

# LATTICE SYNERGY

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Lattice QCD All-hands Meeting

# OUTLINE

MEETING ORGANIZATION

MEETING PROGRAM

HADRON SPECTROSCOPY

HADRON STRUCTURE

SUMMARY

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# LATTICE QCD AND EXPERIMENT: REVEALING THE STRUCTURE OF HADRONS

November 21-22, 2008

Jefferson Lab

<http://conferences.jlab.org/synergy/program.html>

## Organizers:

Kees de Jager (Jefferson Lab)

Curtis Meyer (Carnegie Mellon)

John Negele (MIT)

Kostas Orginos (William and Mary/Jefferson Lab)

David Richards (Jefferson Lab)

## MEETING PURPOSE

The  $1\frac{1}{2}$  day workshop was aimed at fostering the exchange of ideas between nuclear **experimentalists**, and **theorists** working in **lattice QCD**, so as to gain a deeper understanding of the structure and spectroscopy of hadrons. The experimental talks covered a range of topics central to the current and 12 GeV programs at Jefferson Laboratory, and to the RHIC-spin program at BNL. The lattice talks described the current status of calculations, and the prospects for the future. The program provided ample time for discussion, and the workshop was intended as part of an ongoing series.

# MEETING PARTICIPANTS

There were 41 registered participants at the meeting, but a goodly number also just walked into the large meeting room. I would estimate that closer to 60 people attended parts of the meeting.

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# MEETING PROGRAM

- ▶ **Spectroscopy**
- ▶ **Hadron Structure**
- ▶ **Other Topics...** (Many body,  $NN$  and  $NNN$ ).

# MEETING PROGRAM

- ▶ **Spectroscopy**
- ▶ **Hadron Structure**

# MEETING PROGRAM: SPECTROSCOPY

- ▶ *Status and Prospects for Meson Spectroscopy*— Ryan Mitchell (Indiana)
- ▶ *Hadron Physics from Lattice QCD, and the Study of Meson Spectroscopy*—Mike Peardon (Trinity College)
- ▶ *Status and Prospects for  $N^*$  Spectroscopy*—Volker Crede (FSU)
- ▶ *Lattice Studies of Baryon Resonances*—Steve Wallace (Maryland)
- ▶ *Summary - Prospects for Spectroscopy*—Frank Close (Oxford)

## MEETING PROGRAM: HADRON STRUCTURE

- ▶ *The experimental study of nucleon form factors*—Ron Gilman (Rutgers)
- ▶ *Nucleon Form Factors on the Lattice*—Meifeng Lin (MIT)
- ▶ *The phenomenology of Nucleon Form Factors*—Hans-Werner Hammer (Bonn)
- ▶ *The transverse structure of hadrons*—Matthias Burkardt (NMSU/JLab)
- ▶ *Expt. Study of GPDs*—Charles Hyde (Blaise Pascal/ODU)
- ▶ *Expt. Study of Transversity*—Matthias Grosse-Perdekamp (Illinois)
- ▶ *Lattice studies of Hadron Structure*—Gerrit Schierholz (DESY)
- ▶ *Expt. and Lattice: building a picture of the Nucleon*—Anthony Thomas (JLab)

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# THE HADRONS SPECTRUM

[Ryan Mitchel](#) showed new results on charm coming out of the B-factories, CLEO and expected from BES. This includes the  $X, Y, Z$  states that have been discovered as well as some details on light vector states. Compass (CERN) is starting a spectroscopy program with pion beams, in the future GlueX will do this with photoproduction.

[Volker Crede](#) spoke on baryon spectroscopy, with particular emphasis on light-quark ( $u, d, s$ ) baryons. There has been a lot of new data from photoproduction collected over the last few years, and the emphasis has now shifted to polarization observables. There are also new analysis techniques being employed. Some hints of the so-called *missing* baryons.

# THE HADRON SPECTRUM

**Michael Peardon** presented an excellent introduction on lattice QCD, then went on to describe glueball, charmonium and light-quark system calculations. Then discussed where things are going and what needs to happen to make progress.

**Steve Wallace** presented the current status of baryon calculations on the lattice as well as details on what the issues are. Showed good agreement with the lowest negative parity states and results on form factors and  $E/M$  for the  $\Delta$ . He also showed the first lattice evidence of a spin  $\frac{5}{2}$  baryon. There was also a nice connection from Gerrit's talk on using leading-twist wave functions to compute  $\gamma^* N \rightarrow N^*(1535)$ .

# THE HADRON SPECTRUM

**Frank Close** gave a very nice talk that covered many aspects of meson spectroscopy and where lattice can make an impact. This included comments on phenomenology and recent work on decays of mesons. In particular, there was a plea for calculations of radiative decays on the lattice.

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# NUCLEON FORM FACTORS

Ron Gilman presented an overview of the current experimental status of form factors, and what one expected to be able to measure in the next five years. There is substantial data on  $G_E$  and  $G_M$  for the proton and good results for the neutron. There is also quite a bit of progress on the strangeness form factors,  $G_{E,M}^s$ .

# NUCLEON FORM FACTORS

**Hans-Werner Hammer** talked about using dispersion relations to analyze form factors, where this allowed one to connect many different measurements together. Took advantage of better spectral functions for  $\pi\pi$ ,  $K\bar{K}$ , ... . The analysis yielded a consistent description of a diverse data set and provided a mechanism to produce error bands. Hard two-photon effects appear to remove the discrepancy between Rosenbluth and polarization measurements.

# NUCLEON FORM FACTORS

**Meifeng Lin** described the techniques used on the lattice to extract momentum-dependent form factors, then went on to compare the current state of lattice calculations with the experimental results. Particular detail paid to small and large  $Q^2$ . Lighter pion masses are needed to have better agreement with  $\chi$ PT. Overall, there appeared to be a very nice overlap with the experimental programs and good agreement between the lattice and experiment on the isovector charge radius.

# GENERALIZED PARTON DISTRIBUTIONS

[Charles Hyde](#) Presented a summary of what GPDs are and some details on how one would try to extract them from data. Then summarized the current measurements that will contribute to GPD measurements as well as future measurements, particularly at 12 GeV JLab.

# TRANSVERSITY

**M. Grosse Perdekamp** Presented a summary of the current measurements and our interpretation. Then laid out what measurements were going to be made.

**Matthias Burkhardt** Presented a lot of information on transversity and form factors. Lattice can have important input on both moments of GPDs and on impact parameter dependence of PDFs.

# HADRON STRUCTURE

**Gerrit Schierholz** Presented the current status of work on the lattice. Physical pion mass is feasible. Large volume extrapolations mostly under control. Challenge to evaluate disconnected diagrams. There is an understanding of how lattice QCD calculations of moments relate to experiments building a consistent picture of the spin of the proton.

## BUILDING A PICTURE ...

**Anthony Thomas** A very nice closing talk. Documented synergy between experiment and lattice and talked about a number of successes. Left with a number of open questions: “Does LQCD precisely reproduce the best experimental data?” “Are some observable better than others?” “Can the lessons from hadron structure help in nuclear structure?” “What does varying quark masses tell us?” “Why is quenched LQCD typically within 10% of data?” ....

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- ▶ The conference was a very positive event.
- ▶ Well attended.
- ▶ A good balance of talks.
- ▶ Nice format to see where things are.
- ▶ The talks can be found at:  
<http://conferences.jlab.org/synergy/program.html>