Theoretical Nuclear Physics Laboratory

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The Theoretical Nuclear Physics (TNP) Laboratory started in August 2007 when I was appointed as an Associate Chief Scientist. This was the first research group in RIKEN focusing on studies of theoretical nuclear physics. Main aims of the Laboratory were to develop theories for finite quantum many-body systems and to discover/predict new concepts/phenomena in exotic nuclei. To achieve these goals, we have also developed efficient computational methodologies. Daily contacts with experimental groups provided us with stimulating environments. It was an exciting opportunity as a member of RIKEN Nishina Center, sitting inside the most powerful RI-beam facility in the world.

Soon after the TNP Laboratory was established, Dr. Kohama, who was a research staff working on the nuclear theory, moved to the TNP Laboratory from Heavy-Ion Nuclear Physics (HINP) Laboratory (Chief Sci.: Dr. Motobayashi). Thanks to many brilliant young postdoctoral fellows, we succeeded to maintain a high level of activities in our group. The number of group members changed year by year, but steadily increased up to 2010. Dr. Dinh Dang, who had been a Nishina Center Research Scientist in the HINP Laboratory, also joined the TNP Laboratory in 2010 when the HINP Laboratory was closed at the retirement of Dr. Motobayashi. We had fourteen members and several regular visitors in 2010. In 2013, I myself decided to leave RIKEN, and moved to University of Tsukuba in April 2014. Since then, the group was entering a closing stage, for which I was acting as an invited group head for two years. There were three postdocs in 2014, only one in 2015. *And Then There Were None.* The TNP Laboratory was officially closed in March 2016.

Exploring elementary modes of excitation in nuclei was one of major research subjects in the TNP Laboratory; collective motion under ultra-fast rotation, those associated with the isospin degrees of freedom, shell-structure dependence, non-adiabatic effect, strong anharmonicity in low-lying collective states, and their dissipation. The finiteness of nucleus and the nature of the strong interaction lead to unique properties of collective modes. We were interested in this uniqueness of nuclear-structure physics as a strong-coupling finite-quantum system. Currently in University of Tsukuba, I am working on somewhat continuous line of these subjects, together with graduate students.

Theoretical methodologies developed in nuclear physics have many things in common in other fields of physics. In the TNP Laboratory, there were activities in these related areas. We studied superfluidity in fermionic cold atoms, electronic dynamics in solids, photoresponse in molecules and clusters, etc., using techniques identical (similar) to nuclear physics. Quantum statistics of mesoscopic systems, dissipation in finite systems, microscopic description of macroscopic properties, etc., these are long-standing problems in the nuclear physics and important issues in the other fields of mesoscopic physics as well.

When I started the TNP Laboratory, RIKEN was in charge of constructing a peta-flops supercomputer, currently known as the "K" computer. I was involved in HPCI Strategic Program Field 5 (URL: `http://www.jicfus.jp/field5/en/`) to develop applications in nuclear physics for the K computer. This became one of major research issues in the TNP Laboratory. We made extensive effort to develop computer codes for large-scale parallel computation, based on the time-dependent density-functional approaches to collective dynamics in nuclei. Our project on the K computer produced a number of novel results in the field of nuclear physics, including photonuclear reaction, nucleus-nucleus collision, charge-exchange reaction, and neutrinoless double-beta decay.

University of Tokyo and University of Tsukuba established Joint Center for Advanced High Performance Computing (JCAHPC). JCAHPC has recently introduced a new supercomputer system "Oakforest-PACS" with 25 PFLOPS peak performance, currently the fastest in Japan. The developments done in the TNP Laboratory have produced several applications, running on the Oakforest-PACS.

I thank all the former members and visiting scientists in the TNP Laboratory. Their contributions and support were essential elements to keep the TNP Laboratory lively and active. More details about researches and history of the TNP Laboratory can be found at the following site:

`http://www.nishina.riken.jp/lab/TNP/`.

Cheers and thank you to all!

Fig. 1. Photograph on March 28, 2016, at RIBF Conf. Room.

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