Lattice Field Theory

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- LQCD provides a systematic method for calculating hadronic parameters from QCD first principles.

Developments

- Lattice QCD has achieved accurate calculation of the bound state spectrum, quark masses and α_s.
- Calculation of weak matrix elements is an important part of the flavor physics program and search for new physics. (See J. Laiho Thursday morning talk.)

✦ Keys to success:

- Improved actions
- Improved algorithms
- Increased computer power, allowing 2+1 dynamical quarks, ...
- Lattice specific chiral perturbation theory
 - These require considerable intellectual effort, even coding to take advantage of new computer hardware.

Examples: charm decay constants, α_s



- (L) 8 years of progress on decay constants. This work=FNAL/MILC Lattice 13 results. Red points only show statistical error, blue include systematics. Recent work includes a dynamical charm quark.
- (R) LQCD is the most precise source of α_S. Several groups contribute.
 S. Gottlieb, CSS2013, 8-4-13

Contributions to other fields

- Particularly in the early days, there was considerable interplay with condensed matter simulations. (E.g., Scalapino, Sugar & Toussaint.)
 - There are still common issues like the sign problem, most relevant for finite chemical potential.
- An especially interesting success story is the involvement of the Columbia and Edinburgh groups in the development of the IBM Blue Gene series of computers.
 - currently on third generation
- MILC code has been used to benchmark computers for many purchases, and was part of hardware diagnostics for at least one parallel computer.

Future Prospects

- We continue to strive for smaller errors and more realistic fermion content.
 - Now including dynamical charm quark
 - Up and down quark masses down to physical value
- Expect future calculations will include isospin breaking and fully dynamical QED.
- Breakthroughs expected:
 - First principles calculations of strong coupled BSM physics if it is found at LHC.
 - For the LHC and ILC determination of m_b and **α**_s to 0.25% or better.
 - Calculation of hadronic contributions to μ g-2

A Plea

- Paul Mackenzie and Ruth Van de Water of FNAL asked me to stress:
- Universities teach and raise the next generation of particle theorists; therefore, lattice field theory needs to be supported at universities (and not just at laboratories) for the future of the field.
 - It is much less self-serving coming from them.