No Core Shell Model Workshop Summary and Outlook

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Workshop Summary

The No Core Shell Model is alive and well and living worldwide!

Three Nucleon Forces

The 3N force is here to stay! Can the 4N force be far behind?

1. Theoretical Work: Much work remains to be done. The full delta force; the 3N force in sub-leading order (N3LO); the 4N force in N3LO, etc.

Clearly need more people-power!

2. Applications: To significant and relevant problems, e.g., 14C beta lifetime, 14F, superallowed Fermi beta decay... The NEW predictive power of theory!

3. Approximations: Averages, centroids, etc. Do we want to do this?

If the 3N forces are really so important in determining the true properties of nuclear structure and reactions, why not make the effort to include them as fully as possible?

The Similarity Renormalization Group (SRG)

A systematic approach to producing softer nuclear potentials, which can be as bare interactions.

The era of DESIGNER RENORMALIZATIONS has arrived. One can choose Gs so as to minimize many-body forces.

For OPEN QUESTIONS regarding the SRG see the TRIUMF colloquium by Dick Furnstahl.

Nuclear Reactions: The NCSM/RGM

Much new progress: Several particle projectiles, NCSM + Green's function method, etc.

Use theoretical calculations of scattering results to test NN, 3N, etc. interactions.

The new predictive power of theory to assist both experiments and other theory.

Extensions of the NCSM

1. Ab initio Shell Model with a core.

2. Importance Truncations.

3. Ab initio NCSM in an SU(3) symmetry-adapted basis.

4. No Core Monte Carlo shell model.

5. NCSM in an EFT framework (nucleons in a trap)

6. Factorization algorithms, etc., etc., ...

Theoretical Error Analysis

Uncertainty quantification/converging sequences

It is time for theorists to evaluate their own results by giving them an error estimate!

OUTLOOK

How do we now build on the various and numerous successes of the NCSM?

Recruitment ---> Need more people

Things to do:

1. Use the NCSM and NCSM/RGM to predict new physics.

   a.) E.g., use NN + 3N + ... forces to do Many-body Theory, then use the many-body results to build improved forces, i.e., the ``looping effect” accelerates new advances.

2. Theoretical Error Analysis/Uncertainty Quantification

3. NCSM and NCSM/RGM extensions, e.g., use Monte Carlo

4. SRG and Designer Renormalizations

6. Efficient and effective utilization of rapidly growing computational resources.

E.g., the forming of groups of theorists to attack a particular problem, such as the UNEDF collaboration.

The sharing of resources for a common goal.

PROCEEDINGS
OF THE
INTERNATIONAL CONFERENCE
ON
NUCLEAR STRUCTURE

KINGSTON, CANADA

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how matter came about, and they add a great deal of significance and importance to nuclear physics and to certain experiments in nuclear physics which would have only little importance to the problems we have discussed here. Perhaps in the next conference we should have a session where we discuss these things; it is not enough just to go to Mr. Cameron or Mr. Fowler and ask him what shall we measure, we ought to know why we do it.

The second and last point I would like to raise is this. To round up the conference I come back to the first remark of Peierls, when he opened up the conference and asked the question, why are we interested in nuclear structure. May I add my own little verse to this. I have heard many people say that Nuclear Structure is not a fundamental problem, the real thing is high energy physics; the object of nuclear structure is after all nothing else but solving a Schroedinger equation for A particles. I strongly disagree with this point of view. The discovery and the understanding of phenomena hidden in a many-body problem can be a task of fundamental importance, if the object itself is of central interest.

Physics inquires into the nature of things. The nucleus, our nucleus, is an essential part of nature, it is the centre of the atom. It is not just a little phenomenon, it is the most prominent constituent of matter. The understanding of the phenomena occurring in this nucleus is therefore of paramount importance. Hence Nuclear Physics is an essential part of physics. I found out that some theorists, both in the east and in the west, consider the only thing worth doing is elementary particle physics. Experimentalists usually don't say so because they work with real matter and hence they know that the nucleus is an important thing. These theorists, however, worship the theory of elementary particles, a theory which in fact doesn't even exist. They knock their heads daily against a wall of dispersion-relations, Mandelstam representations and the like. Let them do it. After all the proton and the meson are also an important part of nature. In fact we should give them all the moral support they need. They are a brave lot who fight a very difficult fight and some day they will find the theory. But don't let yourself be talked into believing that the nucleus is not interesting. It is so small and it has so few parts and still it shows a tremendous variety of phenomena. Its investigation requires the whole arsenal of presently available experimental techniques and its understanding makes use of almost all branches of theoretical physics. What a marvellous invention! It is worth devoting a lifetime to it.

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Our thanks to Petr Navratil for organizing this very successful and stimulating workshop, which has given increased excitement to the NCSM program.