Purpose: Deliver an international venue for research on the physics of exotic nuclei during the new era of experimental investigation of rare isotopes.

Location: RIKEN, at the new RIB Factory

US Participation: Provide travel and local support for U.S. visits to JUSTIPEN.

Funding: Funding for JUSTIPEN is being provided by the Office of Nuclear Physics of the U. S. Department of Energy. Additional local support is provided by the University of Tokyo and RIKEN.
A note from David Dean:
I apologize for missing this very nice workshop that has been put together, and I appreciate on short notice James Vary stepping in. One never knows what is going to happen at the last minute in DC when working for an Under Secretary at DOE.

Had I been in Hawaii, I would have said a few words along the following lines.

Science stretches across international boundaries, involves many cultures, and has broad societal implications through the implementation of basic scientific ideas in real-world applications. In physics, the US and Japan are partners in various areas including the physics of nuclei and nuclear astrophysics. The advent of RIBF at RIKEN and the future FRIB at Michigan State University, and FAIR at GSI, along with existing present generation facilities, will enable continued exploration of exotic nuclei and nuclear astrophysics.

These facilities will produce data that will be important for validation of theoretical constructs that underpin our understanding of the entire domain of nuclei, and they should enable us to probe reactions that produce nuclei in exotic stellar explosions. In this context, we began pursuing JUSTIPEN, the Japan-U.S. Theory Institute for Physics with Exotic Nuclei. JUSTIPEN was conceived early 2005, and was discussed by the principle agency representatives from the US and Japan at the last APS-JSPS Hawaii meeting, held in Maui. JUSTIPEN officially opened its doors in July, 2006 with office space and infrastructure provided by RIKEN and the University of Tokyo through the JSPS. The US Department of Energy enables travel of US researchers (both theorists and experimentalists) to JUSTIPEN (and to other research institutions in Japan) in order to foster and grow collaborative research between the two nations. A concurrent effort for Japanese scientists to visit the US has culminated in a new JUSTIPEN-US theory building, part of the Joint Institute for Heavy-Ion Research at ORNL. We have had three workshops associated with JUSTIPEN in the US, and I expect that these efforts will grow over time.

On a personal note, fostering this program along with my colleagues in Japan and the US has been a most excellent experience that indeed adds value to both the US and Japanese nuclear physics programs. I believe we did something interesting with the concept of JUSTIPEN, and I believe others who are pursuing similar structures should find success (for example in nuclear experimental physics). I wish I were there to celebrate with you as JUSTIPEN continues its 4th year. Now on to a physics discussion about work I did while visiting JUSTIPEN in 2007 – on the role of size extensivity in nuclear many-body approaches including coupled-cluster theory…. (well, I guess James will tell you about something a little different).
JUSTIPEN’s purview is in the area of physics of or with exotic nuclei, including nuclear structure and reaction theory, nuclear astrophysics, and tests of the standard model using exotic nuclei. While JUSTIPEN primarily focuses on theory collaborations, experimentalists with theoretical collaborators in Japan are also encouraged to apply.

The U.S. component of JUSTIPEN program is intended to primarily fund travel grants for research scientists, post-doctoral fellows, and students whose current primary institutional affiliation is with a U.S. institution.
Governing Board

• Takaharu Otsuka (University of Tokyo) Managing Director
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• Hideyuki Sakai (University of Tokyo)

Further information and application forms are available at http://www.phys.utk.edu/justipen/
JUSTIPEN RNB Resources

RNB Resources

RNB User Facilities in Japan and U.S.
- RIKEN Accelerator Research Facility
- ATLAS at ANL
- HRIBF at ORNL
- NSCL at MSU
- Rare Isotope Accelerator Users Organization

RNB Theory Activities in Japan and U.S.
- JSPS Core-to-Core EFES program
- RIA Theory Group
- UNEDF SciDAC Project
- Institute for Nuclear Theory

For more information on JUSTIPEN, please contact deandj@oml.gov
JUSTIPEN Opening Meeting, July 2006
Joint JUSTIPEN - LACM meeting at Oak Ridge (March 2007)
Hokudai-TORIJIN-JUSTIPEN-EFES workshop
"Perspectives in Resonances and Continua on nuclei"
&
JUSTIPEN-EFES-Hokudai-UNEDF meeting
21-25 July 2008, Onuma International Seminar House, Hokkaido, Japan

http://www.cns.s.u-tokyo.ac.jp/torijn/Hokkaido-meeting/index.html

Organized by:
Nuclear Theory Group, Hokkaido University.
International Research Network for Exotic Femto Systems (EFES)
Todai-RIKEN Joint International Program for Exotic Nuclei (TORIJIN)
Japan-US Theory Institute for Physics with Exotic Nuclei (JUSTIPEN)

Organizing Committee:
K. Kato, T. Otsuka, T. Motobayashi, S. Shimoura,
N. Nakatsukasa, N. Itagaki, M. Kimura
B. Balantekin, B. Barrett, W. Nazarewicz, J. Vary
Meeting held in Oak Ridge in February 23-25, 2009 (Address by Arima)
Dedication of building expansion of JIHIR (8 offices)
Funded by State of Tennessee, University of Tennessee, ORNL, and Vanderbilt

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David Dean/Thomas Papenbrock (ORNL)
Richard Casten (Yale U.)
Baha Balantekin (U. Wisconsin)
Hiashi Horiuchi (Kyoto/Osaka) Tohru Motobayshi (RIKEN)
Witek Nazarewicz (UT/ORNL)
Hideyuki Sakai (U. Tokyo)

recent review:
D.J. Dean, Nuclear Physics News 18, 21 (2008)

“E” = Experiment
“F” = France
2008 article by David Dean

Nuclear Physics News
Volume 18/No. 4

facilities and methods

JUSTIPEN—The Japan U.S. Theory Institute for Physics with Exotic Nuclei

Next Meeting
December 7-8-9 in Tokyo
Benchmark investigation of *ab initio* No Core Methods
NCSM, NCFC, FCI, MCSM

JUSTIPEN-initiated collaboration
T. Abe, P. Maris, T. Otsuka, N. Shimizu, Y. Utsuno, J.P. Vary

Major goal: *ab initio* description of clustering phenomena

First results reported yesterday:
Workshop on *ab initio* calculations and nuclear forces
October 12, 2009
Waikoloa, Hawaii
“Digital FRIB” and beyond

Nuclear Landscape

- Ab initio
- Configuration Interaction
- Density Functional Theory

GFMC & NCSM
Coupled Cluster & CI
DFT & Extensions

Astro

12C(α,γ)

Hoyle

Standard Model
QCD/χEFT

ν-ββ

Beyond Standard Model

Nuclear Energy

fission

Astro

r-process

neutron star crust
Monte Carlo shell model (MCSM)

- Importance truncation

Conventional shell model

\[ H = \begin{pmatrix}
* & * & * & * & \cdots \\
* & * & * & * \\
* & * & \ddots & \\
\vdots & \ddots & & \\
\end{pmatrix} \]

Diagonalization

\[ |\Psi\rangle = \sum_{i=1}^{d_{QMC\sim30}} c_i |\psi_i(\sigma)\rangle \]

Monte Carlo shell model

\[ H \sim \begin{pmatrix}
* & * & \cdots \\
* & \ddots & \\
\vdots & & \\
\end{pmatrix} \]

Diagonalization

\[ \begin{pmatrix}
E_0 & 0 \\
E_1 & \ddots \\
0 & \ddots & \\
\end{pmatrix} \]

Important bases stochastically selected

Work in progress: Alternative no core truncation schemes

- No-Core Shell Model, No-Core Full Configuration
  - truncation on total number of H.O. quanta, $N_{\text{max}}$, in many-body basis space

- Full Configuration Interaction
  - truncation on single-particle basis space, retaining all many-body states allowed by the symmetries

- Monte-Carlo Shell Model
  - sampling of the many-body basis in a FCI truncation

- Importance Sampling
  - Navratil, Roth
  - sampling of the many-body basis in a $N_{\text{max}}$ truncation

- Symplectic No-Core Shell Model
  - Draayer et al., PetaApps grant
Snapshot comparisons

Ab initio method limited to systems
NCSM/NCFC/UMOA $A \leq 40 \ (56)$
GFMC $A \leq 12$
Coupled Cluster near closed subshells
Shell Model with core to be determined (Barrett)

Outstanding challenges
Large amplitude collective motion, clustering, halo nuclei, long range correlations, continuum physics,…..

<table>
<thead>
<tr>
<th>snapshot comparison</th>
<th>FCI</th>
<th>MCSM</th>
<th>NCSM/NCFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.M.</td>
<td>approximate</td>
<td>exact</td>
<td>exact</td>
</tr>
<tr>
<td>Coulomb</td>
<td>exact</td>
<td>perturbative</td>
<td>OK</td>
</tr>
<tr>
<td>Spectra</td>
<td>OK</td>
<td>some</td>
<td>OK</td>
</tr>
<tr>
<td>wfns $\rightarrow$ occ.probs.</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
</tr>
<tr>
<td>(diagonals of OBDM)</td>
<td>$\lesssim 10^{10}$</td>
<td>$\lesssim 10^{30}$</td>
<td>$\lesssim 10^{10}$</td>
</tr>
</tbody>
</table>
Many-Body Basis Spaces

$^{12}\text{C}$

MCSM includes $N_{\text{max}}$ space

Region sampled in different ways by MCSM and NCSM

NCSM includes $N_{\text{shell}}$ space

$N_{\text{shell}}$ [FCI]

$N_{\text{max}}$ [NCSM]
Convergence Pattern for NCFC

JISP16 NN interaction

NCFC: P. Maris, J.P. Vary and A. M. Shirokov,

JISP16: A.M. Shirokov, J.P. Vary, A.I. Mazur and T.A. Weber,
Convergence patterns of Nmax vs FCI truncations
JISP16 NN interaction
Convergence pattern of the $^4\text{He}$ g.s. energies w.r.t. QMCD basis dimension

- Comparison of MCSM (solid symbols) w/ MSHELL (dashed lines) @ Nshell = 2 (sp) & 4 (spsdpf)
hw dependence of $^4$He g.s. energies

- Comparison of MCSM (solid symbols) with FCI (open symbols w/ curves) @ $N_{\text{shell}} = 2$ (sp) & 4 (spsdpf)
Removal of spurious CM motion effect

- Comparison of MCSM (stochastic) w/ FCI (exact) @ Nshell = 2 (sp)

Consistent w/ FCI calc @ Nshell= 2
Ground-state energies of the other p-shell nuclei

Comparison of MCSM (solid symbols) with FCI (open symbols w/ curves)

\[ H = H_{\text{int}} + \beta H_{\text{cm}} \text{ with } \beta = 0 \]
Observation

Faster convergence with basis dimension is not necessarily required as MCSM samples much larger basis spaces

Key issue

How to optimize use of computational resources to achieve discovery physics potential of ab initio no core methods

Conclusions

MCSM offers opportunity to expand the discovery potential of ab initio no core methods

JUSTIPEN support critical to this international team effort
Thank you!