Description of the results and outputs		We have a weekly meeting on the project with the remote only, or mixing the remote and the face-to-face communiation at RCNP. Through the data analysis and the comparison with the model, the relaxation time of Lanthernum and Alminum nuclear spins has been estimated to be more than 1 hour at 0.1 [K] and in 0.1 [T]. This result has encouraged to investigate a possibility of a low-field DNP in 0.1 [T]. The summarization of the result has been almost finished toward a submission as a paper. Then, we have performed the first experiment with our grown crystals and made an argument on the results at Yamagata University. Although the polarization of about 0.2 % has been small at 1.3[K] in 2.3 [T], this result has become a first significant step toward the 50 % polarization.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet027 PI: TAKIZAWA Makoto

1	Title of research		"Tensor and quark dynamics in the Pc and X(3872)"
2	List of Participants (Name and affiliation)		Yasuhiro Yamaguchi, Advanced Science Research Center, Japan Atomic Energy Agency
			Sachiko Takeuchi, Japan College of Social Work
			Elena Santopinto, National Institute for Nuclear Physics (INFN), Genoa
			Atsushi Hosaka, Research Center for Nuclear Physics, Osaka University
			Makoto Takizawa, Showa Pharmaceutical University
3	Period of research		From June 2020 to March 2022
4	Main location of collaboration implementation		RCNP, Osaka University and KEK Tokai Campus
5	Publication list (Please include DOI if available)	Articles	Strange pentaquarks with a hidden heavy quark-antiquark pair, S. Takeuchi, A. Giachino, M. Takizawa, E. Santopinto and M. Oka, Procedings of the 18th International Conference on Hadron Spectroscopyand Structure https://doi.org/10.1142/9789811219313_0056
		Talks	クオーク状態との結合を伴うハドロン分子としての Pcペンタクォーク状態 山口康宏, 保坂淳, 竹内幸子, 瀧澤誠 日本物理学会 2020年秋季大会
			X(3872):ccbar芯が存在する2メソン散乱系と共鳴極に関する研究 竹内幸子, 瀧澤 誠, 山口康宏, 保坂淳 日本物理学会 2020年秋季大会
			Heavy baryons A. Hosaka SnowMass21
			Quark color degrees of freedom in multiquark exotics: Pentaquarks [uudQ$\bar{Q}$, udsQ$\bar{Q}$] S. Takeuchi, H. G.-Tecocoatzi, A. Giachino, M. Takizawa, E. Santopinto and M. Oka, Workshop on Clustering as a window on the hierarchical structure of quantum systems
			Pcペンタクォーク状態におけるパイオン交換力とコンパクト状態への結合 山口康宏 ELPH 研究会 C029「様々なフレーバー領域で探るクォーク・ハドロン多体系の分光と構造」
			Heavy baryon Spectroscopy A. Hosaka APCTP-KPS-JPS meeting
			ハドロン物理入門 瀧澤誠 Floavor Physics Workshop 2020
			Hidden charm pentaquarks with chiral tensor and quark dynamics Y. Yamaguchi Physics of heavy-quark and exotic hadrons 2021
			Pole position of X(3872) in the charmonium hadronic-molecule hybrid approach S. Takeuchi Physics of heavy-quark and exotic hadrons 2021
			Heavy hadronic molecules coupled with multiquark states Y. Yamaguchi The 8th Asia-Pacific Conference on Few-Body Problems in Physics
			X(3872) revisited: the roles of OPEP and the quark degrees of freedom S. Takeuchi, Y. Yamaguchi, A. Hosaka, M. Takizawa The 8th Asia-Pacific Conference on Few-Body Problems in Physics
			Strange pentaquark resonances with a heavy quark antiquark pair [udsQ$\bar{Q}$] S. Takeuchi, A. Giachino, M. Takizawa, E. Santopinto and M. Oka The 8th Asia-Pacific Conference on Few-Body Problems in Physics
			Heavy hadronic molecules with pion exchange and coupling to multiquarks Y. Yamaguchi Hadron in Nucleus 2020
			ハドロン動力学による Pcペンタクォークの質量スペクトル 山口康宏 日本物理学会 第76回年次大会
			Strange hidden-charm ペンタクォークにおけるメソン交換力と5クォーク状態への結合 山口康宏, 保坂淳, 竹内幸子, 瀧澤誠 日本物理学会 第76回年次大会
			重いクォーク対を含むペンタクォークの崩壊の研究 竹内幸子, 瀧澤 誠, 山口康宏, 保坂淳 日本物理学会 第76回年次大会
			X(3872) in the hybrid model of charmonium and hadronic molecule Y. Yamaguchi, S. Takeuchi, M. Takizawa, A. Hosaka Experimental and theoretical status of and perspectives for XYZ states
		Theses	
6	Description of the results and outputs		We have extended our study of hidden charm pentaquark states, the uud ccbar system (Phys. Rev. D 101, 091502(R) (2020)) to uds cc bar systems. We have obtained resonances which should be observed in the LHCb experiment. Recently, LHCb reported the evidence of such a resonance. We have studied the X(3872) state in the meson molecule with a charmonium core coupling. OPEP has been introduced to the meson molecules. We have calculated the X(3872) to D D* bar, J/psi rho and J/psi omega decay spectra in the case of the X(3872) produced in the B decay. The pole position of X(3872) has been carefully studied in the complex scaling method and compared with LHCb result. Our result is consistent with LHCb result. We have reported our results in conferences and workshops. We are now preparing journal papers. The disccion meetings were held about 20 times in the period of research by using Zoom system provided by CORENet, A. Hosaka and M. Takizawa organized the workshop on "Physics of heavy-quark and exotic hadrons 2021" at KEK Tokai campus in Feb. 2021. We were able to gather in the same place and have intensive discussions on physics. We also invited an Italian member, Elena Santopinto, to this workshop for discussion.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet028 PI: MURAMATSU Norihito

1	Title of research		Studies for the future facilities to produce an extremely high energy and polarized photon beam via coherent bremsstrahlung radiation
2	List of Participants (Name and affiliation)		Norihito Muramatsu (ELPH, Tohoku University)
			Tomoaki Hotta (RCNP, Osaka University)
			Kenneth Livingston (University of Glasgow)
3	Period of research		June, 2020 - March, 2022
4	Main location of collaboration implementation		RCNP, Osaka University
5	Publication list (Please include DOI if available)	Articles	
		Talks	"Tests of coherent bremsstrahlung radiation techniques to produce a high energy gamma-ray beam with linear polarization", N. Muramatsu, ATF Mini-workshop (online slide presentation), 28 Aug 2020.
		Theses	
6	Description of the results and outputs		In order to advance the photoproduction research of heavy exotic hadrons including charm and bottom quarks, we conducted technical studies on a method for generating a polarized photon beam with several tens of GeV by coherent bremsstrahlung radiation using an ultra-high energy electron accelerator. Simulations were carried out by assuming the use of ILC which will provide electron and positron beams of 125 GeV, and it was confirmed that a sufficient photon beam intensity will be obtained if an electron or positron beam with an angular divergence suppressed to about 1 urad is passed through a 50 um-thick diamond crystal. Linear polarization will reach about 70% for a photon beam energy of 75 GeV. In order to pave the way for technological development of a diamond radiator, a gonio-meter, a polarimeter, etc., we also examined a future test experiment at the KEK ATF-2 facility.

COREnet030 PI: KIMURA Masaaki

1	Title of research		Research on nuclear clustering by new reaction probes
2	List of Participants (Name and affiliation)		Masaaki Kimura, Hokkaido Univ.
			Yoshiko Kanada-En'yo, Kyoto Univ.
			Kazuyuki Ogata, RCNP
			Yasutaka Taniguchi, Kagawa College
			Yohei Chiba, Osaka City Univ.
			Kazuki Yoshida, JAEA
			Takahiro Kawabata, Osaka Univ.
			Hooi Jin Ong, IMP Lanzhou
			Yuki Shikata, Kyoto Univ.
			Juzo Zenihiro, Kyoto Univ.
3	Period of research		Apr. 2020 – Mar. 2021
4	Main location of collaboration implementation		RCNP (online)
5	Publication list (Please include DOI if available)	Articles	"Neutron dominance in excited states of 26Mg and 10Be probed by proton and alpha inelastic scattering", Y. Kanada-En'yo, Y. Shikata, Y. Chiba and K. Ogata Phys. Rev. C102, 014607 (2020) https://doi.org/10.1103/PhysRevC.102.014607
			"Properties of $K^\pi=0^+_1$, $K^\pi=2^-$, and $K^\pi=0^-_1$ bands of 20Ne probed via proton and alpha inelastic scattering", Y. Kanada-En'yo and K. Ogata, Phys. Rev. C101, 064308 (2020) https://doi.org/10.1103/PhysRevC.101.064308
			"Transition properties of low-lying states in 28Si probed via inelastic proton and alpha scattering", Y. Kanada-En'yo and K. Ogata, Phys. Rev. C 101, 064607 (2020) https://doi.org/10.1103/PhysRevC.101.064607
			"Probing negative-parity states of 24Mg probed via proton and alpha inelastic scattering" Y. Kanada-En'yo and K. Ogata Phys. Rev. C 103, 024603 (2021) https://doi.org/10.1103/PhysRevC.103.024603
			"alpha inelastic Scattering Cross Sections Off 12C with Microscopic Coupled-channel Calculation" Y. Kanada-En'yo and K. Ogata JPS Conf. Proc. 31, 011040 (2020) https://doi.org/10.7566/JPSCP.31.011040
			"Microscopic calculations for Be isotopes within real-time evolution method" B. Zhou, M. Kimura, Q. Zhao and S. Shin, Eur. Phys. J A56, 298 (2020). https://doi.org/10.1140/epja/s10050-020-00306-6
			"α+ 28Si and 16O + 16O molecular states and their isoscalar monopole strengths", M. Kimura and Y. Taniguchi, Phys. Rev. C 102, 024325 (2020). https://doi.org/10.1103/PhysRevC.102.024325
			"Monopole and dipole transitions of the cluster states of 18O" T. Baba and M. Kimura, Phys. Rev. C 102, 024317 (2020). https://doi.org/10.1103/PhysRevC.102.024317
			"Hoyle-analog state in 13C studied with antisymmetrized molecular dynamics" Y. Chiba and M. Kimura, Phys. Rev. C 101, 024317 (2020). https://doi.org/10.1103/PhysRevC.101.024317
			"Unexpectedlyenhanced alpha -particle preformation in 48Ti probed by the (p,p alpha) reaction", Y. Taniguchi, K. Yoshida, Y. Chiba, Y. Kanada-En'yo, M. Kimura, and K. Ogata, Phys. Rev. C 103, L031305 (2021). https://doi.org/10.1103/PhysRevC.103.L031305
			"Microscopic coupled-channel calculation of proton and alpha inelastic scattering to the 4^+_1 and 4^+_2 states of 24Mg" Y. Kanada-En'yo and K. Ogata, accepted for publication in PTEP.
		Talks	"Bound state properties studied by the knockout reaction" Kazuki Yoshida The 8th Asia-Pacific conference on Few-Body problems in Physics, March 3, 2021. invited
			"Knockout-reaction with RIB" Kazuyuki Ogata A3F-CNS Summer School 2020, 2020年8月17日-21日, invited
			"12C + 12C resonances in explosive astrophysical phenomena" Yasutaka Taniguchi International mini-workshop on "Physics in resonant reaction induced by low-energy RI beam", February 22, 2021, invited
			"反対称化分子動力学による光核励起断面積の理論計算 " 木村真明 日本物理学会 2020年秋季大会, オンライン, 2020.09.17, 招待講演
			"爆発的天体現象に関する共鳴状態 " 谷口優宇 RCNP 研究会「原子核における多様な共鳴現象とそれを探る反応機構」 2021年1月18-20日, 招待講演
			"Some note on the correspondence between nuclear clustering and scattering observables" Kazuyuki Ogata 第5回クラスター階層領域研究会 , 2020年9月24日-25日, 一般
			"Molecular dynamics approach for nuclear dipole responses" M. Kimura, PANDORA Workshop 2020, online, 2020.6.30-7.1, 一般講演
			"アルファノックアウト反応断面積による核表面アルファ振幅の決定 " 吉田数貴 日本物理学会第 76回年次大会 , 3月13日, 2021. 一般講演
			"ノックアウト反応で探る原子核構造 " 吉田数貴 RCNP 研究会「原子核における多様な共鳴現象とそれを探る反応機構」 1月19日, 2021. 一般講演
			"陽子およびα非弾性散乱で探る原子核の励起状態 " 金田佳子 RCNP研究会「原子核における多様な共鳴現象とそれを探る反応機構」 2021年1月18-20日,(オンライン開催)一般講演
			"実時間発展法による炭素 12 の E1 励起の研究." 木村真明 RCNP研究会「原子核における多様な共鳴現象とそれを探る反応機構」 2021年1月18-20日,(オンライン開催)一般講演
			"中質量核48Tiの基底状態の表面に発達するαクラスター構造" 谷口優宇 日本物理学会第 76回年次大会 , 2021年3月12-15日, 一般講演
		Theses	"軽い核におけるlow-energy dipole 励起モードのクラスター構造による理解 " 西方悠貴 京都大学大学院理学研究科 , 博士論文(2021年3月)
6	Description of the results and outputs		In 2020, due to the influence of COVID-19, the project research has been conducted through the on-line meetings every few months. The project outcomes have been published as eleven original papers, including those accepted for publication. A Ph. D thesis was also published. Twelve presentations were made at international and domestic conferences, five of which were invited talks. Two primary topics of the project and the outcomes in 2020 are summarized as follows. Topic 1. Analysis of the α-knockout reactions We have studied the α-knockout reactions to investigate the α cluster formation at nuclear surfaces with various densities and proton/neutron asymmetries. To realize the quantitative description of the α-knockout reactions, a theoretical framework has been developed by combining AMD and DWIA, The framework has been applied to the the 48Ti(p,pα)44Ca reaction and the numerical results were compared with the observed data, The analysis showed that the α cluster formation at the surface of 48Ti is much enhanced than a simple estimation. Such analysis can also be extended to the cases of the unstable nuclei for the forthcoming experiments. Theme 2. Analysis of the α inelastic scattering We have studied the α inelastic scattering to investigate the structure of the excited states including the cluster resonances. In 2020, we have systematically analyzed the inelastic proton and alpha scattering data of the sd-shell nuclei including those from RCNP by the microscopic coupled-channel (MCC) calculations. The inelastic cross-sections of 20Ne, 24Mg, 26Mg, and 28Si are successfully reproduced and provided us a new insight to the excited states of these nuclei such as band structure and transition properties. Moreover, dipole transition strengths to 1- states were discussed in relation to cluster structure. We also studied the 12C+12C, 16O+16O and α+28Si resonances related to astrophysical nuclear reactions. Their energies and decay widths have been calculated to estimate the reaction rates. Particularly, we have identified 12C + 12C resonances in the Gamow window which significantly increase the reaction rate. Furthermore, we also calculated the monopole and quadrupole transition strengths and densities which will be used to analyze the α inelastic scattering cross section measured at RCNP.

Report of the RCNP Collaboration Research Network (RCNP-COREnet)

COREnet031 PI: FUKUKYAMA Takeshi

1	Title of research		Hunting for T-violation and Majorana Character of Neutrinos in Muon Decays
2	List of Participants (Name and affiliation)		Koichiro Shimomura, Professor at KEK, ksimomu@post.kek.jp
			Junji Tojo, Associate Professor at Kyushu University, tojo@phys.kyushu-u.ac.jp
			Sohtarou Kanda, Assistant Professor at KEK, kanda@post.kek.jp.
			Dausuke Nomura, Lecturer at International University of Health and Welfare, dnomura@post.kek.jp
			Takeshi Fukuyama (contact person), Research Collaborator at RCNP, Osaka University,
3	Period of research		Two years from April 2020 to March 2022.
4	Main location of collaboration implementation		J-PARC
5	Publication list (Please include DOI if available)	Articles	(i) ￥mu-￥tau symmetry breaking and CP violation in the neutrino mass matrix Takeshi Fukuyama(Osaka U., Res. Ctr. Nucl. Phys.), Yukihiro Mimura(Ritsumeikan U., Kusatsu) (Jan 30, 2020) Published in: Phys.Rev.D 102 (2020) e-Print: 2001.11185 [hep-ph]
			(ii) The Relativistic Corrections of GPS Takeshi Fukuyama(Osaka U., Res. Ctr. Nucl. Phys.), Sueo Sugimoto(Ritsumeikan U., Kusatsu) (Jul 11, 2020) e-Print: 2007.04582 [hep-ph]
		Talks	NEWS1907 (July 18, 2019) Speaker: Prof. Takeshi Fukuyama (RCNP) Title: Searching for New Physics beyond the Standard Model in Electric Dipole Moment
			NEWS1912-2 (December 19, 2019) Speaker: Prof. Takeshi Fukuyama (RCNP) Title: Hunting for T-violation and Majoranality of Neutrinos in Muon Decays
		Theses	
6	Description of the results and outputs		In publication (i): We have discussed the origin of the ￥mu-￥tau symmetry found by us. In publication (ii): We have calculated the special and general relativistic effects of the Global Positioning System (GPS), especially the effects depending on the small deviation of the orbit from the circular one. In the talk of NEWS1912-2 (December 19, 2019), we have explained the outline of our project of this budget. We will apply for this project to the Kakenhi for the coming academic year.