LQCD Project 2009 Annual Review

Answers to questions.

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Questions on physics program

Why does the U.S. program rely on the study of two actions? Perhaps another action will end up being more important? What are the risks involved in this choice?

The following actions are being actively pursued at present: 1) Staggered, 2) Clover-improved Wilson, 3) Twisted-mass Wilson, 4) Domain wall fermions, 5) Overlap fermions.

The USQCD program now focuses on staggered and DWF but uses a specialized anisotropic clover improved Wilson for the excited nucleon spectrum. As MILC has convincingly demonstrated, substantial scientific payoff results from systematically pursing a single action studying a variety of lattice spacings and quark masses. (This program has consumed a substantial fraction of US resources for the past 6 years.)

It is critical to compare the results from more than one action. We believe that DWF is our best choice for a second action:

- Very different from staggered fermions.
- Accurate chiral symmetry which is critical for weak matrix elements and nucleon structure.

We do not have the computer or manpower resources to do an adequate job on the full list. The other actions are the focus of large projects in Europe and Japan. This is an international effort and this distribution of topics is good for science. We expect that other actions will be better for particular problems. However, each of these other actions has serious drawbacks so we believe the risks in our choice of two actions are small.

B factory analyses will present increasingly detailed results in B spectroscopy, with very good spin splittings. Good lattice calculations would help motivate experimental and phenomenological work in B spectroscopy. What are the prospects for improved lattice calculations?

Much more detailed lattice work on B spectroscopy and other spectroscopy is possible and will occur. How fast it appears is a question of priorities, to some extent in computing allocations and to a greater extent in person-power. The B physics projects with the highest priority currently are those such as BBbar mixing and B->pi l nu which play an essential role in the determination of the CKM matrix. Spectrum calculations are important, but to date have not had as high a priority as the weak matrix elements. Furthermore, resonance states cannot be calculated as accurately as hadronically stable states with an equivalent level of effort. They appear to us to be less central to the US high energy program, and so have been given lower priority.

Do enough RHIC and B factory phenomenologists think that lattice calculations are relevant? If not, what can be done to correct the impression?

B physics.

Many B physics CKM phenomenologists understand lattice calculations very well. Lattice theorists participate actively in the Vcb/Vub workshops, the CKM conference, and the FPCP meeting. The Heavy Flavor Averaging Group incorporates lattice results in its averages in a very reasonable way. By continuing active participation in these meetings, as well as by continuing to organize the Lattice Meets Experiment weak matrix element workshops, lattice theorists are trying to broaden the appreciation of the role of lattice calculations among B CKM physicists.

A similar effort is also important among spectroscopy phenomenologists, but as noted above, the level of effort has been smaller here than in CKM physics because of the perceived priorities of the HEP community.

RHIC (from Frithjof Karsch):

Heavy ion phenomenology has many aspects and deals with different processes, reaching from non-equilibrium dynamics and the equilibration process itself to the analysis of equilibrium properties related to the QCD phase diagram. Clearly, not all of them rely on lattice calculations. There are, however, very fundamental questions where phenomenology relies on lattice results. This includes, for instance, lattice results on the equation of state. For a long time the bag equation of state, which has a strong first order phase transition, has been used in hydrodynamic modeling of high energy collisions. That this is inappropriate has now been realized by most model builders They now use an equation of state with a cross-over transition, as found in lattice calculations.

See "Hydrodynamics in Heavy Ion Collisions and QCD Equation of State", http://www.bnl.gov/riken/hhic/ , attended by many equation of state modelers and lattice theorists.

In particular, the discovery that matter created at RHIC is very strongly interacting, which led to the notion of this matter being a nearly perfect fluid, also gave rise to many new phenomenological models. Some of these have been ruled out by lattice calculations quickly. For instance, Shuryak's model of colored bound states in the plasma. The lattice calculations of baryon number and charge fluctuations played a central role in ruling out this model. They have been used by phenomenologists like Volker Koch from Berkeley, who showed that colored bound states cannot exist in the plasma. Other models like ADS-CFT do get confronted with lattice results and are discussed at many conferences at which phenomenologists and lattice theorists meet. - Quark Matter, Strange Quark Matter, Hard Probes, are a conference series to which both lattice theorists and phenomenologists contribute.

Hydrodynamics in Heavy Ion Collisions and QCD Equation of State

RIKEN BNL Research Center Workshop
April 21-22, 2008 at Brookhaven National Laboratory

Welcome to the Workshop on
Hydrodynamics in Heavy Ion Collisions and QCD Equation of State

Meeting Date	Main Meeting Location
April 21-22, 2008	Brookhaven National Laboratory Physics Department, Bldg 510, Large Seminar Room

Registration Is Now Closed...

Motivations & Plans
The interpretation of relativistic heavy-ion collisions at RHIC energies with thermal concepts is largely based on the relative success of ideal (non-dissipative) hydrodynamics. This approach can describe basic observables at RHIC, such as particle spectra and momentum anisotropies, fairly well. On the other hand, recent theoretical efforts indicate that dissipation can play a significant role. Ideally viscous hydrodynamic simulations would extract not only the equation of state but also transport coefficients from RHIC data. There has been a lot of progress with solving relativistic viscous hydrodynamics, however, present calculations by the different groups do not seem to agree.

There are already large uncertainties in ideal hydrodynamics calculations, e.g., uncertainties associated with initial conditions, freezeout, and the simplified equations of state typically utilized. One of the most sensitive observables to the equation of state is the baryon momentum anisotropy, which is also affected by freezeout assumptions. Lately significant progress in lattice QCD calculations of the transition temperature and equation of state has been made using realistic quark masses. However, these have not yet been incorporated into the hydrodynamic calculations.

Therefore it is desirable to have a coherent discussion of these topics within a single workshop.

We aim to discuss the following specific topics:

- Initial geometry and hydrodynamics
- Hydrodynamics, freezeout and equation of state
- Dissipation and hydrodynamics
- Deconfining transition and QCD equation of state
- Dissipation in transport models

http://www.bnl.gov/riken/hhic/

How does the LQCD program in nuclear physics expect to deal with the multi-channel physics that is a central part of the N* program at Jlab?

From Robert Edwards:

Current techniques allow for the extraction of multiple energy levels in some quantum number channels. So far, single particle operators have been used. Very recently, techniques for multi-particle operators have been developed and tested, which allows for coupling to multi-particle states. Together, these methods can be used for the extraction of energy levels in a channel including multi-particle levels.

The next step is extracting resonance masses. Some of the theoretical tools needed to extract resonance masses from finite volume shifts of energy levels is available (Luescher and others now). More theoretical work is needed to extend these techniques to more complicated decays. However, with current analysis methods, resonance masses can be extracted in some low number of levels, at least at moderate quark mass. However, if the state is narrow in width, the resonance mass is approximately an energy level as determined at some sufficiently large lattice size.

Experimental results suggests the Cascade spectrum typically has narrow widths, and it is these channels that are the initial focus of lattice calculations, as well as determination of resonance masses in low-lying levels (such as negative parity states). This work is in parallel with further development of theoretical techniques for matching finite volume shifts of energy levels.