Report: The Second China-US-RIB Workshop on Physics of Nuclei and Hadrons

December 2017

Workshop Summary

The second China-US-RIB Workshop on Physics of Nuclei and Hadrons took place October 16-18, 2017 at the School of Physics, Peking University (PKU). The goal was to explore various forms of collaborative endeavors in experiment and theory relevant to the FRIB and HIAF science program. The Workshop, chaired by Junchen Pei (PKU) and Xiaodong Tang (IMP) and, was organized by a joint US-China-RIB Task Force. It was sponsored by Peking University, Institute of Modern Physics (IMP-CAS), China Center of Advanced Science and Technology (CCAST) and the China–US Theory Institute of Physics of Exotic Nuclei (CUSTIPEN). About 120 participants, including 15 attendees from US, attended the Workshop.

The Workshop was opened by Prof. Xincheng Xie (Dean of the School of Physics/Director of the Department of Mathematics and Physics of the NSFC). Witek Nazarewicz (FRIB Chief Scientist/MSU) presented the greeting slides from Tim Hallman (Associate Director for Nuclear Physics/DOE Office of Science) and Stephen Hsu (Vice President for Research and Graduate Studies/MSU). Yanlin Ye (Chair, Nuclear Physics Society of China/PKU) presented possibilities of expanding cooperation with FRIB through projects from China-side. The plenary part of the scientific program was primarily focused on the progress in collaborative efforts tied to science with rare isotope beams, efforts involving interdisciplinary connections, and presentations from junior scientists. The parallel sessions were dedicated to the meetings of nine Working Groups: (1) Nuclear Structure/Direct Reaction Experiments, (2) Nuclear Astrophysics, (3) Fundamental Interactions, (4) Equation of State, (5) Nuclear Structure Theory, (6) QCD Theory, (7) Facilities, (8) Nuclear Data and Isotopes, and (9) Education.

The general discussions on the evolution of collaborative efforts took place following the presentations of the Working Group reports. The Working Groups assessed the areas of strength, existing joint projects, and prospects for collaborative endeavors. Following Working Group summaries, the panel discussion took place. It has been concluded that there is a need for an agreement that is significantly broader than current institution-to-institution collaborations. The outcome of the workshop was a set of resolutions adopted by the town meeting.

The material generated during the workshop can be found on the CUSTIPEN website http://custipen.pku.edu.cn/meeting/china_us_rib_2nd/Home.htm


2nd China-US-RIB Meeting Oct.16-18 2017 Peking University

The 2nd China-US-RIB Workshop Resolutions

1. We endorse the existing and planned collaborative China-US efforts. Those include, are not limited to, Decay Station, Time Projection Chamber, detector developments, charge-exchange reactions, nuclear data, EDM, EOS, and LQCD.

2. We endorse collaborative topical China-US meetings in nuclear theory (primarily through CUSTIPEN) and experiment. Of particular importance are (i) the "expert meetings" on fast beam diagnostics, gas stopping, laser spectroscopy and ionization, magnet, and target technology, and (ii) series of meetings on intersections of structure and reaction theory.

3. We recommend the creation of the theory infrastructure in China alongside experimental infrastructure. In particular, we endorse the establishment of a national theory effort around HIAF (HIAF-Theory Alliance). If created, it could be a natural partner to the FRIB-TA.

4. We recommend taking the full advantage of CSC-based programs. This includes the current Fellow program, and new programs for scholars and graduate students.

5. We endorse the TALENT-China initiative. Following the TALENT2018 in Henan, there is a programmatic need for TALENT courses on reaction theory and heavy ion reactions.

6. We propose that the third US-China meeting on Physics of Nuclei and Hadrons takes place in two years.

FRIB-China Working Group Reports

WG1: Nuclear Structure/Direct Reactions Experiments

Conveners: Wolfgang Mittig, Feng-Shou Zhang, Shaofei Zhu

The Working Group of Nuclear Structure and Reaction was attended by 49 participants. A total ten short talks (10+5 minutes) were presented, leading to the discussion of possible future collaborative efforts. Through these presentations it was obvious that this topic is closely associated with topics of other working groups of this meeting, such as Basic Nuclear Theory, Fundamental Symmetries, Nuclear Structure Theory, Nuclear Astrophysics, and Nuclear Instruments. The titles of all the presentations are listed as following.

- Northern Boundary of the "Island of Inversion" and Triaxiality in ^{34}Si*; (C. Y. Niu, School of Physics, Peking University)*
- Nuclear-Cluster Studies at PKU; *(Yang Liu, School of Physics, Peking University)*
- Study of exotic structure for the loosely-bound nuclei via transfer reactions at PKU; *(J. L. Lou, School of Physics, Peking University)*
- Nuclear structure studies using precision laser spectroscopy*; (Xiaofei Yang, School of Physics, Peking University)*
- The Applications of Direct Reactions in the Nuclear Structure Studies at High Spins; *(S. Zhu, Argonne National laboratory)*
- Tensor-force-driven shell evolution in the "west" of the double-magic ^{132}Sn: Reduced πg9/2 - πg7/2 splitting; *(Z. Q Cheng, School of Physics, Peking University)*
- Low Energy Reaction Experiment; *(Huiming Jia, CIAE)*
- Study on sub-barrier fusion reactions and multi-nucleon transfer reactions; *(Peiwei Wen, CIAE)*
- Nuclear Reactions (with RIBs); *(Chengjian Lin, CIAE)*
- Gamma Spectroscopy of N~Z nuclei towards ^{100}Sn; *(Zhong Liu, IMP)*

Following these presentations, a list of possible collaborative projects, as well as the possible way of executing the collaborations was identified during the discussion. It was found that before the collaborative efforts are taken effects, the first step should be the mutual participation in existing projects on both sides, China and US. The pathway of successfully proposing experiments to the facilities in US by the group in China was discussed. A list of specific topics that could be mutually beneficial was suggested and discussed.

- Start and initiate the collaboration on the project of "Charge Exchange reactions", such as exchange of detectors and manpower, identify the needs of beams and theoretical support.
- Short periods (about 3 months) of scholar exchange programs with well-defined projects for such a short period, as an addition to the FRIB-CSA post-doc fellow program. The participants should include junior and mid-career scientists and faculties.

- Complete spectroscopy of one selected nucleus of specific interest as subject for a collaborative effort, with complementary methods from US and China, combining experimental and theoretical effort.
- Organizational mechanism of submitting proposals to different facilities.
- Collaborative development and test of detectors.

Compiled by Shaofei Zhu

WG2: Nuclear Astrophysics

Conveners: Michael Smith, Xiaodong Tang

There were 11 participants in the nuclear astrophysics breakout session: Jianjun He (NAOC/IMP Lanzhou), Xiaodong Tang (IMP Lanzhou), Shigeru Kubono (RIKEN/IMP Lanzhou), Michael Smith (ORNL), Weiping Liu (CIAE), Long Zhu (SYSU), Bingshui Gao (NSCL), Baishan Hu (PKU), Yifang Geng (PKU), Ying Jiang (PKU), Xiao Fang (SYSU), and Baohua Sun (Beihang).

To explore future possible collaborative efforts, we started by identifying science topics, facilities & institutions, and specific projects and benefits. Our list is representative rather than exhaustive or complete, and represents the interests of the attendees. While our focus for this session was on experimental activities, we acknowledge the critical role that theory plays in all areas of nuclear astrophysics. At the end of our session, we also discussed establishing a new mechanism for enabling such collaborative efforts in the future. This new mechanism was the basis for a recommendation from this Working Group. We also recommend a mechanism to improve communication between US and China research efforts in the physics of unstable nuclei.

Our scientific focus was on stellar evolution and explosions [rp-process, r-process, nuprocess] and related reactions and structure of unstable nuclei. We identified nine different experimental facilities with radioactive beam capabilities that are important for this research: HIRFL [IMP Lanzhou], HIAF [IMP Huizhou], BRIF [CIAE Beijing], Beijing ISOL [CIAE & PKU, Beijing]; NSCL / ReA3 [MSU], CARIBU [ANL], Twinsol [Notre Dame], TREX and MARS [TAMU], and FRIB [MSU]. We also discussed possibilities for measurements with radioactive targets and other activities at SLEGS [SINAP Shanghai], JUNA [CIAE IMP NAOC …], and CSNS [IHEP, Dongguan], as well as links between HIAF and CIADS.

We then discussed a number of high-priority opportunities for collaborative efforts in nuclear astrophysics with unstable nuclei. These included:

- Beijing ISOL: reactor/linac driver to generate high-intensities of very n-rich nuclei for r-process studies;
- HIRFL/HIAF: charge-exchange reactions, high resolution spectrometer, active targets, astrophysical simulation capability, nuclear data for astrophysics;
- NSCL/ReA3/FRIB: participation in planned experiments, proposing new experiments.

We also discussed mechanisms for improving collaborative opportunities between the US and China. This discussion was not limited to nuclear astrophysics, but was rather more general in nature. Numerous ideas were discussed in detail, and we found two ideas to be

particularly promising: establishing an FRIB-CSC program for Scholars, and establishing a set of web pages on research, facilities, and resources at us-china-rib.org. Below we list our two recommendations:

- **Recommendation 1:** In order to facilitate collaborative research projects in the physics of unstable nuclei, we suggest the establishment of a FRIB-CSC program for Scholars to embed Chinese Scientists and Faculty in research groups in the U.S. This program would mirror the FRIBCSC Fellow program but be targeted at established researchers in China rather than at senior graduate students and new postdocs.
- **Recommendation 2:** In order to improve communication between US and China research efforts in the physics of unstable nuclei, we suggest the creation of an additional set of web pages within the us-china-rib.org website that lists the capabilities, plans, manpower and resource requests, and contact information of research groups in both the US and China.

Compiled by Michael Smith, Xiaodong Tang

WG3: Fundamental Interactions

Conveners: Zheng-Tian Lu, Jaideep Singh

Participants: Zheng-Tian Lu (University of Science and Technology of China), Yue Shi (Harbin Institute of Technology), Jaideep Singh (Michigan State University)

The Facility for Rare Isotope Beams (FRIB) will provide an unprecedented opportunity for the search of permanent electric dipole moments (EDM) of rare isotopes. EDMs violate both T-(time-reversal) and P-(parity) symmetries and, by the CPT theorem, CP-(the combination of charge (C) and parity) symmetry. CP-violation has long been thought to be one of the key ingredients needed to explain the matter-antimatter asymmetry of the visible universe. The amount of CP-violation currently encoded in the Standard Model (SM), observed only in the weak interaction, is far too feeble to explain this observed asymmetry. EDMs are a clean signature of CP-violation and are complementary to CP-violation searches at the LHC. Since SM EDMs are expected to be very small, any observation of an EDM at present and projected levels of sensitivity would mean the discovery of new physics beyond the SM or a non-zero value value for θ_{QCD} angle, a parameter, which describes CP-violation within the strong interaction. EDMs of paramagnetic systems, diamagnetic systems, and neutrons have a complementary sensitivity to new sources of CP-violation such as supersymmetry. Thus far, a non - zero EDM has yet to be measured.

The conventional EDM experiment involves observing a large ensemble of spin-polarized particles in parallel magnetic and electric fields. A small frequency shift that is linearly dependent on the electric field would signal an EDM. Performing such a measurement requires exquisite control of the stability and uniformity of the applied magnetic field and of systematic effects that mimic an EDM-like signal. Rare isotopes provide significant discovery potential for EDM searches because they amplify the observable EDM by orders of magnitude compared to stable species. This implies that less stringent control of the magnetic field environment and systematic effects are required in order to have a highly sensitive EDM search. Diamagnetic systems, which have octupole-deformed nuclei, such as Ra, Rn, and Pa, are favorable candidates because the combination of their unusual nuclear structure and highly relativistic atomic structure amplify the effects of CP-violating interactions originating within the nucleus by several orders of magnitude compared to nearly spherical nuclei such as Hg or Xe. Another attractive feature of rare isotopes is that the theoretical uncertainties in interpreting EDM results are more under control than for their stable counterparts. Nuclear theory calculations for octupole-deformed species are more robust because knowledge of just the lowest nuclear energy levels are required to calculate the new physics sensitivity, which is not true for Hg nucleus. We also note that Fr is a very promising candidate for EDM searches in paramagnetic systems. Its atomic theory is relatively simple because it has only one valence electron and its highly relativistic atomic structure gives it the largest enhancement factor of all the alkali atoms.

FRIB is expected to provide quantities of Ra, Rn, and Pa that rivals or are orders of magnitude more than what is currently available. In order to take full advantage of this upcoming opportunity, several technical, chemical, atomic, and nuclear physics techniques will have to be developed in the intervening years. Because of the specific atomic structure of each of these isotopes and their different half-lives, a variety of different techniques will be required to collect the atoms, spin-polarize them, and then monitor the spin precession in order to

perform the EDM searches. This presents a broad range of opportunities for EDM collaborations for the foreseeable future.

At the workshop, we first reviewed progress from the last workshop held in May 2015 at MSU and then enumerated specific scientific opportunities, the areas where technical expertise could be shared, and the continued opportunities for collaboration. First, tighter collaboration between nuclear and atomic theorists and experimentalists are required to both identify promising EDM candidates as well as to interpret EDM results. In anticipation of new results, new or updated calculations of the Schiff moment of 129Xe, 171Yb, 199Hg, 205Tl, 221/223Rn, 225Ra, and 229Pa are needed. In particular, these calculations should start to quantify the uncertainties due to choices made regarding the computational technique. This is particularly relevant since a second EDM result from the 225Ra laser trap experiment along with a detailed analysis of systematics was published in 2016. Furthermore, there are plans for a new 171Yb laser trap experiment at USTC which will initially be used to test upgrades for the 225Ra experiment & to study laser trap systematics and, eventually, to control for systematic effects as a co-located magnetometer for the 225Ra experiment. Another intriguing possibility is 229Pa, which has long been thought to be significantly more sensitive than 225Ra. However, there is not yet enough information available about 229Pa to put this claim on firm quantitative footing. This is strong motivation for 229Pa nuclear structure studies in the early days of FRIB. Because of its chemistry, halflife, and nuclear spin, the most promising experimental techniques for searching for the 229Pa EDM may be an atomic beam-style experiment or experiment using Pa ions embedded inside of an optical crystal. These possibilities need to be explored more carefully by studying the possible systematic limitations of these two alternate approaches. Finally, there is also an ongoing EDM effort that utilizes Rn isotopes. Some of the development work for Rn EDM, such as well as two photon optical magnetometry using stable Xe isotopes, can occur now at the NSCL.

Many of the experimental techniques & challenges are largely common to all EDM experiments. This includes laser spectroscopy, generation, control, & monitoring of magnetic fields, generation, control, & monitoring of high electric fields, and sustaining deep ultrahigh vacuum. By working together, we can avoid reinventing the wheel, while pursuing different approaches. One significant and urgent need for FRIB EDM experiments is knowledge of the radiochemistry needed to extract and purify the relevant isotopes, which will be developed by Greg Severin as a part of the larger isotope harvesting effort at FRIB. We resolved to share the aforementioned technical expertise via the following collaboration mechanisms:

- First, we have submitted proposals to our mutual funding agencies.
- Second, we have and plan on regular visits to our respective labs.
- Third, we agreed to the possibility of co-advising PhD students from both institutions.
- Fourth, we resolved to co-organize bilateral workshops that would alternate between the Yellow Mountains of China and the Grand Rapids of Michigan. This fundamental interactions and precision measurements with rare isotopes workshop would include a range of topics beyond EDMs, such as atomic & nuclear theory, radiochemistry, tests of parity violation, nuclear moments and radii, and precision mass measurements.
- Fifth, we agreed on the need to bring EDM theorists & experiments from all disciplines (atomic, neutron, molecular, nuclear) simultaneously for a INT-style workshop with the goal of producing a white paper which articulates specific theory needed interpreting experimental results within a global analysis framework.

Compiled by Jaideep Singh

WG4: Equation of State

Conveners: Lie-Wen Chen, Umesh Garg, Jorge Piekarewicz, Betty Tsang

Attendees:
Lie-Wen Chen (SJTU); Pawel Danielewicz (NSCL/MSU); Zhao-Qing Feng(IMP); Umesh Garg (Notre Dame); Bao-An Li (TAMUC); Yu-Gang Ma (SINAP); Jorge Piekarewicz (FSU); Betty Tsang (NSCL/MSU); Renxin Xu(Peking University), Chang Xu (Nanjing); YingXun Zhang (CIAE)

The session on the equation of state (EOS) revolved around two main scientific themes: (a) the ongoing comprehensive effort to benchmark transport codes to properly analyze laboratory experiments and (b) the impact of the first detection of gravitational waves from a binary neutron star merger—a historical event that was announced during the meeting.

Various presentations were made including an overview and status of the transport code evaluation project that highlighted the significant progress that has been made so far. Indeed, this large collaboration of nearly 30 scientists from across China and the US (and Europe) has recently submitted their second publication. (Their first joint paper was published in Phys. Rev. C 93, 044609 (2016)). It is clear that the collaboration will continue their efforts to benchmark their various transport codes.

The announcement of the historical first detection of gravitational waves from a binary neutron star merger by the LIGO/VIRGO collaboration provides critical constraints on the EOS of dense matter. Indeed, this first event already disfavors neutrons stars with very large radii—suggesting that the symmetry energy at high densities cannot be overly stiff; recent estimates suggests an upper limit on the radius of a 1.6 solar-mass neutron star of about 13.25 km. The detection of gravitational waves together with the observation of the electromagnetic counterparts from both the associated short gamma-ray burst and the "kilonova" powered by the radioactive decay of r-process elements officially opened the new era of multi-messenger astronomy. This represents a unique opportunity for new and fruitful US-China collaborations relevant to the physics of exotic nuclei. To capitalize on these unique opportunities, the working group on the EOS drafted the following set of recommendations:

1. Continue to benchmark various aspects of transport codes in an effort to minimize model dependences.

2. Perform experiments at the Cooler Storage Ring at the Heavy Ion Research Facility in Lanzhou to probe the incompressibility of neutron-rich matter.

3. Secure funding from the Institute of Modern Physics of the Chinese Academy of Sciences for the construction of equipment for external target experiments.

4. Embark on collaborative efforts to calculate the many physical observables that are informed by the new gravitational-wave detection.

Compiled by Jorge Piekarewicz

WG5: Nuclear Structure Theory

Conveners (low-energy): Calvin Johnson, Furong Xu

Twenty-one attendees participated in the nuclear theory working group, which focused on nuclear structure and low-energy reaction theory. Names and affiliations are given at the end.

We had eleven presentations, on topics ranging from the phenomenological shell model and the nuclear pair approximation, to ab initio nuclear structure calculations. Of particular note were several talks on the Gamow shell model, which is a prominent approach to open quantum systems, and an overview talk on the status and needs of low-energy reaction theory. We agreed that we should expand the definition of this working group from just low-energy nuclear structure theory to the theory of low energy structure and reactions.

Following the first meeting at MSU in 2015, our discussions centered mostly upon structural recommendations. Reviewing the report of this working group from 2015, we found that four out of five recommendations had been implemented or were being implemented. These included a program supporting Chinese postdocs in the US, a US-China coordinating committee, and bringing the TALENT education program to China.

The fifth recommendation was: "Encourage the formation of a Chinese nuclear physics and/or nuclear theory coordinating committee, to help develop coherent research plans across many institutions. Those plans will be further discussed with the FRIB Theory Alliance and CUSTIPEN to form topical collaborations." This recommendation was probably premature for its time.

Our discussions in the current working group had two major threads: further strengthening of US-China exchanges, through postdocs, students, and senior scholars, and better alignment of theory in China with experimental programs in China. This latter naturally lead to the discussion of encouraging low-energy reaction theory in China, of which there is currently very little.

In our discussions, certain structural issues were pointed out. For example, while there was broad support for expanding the CSC postdoctoral program (sending students to the US as postdocs) to candidates from institutions beyond PKU and IMP, any expansion would formally require a new proposal and possibly a new PI.
Another concern emphasized by the Chinese students was the viability of getting positions in reaction theory in China.

Taking these goals and concerns seriously, we crafted the following two broad recommendations with specific recommendations under each of them:

Build up theory infrastructure in China alongside experimental infrastructure

- Create national theory effort around HIAF (HIAF-TA). This would be a natural partner for the US-based FRIB-TA.
- Send US-based postdocs to China, keeping connections back in US, especially in topics with strong needs.
- Encourage excellent nuclear theory students for apply for CSC graduate student funds to study in US.

- Explore expanding CSC postdoc fellows from Chinese institutions besides PKU, IMP (will require new proposal and, possibly, a new principle investigator).

Build up low-energy reaction theory, important for current and planned Chinese experimental program, in terms of capability, visibility, and status.

- HIAF needs low-energy reaction theory for success.
- Hold conferences on intersection of structure and reaction theory, sponsored in part by labs such as IMP.
- Propose transnational topical collaborations on intersection of structure and reaction theory (funding source unclear)
- Run a TALENT course in China on reaction theory.

Attendees and Affiliations

1. GuoXiang Dong (Huzhou University)
2. SiJie Dai (PKU)
3. Charlotte Elster (Ohio University)
4. Yuan Gao (PKU)
5. BaiShan Hu (PKU)
6. Calvin Johnson (SDSU)
7. YuanZhuo Ma (PKU)
8. Witold Nazarewicz (MSU)
9. DanYang Pang (Beihang University)
10. JunChen Pei (PKU)
11. Yue Shi (Harbin Institute of Technology)
12. ZhongHao Sun (University of Tennessee)
13. Qiang Wu (PKU)
14. XiaoBao Wang (Huzhou University)
15. FuRong Xu (PKU)
16. WeiPing Xu (Beihang University)
17. Cenxi Yuan (Sun Yat-Sen University)
18. XiaoYan Yun (Beihang University)
19. ShanGui Zhou (Institute of Theoretical Physics, Chinese Academy of Science)
20. YuMin Zhao (ShangHai Jiaotong University)
21. ZhiWei Zuo (PKU)

(Not attending but contributed slides: Pieter Maris, Iowa State University)

Compiled by Calvin Johnson

WG6: QCD Theory

Conveners (QCD): Bo-Qiang Ma, Andrea Shindler

In the QCD Working Group participated: Bo-Qiang Ma (Peking University), Chuan Liu (Peking University), Andrea Shindler (FRIB/MSU), Pieter Maris (ISU), Yan-Qing Ma (Peking University), Xu Feng (Peking University), Ming Gong (IHEP). Several students audit the presentations and the discussions. The core of the presentations and discussion was focused on lattice QCD with some contributions from different non-perturbative approaches.

Physics Program
Based on the seminars presented we have isolated a set of physics problems that we believe deserve priority in the near future.

3-body interactions
The evaluation of 3-nucleon binding energy is still in its infancy but plays a key role in the estimate of the 3-nucleon forces and the corresponding impact on the location of the drip line. Formalism is developing for the determination of scattering parameters from the finite volume binding energy. Numerical determination are yet to come but a first attempt could be matching the lattice QCD binding energy with the same calculation performed in effective field theories. A longer-term project is consider binding energies of 3 bodies nucleon-hyperon systems. They would provide relevant information to constrain the equation of state of neutron stars. Collaborative efforts with European colleagues are already ongoing.

Parton Distribution Functions
After almost 40 years since the invention of lattice QCD we are moving towards a non-perturbative determination of the PDF. Several techniques are in the development phase: quasi-PDF, pseudo-PDF, OPEwOPE and lattice cross sections. This research thrust is also in an exploratory status because several issues are still to be solved. Confronting different techniques will certainly help in clarify those issues. Comparison with other approaches to QCD and hadron physics, such as Light-Front QCD, which provide direct access to the light front wave functions, may be useful to complement the lattice QCD efforts. There are already collaborative efforts in this direction.

Fundamental Symmetries
The two main physics problems we want to address is the double beta decay and the electric dipole moment. The double beta decay is a perfect first example of matrix elements between light nuclei. We believe that lattice QCD has reached the maturity to perform first calculations of light nuclei matrix elements. Here the big challenges are the renormalization (and continuum limit) together with the signal-to-noise problem.

Resonances and exotics
One of the main experiments at JLAB is GlueX. The goal of GlueX is to look for exotic hybrid mesons and study their properties. This is a very strong test of low energy QCD where gluonic degrees of freedom are explicitly manifest. A LQCD group at JLAB, W&M and ODU is currently studying the spectroscopy of exotic hybrid mesons and the corresponding decay channels. There is at the moment no LQCD activity connected to this problem in this WG, but we believe it is a very important research thrust. Light-Front QCD can also be used to provide can be

used to provide additional information to the heavy quarkonium spectra and potentially also exotic hybrid mesons.

Synergistic activities

We have identified 2 practical directions for potential synergies:

- *Potential future collaborations*: During the working group we have identified two different collaborations for potential collaborations: parton distribution functions (Xu Feng and Andrea Shindler), heavy quark physics (Ming Gong, Zhaofeng Liu and Andrea Shindler).
- *Student postdocs exchange:* We will advertise the possibility of the FRIB-CSC fellowships to spend in the US together with the possibility of Chinese PhD and postdocs grants to spend in China. We have not isolated a suitable candidate yet.

Computational resources

There are substantial computational resources in China at the moment not completely exploited. The reasons is twofold: the hardware architecture is not user friendly with existing codes and the computer time application system is still based on a buy-in method that can be inconvenient for large scale project such as lattice QCD calculations. A newly founded Chinese Lattice QCD consortium is investing man power in writing new codes developed for these particular architectures.

Conclusions

The newly Chinese LQCD consortium is a great opportunity to launch large scale initiatives in China. At the moment, most of the efforts are focused on writing optimized LQCD codes capable to run on Chinese developed hardware. Given the current situation, it is difficult to imagine large-scale collaborative efforts. Many issues have to be solved such as the intellectual property and software development. It is possible though and highly encouraged to have smaller collaborations on specific physics problems. Once the Chinese LQCD community has reached the same level of development concerning LQCD codes, this should be the basis for potential larger scale efforts.

Compiled by Andrea Shindler

WG7: Facilities

Conveners: Bradley Sherrill, Yanlin Ye, Xiaohong Zhou

Time: October 17, 2017
Location: Peking University
Participants:
IMP: Zhou Xiaohong, Liu Zhong and Huang Wenxue
MSU: Bradley Sherrill
PKU: Ye Yanlin and Yang Xiaofei
CIAE: Liu Weiping

The purpose of the facility working group was to identify the mutual interests the present and future facilities in US (e.g. NSCL and FRIB) and China (e.g. BISOL, HIRFL and HIAF). We discussed experimental techniques and setups at ongoing-facilities and projects FRIB, HAIF, JUNA, and future planned facility BISOL. After extensive discussions in the meeting of the working group we identified several interests that could form the basis for future collaboration. A brief summary of each discussed topic is given below.

- We should make an effort to contribute in-kind from China side to a Decay Station project. The Decay Station is composed of the implantation system, gamma-ray detector array, charged particle detector array, neutron detector array, electronics and data taking system. In China, there are several research groups engaged in nuclear decay spectroscopy for long time, and they have very strong interest to get involved in the construction of the Decay Station for rare isotope facilities. At the beginning of 2018, we will organize a meeting in China to identify the interests from IMP, PKU, CIAE and other Chinese institutions, and establish a working team. This team will take the responsibility to apply for a program from NSFC dedicated to international collaboration, and if we succeeded in getting the financial support we will negotiate with the researchers concerned in the U.S. and try to make some parts for the whole system of a Decay Station, such as the LaBr3. Hopefully, the Decay Station could move between laboratories and conduct experiments at both FRIB and HIAF.

- We should encourage collaboration in areas of joint technical interest. A solid collaboration already exists on TPC development. We encourage this to be further developed and include future collaboration and mutual participation in TPC experiments.

- We think the time is right to organize “Expert Meetings” on fast beam diagnostics, gas stopping, LASER spectroscopy and ionization, magnet, and target technology. A goal would be to have one or two of these meetings in the next few years.

- Invitations for individual visits to Chinese and US Institutes should be initiated. The China-US Steering Committee should make recommendations for possible visits.

Compiled by Zhou Xiaohong

WG8: Nuclear Data and Isotopes

Conveners: F.G. Kondev, Meng Wang

Participants:

IMP: M. Wang and Guang-Shun Li
CSNSM: G. Audi and W. Huang
FRIB & MSU: W. Nazarewicz
ANL: F.G. Kondev
Jilin U: D. Yang
Sun Yat-Sen U: C. Yuan

The purpose of this working group was to identify mutual interests in the present and future RIB facilities in China and US in the area of Nuclear Data. Reliable nuclear data represent the fundamental building blocks of basic nuclear physics and astrophysics research, and are also of importance in many applications. There is a continuous demand for high-quality updates of the main nuclear physics databases via the prompt compilation and evaluation of the latest experimental and theoretical results. Such credible databases also act as a bridge between science, technology, and society by making the results of basic nuclear physics research available to a broad audience of users, and hence expanding the societal utilization of nuclear science. It was concluded that:

- Continuation of the international Atomic Mass Evaluation (AME) collaboration activities under the leadership of Institute of Modern Physics (CAS, China) are critical for the future mass measurement programs at the premier RIB facilities. Continuing support by the community and funding agencies is imperative for securing the future of these activities.

- It is advocated to establish stronger collaboration links between scientists from US and China in the Nuclear Structure and Nuclear Astrophysics data areas. It is recommended to include theoretical predictions into the nuclear data activities in order to provide better consistency and credibility to the evaluated nuclear data.

Compiled by F.G. Kondev and Meng Wang

WG9: Education

Conveners: Morten Hjorth-Jensen, Shan-Gui Zhou

Participants: Many participants of the meeting have taken part in the discussions of Education either in the breaks and plenary sessions (in particular, in Hjorth-Jensen's talk on TALENT, Zhou's WG8 report, and the Town Meeting) or in the dedicated parallel session WG8 Education from 10 am to 3 pm on Oct. 17. Those who were involved in the latter include: De-Qing Fang (Shanghai Institute of Applied Physics, Chinese Academy of Sciences, SINAP/CAS), Chun-Wang Ma (Henan Normal University, HNU), Witek Nazarewicz (Michigan State University, MSU), Junchen Pei (Peking University, PKU), Furong Xu (PKU), Yu-Min Zhao (Shanghai Jiaotong University, SJTU), and Shan-Gui Zhou (Institute of Theoretical Phys., Chinese Academy of Sciences, ITP/CAS). Discussions were mainly focused on the TALENT2018 in China and Chun-Wang Ma gave a nice presentation about the preparation for this TALENT program and the resources his University will provide; other topics include survey courses of nuclear science, the FRIB-CSC program, and postdoctoral fellows.

TALENT2018 in China

The nuclear TALENT initiative (www.nucleartalent.org) has successfully organized and run ten advanced courses in low energy nuclear theory. During the 1st US-China-RIB meeting held at Michigan State University in May 2015, it was recommended that the Chinese community should join the nuclear TALENT initiative. Since then much effort has been made in order to achieve this goal. Upon a suggestion of Yugang Ma from SINAP, Chun-Wang Ma and colleagues from HNU showed a strong interest to host the 1st TALENT program in China. Furong Xu and Shan-Gui Zhou from the Chinese side and Dick Furnstahl and Morten Hjorth-Jensen from the TALENT Board communicated a lot and finally agreed that the 1st TALENT program in China will be held in HNU in 2018 (in short, TALENT2018) and the local organizer will be Chun-Wang Ma.

During the 2nd China-US-RIB Collaboration Meeting, many participants were involved in the discussions on TALENT programs in China, in particular on TALENT2018. It was fully agreed that TALENT programs in China should benefit Chinese nuclear physics community and we should work hard to ensure the success of TALENT2018 so that TALENT programs can be continued in China in the future. The consensus was made concerning the following aspects:

- Date: Middle July to middle August, 4 weeks
- Topic(s): Many-body methods for nuclear structure and reactions, focusing on nuclear shell model with applications to structure and reactions.
- Budgets: Mainly from National Natural Science Foundation of China (NSFC) with additional supports from PKU, Beijing Normal University, HNU, China Institute of Atomic Energy (CIAE) and several institutes of CAS including ITP, the Institute of Modern Physics (IMP), and SINAP, etc.
- There should be Chinese lecturers(s).
- Junior researcher(s) may be included as "students".

Survey courses of nuclear science

Since many research groups are small and fragmented, courses of general interests are not available in many institutions. Therefore, we should promote not only specialized courses like TALENT, but also basic courses. Now there are some, e.g.,

- Survey of Nuclear Physics 2017 by Witold Nazarewicz at MSU: https://people.nscl.msu.edu/~witek/Classes/PHY802/NuclPhys802-2017.html
- Topics in Nuclear Physics 2017 by Dick Furnstahl at Ohio State University: http://www.physics.ohio-state.edu/~ntg/6805
- Courses of nuclear physics by Yanlin Ye and Hui Hua at PKU.
- Courses of nuclear theory by Yu-Min Zhao at SJTU.
- Courses of nuclear astrophysics by Michael Smith at Beihang University (BUAA).

The main issues which have been discussed are:

- Is it possible to integrate material developed in different TALENT courses, offering thereby a coherent source for educating the next generation of nuclear physicists?
- How many basic courses can an institution offer, and which courses should be offered?
- How can we coordinate an advanced training in nuclear physics?
- Can we integrate the (ad hoc) TALENT courses/initiative in our education?

Postdoctoral fellows. The main conclusions are:

- Young researchers from the US are encouraged to take postdoctoral positions in China.
- The FRIB-CSC fellows are now mainly from IMP and PKU. Since each CSC project may only have limited coverage, application of new projects should be proceeded by other institutions in order to take more advantages of the CSC-based programs.
- In TALENT2018, FRIB-CSC postdoctoral fellows could teach as assistants.

Compiled by Shan-Gui Zhou

Appendix: The Second China-US-RIB Workshop Program

Oct. 15, 14:00 to 20:00 PM

Registration: The lobby of Shaoyuan hotel

18:00 Dinner: Buffet at the Shaoyuan hotel first floor .

Oct. 16 **Morning Plenary Session (West-202, Physics Building)**

Time	Agenda
Chair	Furong Xu
9:30-9:40	Welcome address (Xincheng Xie and Guoqing Xiao)
9:40-9:55	Greetings from DOE and MSU (Witek Nazarewicz)
9:55-10:10	Possibilities of Expanding Cooperation with FRIB through Projects from China-side (Yanlin Ye)
10:10-10:20	Purpose and organization of this workshop（Junchen Pei）
10:20-10-50	Tea Break and Photo
Chair	Umesh Garg
10:50-11:40	FRIB overview (Bradley Sherrill)
11:40-12:30	HIRFL-Lanzhou and HIAF overview (Xiaohong Zhou)
12:30	Lunch (Nongyuan Cafeteria first floor)

Oct. 16 **Afternoon Plenary Session (West-202, Physics Building)**

Chair	Charlotte Elster
14:00-14:20	CUSTIPEN (Bao-An Li)
14:20-14:40	FRIB-CSC (Michael Smith)
14:40-15:10	Nuclear Data Program (Filip Kondev)
15:10-15:30	FRIB Theory Alliance (Witek Nazarewicz)
15:30-16:00	Tea Break
Chair	Huanqiao Zhang
16:00-16:30	TALENT (Morten Hjorth-Jensen)
16:30-16:45	FRIB-CSC fellow presentation (Bingshui Gao)
16:45-17:00	Student presentation (Xinliang Yan)
17:00-17:15	Student presentation (Chang Gong)

17:15-17:30	Student presentation (Kai Wang)
18:00	Dinner (Zhongguan Xinyuan Building-6, Chenguang Buffet)

Oct. 17 **Morning Parallel Session**	
9:30-12:00	Meeting Rooms of the Working Groups, Physics Building WG1 Nuclear Structure & Reactions: West 202 WG2 Nuclear Astrophysics: West 125 WG3 Fundamental Interactions: West 206 WG4 Equation of State: South 506 WG5.1 Nuclear Theory: West 213 WG5.2 QCD: South 408 WG6 Facilities: West 113 WG7 Nuclear Data: Middle 508 WG8 Education: North 216
12:30	Lunch (Nongyuan Cafeteria first floor)
14:00-15:00	Working Groups

Oct. 17 **Afternoon Plenary Session: Working Group reports by conveners (West-202, Physics Building)**	
15:00-15:30	Tea Break
Chair	Pawel Danielewicz
15:30-15:50	WG1 report: Nuclear Structure & Reactions
15:50-16:10	WG2 report: Nuclear Astrophysics
16:10-16:30	WG3 report: Fundamental Interactions
Chair	Weiping Liu
16:30-16:50	WG4 report: Equation of State
16:50-17:10	WG5.1 report: Nuclear Theory
17:10-17:30	WG5.2 report: QCD
18:00	Dinner (Nongyuan Cafeteria third floor)

Oct. 18 **Morning Plenary Session (West-202, Physics Building)**	
Chair	Yugang Ma
9:00-9:30	WG6 report: Facilities

9:30-9:50	WG7 report: Nuclear Data
9:50-10:10	WG8 report: Education
10:10-10:30	Tea Break
Chair	Jorge Piekarewicz
10:30-10:50	Summary of main issues to be addressed (Yanlin Ye)
10:50-12:20	Town Hall Meeting (Discussion Coordinator: Witek Nazarewicz; Xiaohong Zhou)
12:30	Lunch (Nongyuan Cafeteria first floor)