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

COREnet030 PI: KIMURA Masaaki

1	Title of research		Research on nuclear clustering by new reaction probes
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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 " 谷口僚宇 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" 谷口僚宇 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 " 四方悠貴 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.