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
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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.