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1 Hadron spectrum and quark masses

Pion Form Factor with Twisted Mass QCD

Presented by: Abdou M. Abdel-Rehim
Abdou M. Abdel-Rehim, Randy Lewis

The pion form factor is calculated with quenched twisted mass QCD at different values of the momentum transfer Q^2 and quark masses. The results are compared to existing analyses in the literature.

Momentum dependence of the N to Delta transition form factors

Presented by: C. Alexandrou
C. Alexandrou, Ph. de Forcrand, H. Neff, J. W. Negele, W. Schroers, A. Tsapalis

We present a new method to determine the momentum dependence of the N to Δ transiton form factors and demonstrate its effectiveness in the quenched theory at $\beta = 6$ on a $32^3 \times 64$ lattice. We address a number of technical issues such as the optimal combination of matrix elements and the simultaneous overconstrained analysis of all lattice vector momenta contributing to a given momentum transfer squared, Q^2. The Q^2-range covered in the calculation is from 0.13 to 1.3 GeV^2. We obtain qualitative agreement with experiment.

Analysis of N^* spectra using matrices of correlators based on irreducible baryon operators

Presented by: S. Basak
S. Basak, LHP Collaboration:, R. Edwards, R. Fiebig, G. Fleming, U.M. Heller, C. Morningstar, D. Richards, I. Sato, S. Wallace

We present results for ground and excited state baryon masses in quenched lattice QCD using anisotropic lattices. Group theoretical constructions of local and 1-link irreducible operators are used to obtain suitable sources and sinks. Matrices of correlation functions are diagonalized at an early time to determine the eigenvectors. The correlation functions based on these eigenvectors are used at later times to separate the ground and excited states. Both the plateau method and Bayesian inference with entropic prior are used to extract masses from the correlation functions in a given eigenchannel. We observe clear separation of the excited state masses from the ground state mass. A spin 5/2-N^* state is obtained by use of a G_2 lattice irreducible representation.

Results for light pseudoscalars from three-flavor simulations

Presented by: Claude Bernard
Claude Bernard, C. Aubin, T. Burch, C. DeTar, Steven Gottlieb, E.B. Gregory, U.M. Heller, J.E. Hetrick, J. Osborn, R. Sugar, D. Toussaint

We present final results for f_π, f_K, and chiral low energy constants from simulations using three flavors of dynamical staggered quarks. We analyze configurations with lattice spacings of approximately 0.125 fm and 0.09 fm and with a large number of different sea quark masses. The effects of violations of taste symmetry at finite lattice spacing are taken into account by fitting to forms derived from “staggered chiral perturbation theory.” There is good evidence for chiral logarithms. When coupled with a perturbative calculation of the mass renormalization constant by Q. Mason and collaborators, the same chiral fits determine the strange and light quark masses, as discussed in recent joint work with the HPQCD and UKQCD collaborations.

Lattice calculation of the hadronic contributions to the muon anomalous magnetic moment

Presented by: Tom Blum
Tom Blum

I report on the lattice calculation of the hadronic contributions to the muon anomalous magnetic moment, a_μ. The low q^2 and small mass behavior of the vacuum polarization, which dominates the $O(\alpha^2)$ contribution, are discussed. New preliminary results for the vacuum polarization computed using quenched domain wall and dynamical a^2-tad fermions are presented. Prospects for a 1% precision lattice calculation, and its impact on experiment are discussed.

Preliminary results of the heavy-light meson spectrum using chirally improved light quarks

Presented by: Tommy Burch
Tommy Burch, Christof Gattringer, Andreas Schaefer

Using a “wall” of quark point sources, we invert the chirally improved Dirac operator to create an “incoherent” collection of quark propagators which arise from all spatial points of the source time slice. The static and (lowest-order) NRQCD approximations are then used to create heavy-quark propagators from the same wall source. However, since the numerical cost involved in computing such heavy-quark propagators is low, we are able to use a number of source gauge paths to establish coherence between the heavy and light quarks at several spatial separations. The resulting collection of heavy-light meson correlators is analyzed to extract the corresponding mass spectrum.

Pentaquark baryons in lattice QCD

Presented by: Ting-Wai Chiu
Ting-Wai Chiu, Tung-Han Hsieh

The mass spectra of pentaquark baryons are determined in quenched lattice QCD with exact chiral symmetry. For 100 gauge configurations at $\beta = 6.1$ on the $20^3 \times 40$ lattice, and 221 gauge configurations at $\beta = 6.0$ on the $16^3 \times 32$ lattice, we measure the time correlation fucnctions and extract the masses of even and odd parity states respectively. Our results suggest that the parity of $\Theta^+(1540)$ and $\Xi_{3/2}^{--}(1860)$ is positive.

Hadron Spectrum and Decay constants from $N_F = 2$ Domain-Wall QCD

Presented by: Taku Izubuchi (RBRC, Kanazawa Univ.) for RBC Collaboration
Taku Izubuchi (RBRC Kanazawa Univ.) for RBC Collaboration

We report our results for the light hadron spectrum and quark masses as well as decay constants calculated in two-flavor QCD with $L_s = 12$ dynamical domain-wall quarks and the DBW2 gauge action. The masses of the dynamical quarks range from half of the strange quark mass to the strange quark mass. The lattice volume is $16^3 \times 32$ and $a^{-1} \sim 1.7GeV$.

The Quenched Continuum Limit

Presented by: Christine Davies
Christine Davies, Peter Lepage, Ferenc Niedermayer, Doug Toussaint

We present plots for the nucleon and vector masses at fixed physical quark mass as a function of lattice spacing for a variety of formalisms (staggered, Wilson, perfect action, domain wall) in the quenched approximation. Simultaneous fits to all formalisms with a single continuum limit work well when appropriate higher order polynomials are included for each formalism with a Bayesian analysis to control the coefficients. We conclude that there is consistency among formalisms in the continuum limit, as expected. This lays to rest speculation about this limit raised by S. Aoki at LAT00.

Roper and Nucleon Wavefunctions of Overlap Fermions

Presented by: Shao-Jing Dong
Shao-Jing Dong, A. Alexandru , Y. Chen, S. J. Dong, T. Draper, I Horvath, F. X. Lee, K. F. Liu, N. Mathur, S. Tamhankar, J. B. Zhang

The Coulomb gauge fixed two-point functions of nucleon are calculated in quenched lattice QCD with overlap fermions. The weights of the first excited state from the wall-source and point-sink data are negative at high and low quark masses. The Bethe-Salpeter wavefunctions are extracted from the point-source data with spatially extended nucleon sink operators. We find that the wavefunctions of the first excited state have a node in the radial direction.

The Nucleon Electromagnetic Elastic and Transition Form Factors

Presented by: Robert Edwards
Robert Edwards

We present a calculation of the nucleon electromagnetic form-factors as well as the nucleon to delta transition form-factors using a chiral fermion action at several values of momentum transfer. The approach to the chiral regime is investigated.

Quark mass dependence in unquenched twisted-mass lattice QCD

Presented by: F. Farchioni
F. Farchioni, I. Montvay, E. Scholz, R. Frezzotti, K. Jansen, G. C. Rossi, A. Shindler, N. Ukita, C. Urbach, I. Wetzorke

This study is part of an analysis of the quark mass dependence in QCD for light quarks, the final goal being the determination of the low-energy constants in the chiral lagrangian. Previous results are based on N_f=2 QCD with unquenched Wilson quarks (qq+q Collaboration). We now turn to the approach to QCD based on Wilson twisted-mass fermions. This part of the work is done in collaboration with the research groups at DESY Zeuthen and Humboldt University Berlin. We simulate the model on $12^3 \times 24$ and $16^3 \times 32$ lattices at $\beta = 5.1$ and 5.2 by the Two-Step Multi-Boson (TSMB) Algorithm for dynamical fermions. As a first task, we search for the value of the critical hopping parameter at fixed value of the twisted mass. At the critical value, corresponding to a rotation angle $\omega = \pi/2$, the theory is $O(a)$ improved. Quark mass and rotation angle are determined by means of the chiral Ward Identities. Basic physical quantities including the pion mass and decay constant are measured.

Final results for pion form factor using domain wall valence and asqtad sea quarks

Presented by: George T. Fleming (Jefferson Lab)
George T. Fleming (Jefferson Lab), Frederic D. R. Bonnet (Regina U. and Jefferson Lab), Robert G. Edwards (Jefferson Lab), Randy Lewis (Regina U.), David G. Richards (Jefferson Lab)

Hybrid calculations with domain wall valence quarks and improved staggered (`asqtad`) sea quarks are being used to explore hadron structure in full QCD in the light pion regime. A preliminary calculation of the pion electromagnetic form factor was presented at last year's meeting (hep-lat/0310053). Final results will be presented and compared with existing quenched calculations, other theoretical calculations and experimental data.

Pion scattering with chirally improved fermions

Presented by: Christof Gattringer
Christof Gattringer, Dieter Hierl, Rainer Pullirsch

We study the pion scattering length in a quenched simulation with chirally improved fermions at pion masses down to 250 MeV. Different forms of the extrapolation to the chiral limit are compared. We find good agreement with recent experimental data.

Static $\bar{\mathrm{Q}}$-Q Potential from $N_f = 2$ Dynamical Domain-Wall QCD

Presented by: Koichi Hashimoto
Koichi Hashimoto, Taku Izubuchi

We will discuss static quark and anti-quark potential both in $N_f = 2$ dynamical quark and quenched lattice QCD using DBW2 gauge and domain-wall quark actions. We will show the following results:

1. determination of lattice spacing a from Sommer's scale,
2. dynamical quark effect from the static potential,
3. scaling study of quenched DBW2 lattice,

4. scaling violation of parameters (e.g. f_π, m_ρ).

We will also mention about an exploratory study of excited state and possible signal of the string breaking.

Towards a determination of the Lambda parameter from (quenched and) two flavour unquenched QCD

Presented by: R. Horsley (for QCDSF and UKQCD)

R. Horsley for QCDSF and UKQCD

We present an update on our previous determination of the Lambda parameter in QCD. The main emphasis of the talk is on results for two flavours of light dynamical quarks, where we can now almost double the amount of data used in the previous analysis including values at smaller lattice spacings. The calculations are performed using $O(a)$ improved Wilson fermions.

Penta-Quark Anti-Decuplet in Anisotropic Lattice QCD

Presented by: Noriyoshi Ishii

Noriyoshi ISHII, Hideaki IIDA Mokoto OKA Fumiko OKIHARU Hideo SUGANUMA

Penta-quark anti-decuplet baryons [1] are investigated in anisotropic lattice QCD with renormalized anisotropy $\xi = a_s/a_t$=4 [2] at the quenched level. The lattice simulations are performed with the standard Wilson action at $\beta = 5.75$ and the $O(a)$ improved Wilson quark action with $\kappa = 0.1210, 0.1220, 0.1230$ on a $12^3 \times 96$ lattice. We compare the lattice data with the experimentally observed penta-quark baryons, $\Theta^+(1540)$ and $\Xi^{--}(1862)$, and attempt to determine their quantum numbers.

References

[1] LEPS Collaboration (T. Nakano *et al.*), Phys.Rev.Lett. **91** (2003) 012002.
[2] Y.Nemoto, N.Nakajima, H.Matsufuru, H.Suganuma, PR**D68** (2003) 094505.

Light hadron spectrum in 2+1 flavor full QCD by CP-PACS and JLQCD collaboration

Presented by: Tomomi Ishikawa

Tomomi Ishikawa, S. Aoki, O. Baer, M. Fukugita, S. Hashimoto, K.-I. Ishikawa, N. Ishizuka, Y. Iwasaki, K. Kanaya, T. Kaneko, Y. Kuramashi, M. Okawa, T. Onogi, Y. Taniguchi, N. Tsutsui, A. Ukawa, T. Yoshie

CP-PACS and JLQCD collaboration is carring out a joint project of the 2+1 flavor full QCD with the non-perturbatively $O(a)$-improved Wilson quark action and the RG-improved gauge action. This simulation removes quenching effects of all three light quakrs, whichi is the last major uncertainty in lattice QCD. In this talk, we present our results for the light meson spectrum and quark masses on a $20^3 \times 40$ lattice at the lattice spacing $a \sim 0.1$fm. We compare these results with experimental value and our previous results in the 2 flavor full and quenched case.

I=2 Pion Scattering Length from Two-Pion Wave Function

Presented by: Naruhito Ishizuka
Naruhito Ishizuka, S. Aoki , M. Fukugita , K-I. Ishikawa , T. Ishikawa , N. Ishizuka , Y. Iwasaki , K. Kanaya , T. Kaneko , Y. Kuramashi , M. Okawa , A. Ukawa , T. Yamazaki , T. Yoshié , (CP-PACS Collaboration)

We present results for the two-pion wave function for the I=2 two pion systyem. They allow us to investigate the interaction range between two pions and the validity of the necessary condition for the applicability of the finite volume method of Luescher for scattering amplitudes in our current lattice simulations. We also calculate the scattering length from the wave function and compare it with that obtained from time correlator function of two pions by the finite volume method.

Finite size mass shift formula for stable particles revisited

Presented by: Yoshiaki Koma
Yoshiaki Koma, Miho Koma

Lüscher's finite size mass shift formula, related to forward scattering amplitudes in the infinite volume, is revisited for a two stable distinguishable particle system. The problem on the factor two discrepancy between Lüscher's nucleon mass shift formula and that within ChPT at the one loop level computed recently by the QCDSF-UKQCD collaboration is solved.

The pentaquark static potential and density-density correlator

Presented by: G. Koutsou
G. Koutsou, C. Alexandrou, A. Tsapalis

We present first results on the static tetraquark and pentaquark potentials in the quenched theory. We look for diquark formation in the context of the density-density correlators.

Excited hadrons from improved interpolating fields

Presented by: C. B. Lang
C. B. Lang, Tommy Burch, Christof Gattringer, Leonid Ya. Glozman, Reinhard Kleindl, Andreas Schäfer,

We study the spectrum of the lowest excited states in the baryon and meson system for quenched QCD with the chirally improved Dirac operator. Quark sources of different widths are combined and provide a larger basis of interpolating fields. The cross-correlation matrix is then analyzed with the variational method. This leads to optimized combinations of hadron operators that provide us with better signals for the excited states.

Finite volume effects using lattice chiral perturbation theory

Presented by: Randy Lewis
Randy Lewis, Bugra Borasoy, Daniel Mazur

Observables are studied with chiral perturbation theory in a finite volume. Lattice regularization is employed as a convenient method for obtaining numerical results.

Chiral perturbation theory for twisted mass QCD

Presented by: Gernot Münster
Gernot Münster

Quantum Chromodynamics on a lattice with Wilson fermions and a chirally twisted mass term for two degenerate quark flavours is considered in the framework of chiral perturbation theory. The pion masses and decay constants are calculated in next-to-leading order including terms linear in the lattice spacing a. We treat both unquenched and partially quenched QCD.

Pentaquark baryons with overlap fermions

Presented by: Nilmani Mathur
Nilmani Mathur, F.X. Lee, A. Alexandru, C. Bennhold, Y. Chen, S.J. Dong, T. Draper, I. Horváth, K.F. Liu, S. Tamhankar, J.B. Zhang

We present a lattice calculation of spin-1/2 pentaquark states. Both positive and negative parity channels with isospin I=0 and I=1 are considered. We do not observe a pentaquark state in either parity channels and observe only five-quark KN scattering states and KNη' ghost states. The observed two-particle scattering states have characteristic volume dependence in their spectral weight. Results are obtained by using overlap fermions on quenched Iwasaki $16^3 \times 28$ ($La = 3.2\,\mathrm{fm}$) and $12^3 \times 28$ ($La = 2.4\,\mathrm{fm}$) lattices.

Group-theoretical construction of extended baryon operators

Presented by: Colin Morningstar
Colin Morningstar, Subhasish Basak, Robert Edwards, Rudolf Fiebig, George Fleming, Urs Heller, David Richards, Ikuro Sato, Steve Wallace

The design and construction of large sets of spatially extended baryon operators for use in lattice simulations is described. The operators are designed to maximize overlaps with the low-lying states of interest, while minimizing the number of sources needed in computing the required quark propagators.

Chiral extrapolations with small sea quark mass data in two-flavor lattice QCD

Presented by: Yusuke Namekawa
Yusuke Namekawa, S.Aoki, M.Fukugita, K-I.Ishikawa, N.Ishizuka, Y.Iwasaki, K.Kanaya, T.Kaneko, Y.Kuramashi, V.Lesk, M.Okawa, A.Ukawa, T.Umeda, T.Yoshié

We present our results on the light hadron spectrum and quark masses in two-flavor QCD calculated with small sea quark masses down to $m_{PS}/m_V = 0.35$. The configurations are generated using the RG improved gauge action and the tadpole-improved clover action at $\beta = 1.8$, where $a^{-1} \simeq 1$ GeV. Chiral extrapolations are carried out using not only polynomials and ChPT in the continuum but also formulae of Wilson chiral perturbation theory (WChPT) including $O(a^2)$ terms. We examine the viability of WChPT and its influence on quark masses.

Quenched hadron spectroscopy with overlap quarks.

Presented by: Claudio Rebbi
Claudio Rebbi, Federico Berruto, Nicolas Garron, Christian Hoelbling, Joseph Howard, Laurent Lellouch, Silvia Necco, Noam Shoresh

I will present results for meson and baryon masses, quark mass and condensate, final state “wave function” and other observables in quenched QCD, obtained with overlap quarks on an $18^3 \times 64$ lattice at $\beta = 6$.

Nucleon structure with domain wall valence quarks and improved staggered sea quarks

Presented by: Dru B. Renner
Dru B. Renner, R. Edwards, G. Fleming, Ph. Hagler, J. W. Negele, K. Orginos, A. V. Pochinsky, D. Richards, W. Schroers, Th. Lippert, K. Schilling

Hybrid calculations with domain wall valence quarks and improved staggered sea quarks are being used to explore nucleon structure in full QCD in the light pion regime. Initial results for moments of structure functions, form factors, and generalized form factors will be presented and compared with previous results in the heavy pion regime.

Optimization of baryonic sources using irreducible representations of the octahedral group

Presented by: Ikuro Sato
Ikuro Sato, S. Basak, R. Edwards, R. Fiebig, G. Fleming, U. M. Heller, C. Morningstar, D Richards, I. Sato, S. Wallace

Irreducible representations (IRs) of the double-covered octahedral group are used for lattice source and sink operators in matrices of correlation functions. The goal is to achieve a good coupling to higher spin states as well as ground states. An elementary construction of complete sets of local and one-link operators is discussed for isospin 1/2 and 3/2 baryons. The orthogonality relations of the operators are demonstrated in free field and using gauge fields.

Improving meson correlation functions by low mode averaging

Presented by: Stefan Schaefer
Stefan Schaefer, T. DeGrand

Some meson correlation functions have a large contribution from the low lying eigenmodes of the Dirac operator. The contribution of these eigenmodes can be averaged over all positions of the source. This can improve the signal in these channels significantly. We test the method for mesonic two and three point functions.

Truly unquenched quark masses

Presented by: G. Schierholz
G. Schierholz, M. Gockeler, R. Horsley, D. Pleiter, P. Rakow, H. Stueben

A calculation of light quark masses for $N_f = 2$ O(a) improved Wilson fermions, taking properly account of flavor singlet renormalization factors in a nonperturbative fashion, is presented.

Unquenched simulations with $N_f = 2$ light quark flavours

Presented by: Enno E. Scholz (DESY Hamburg)

Enno E. Scholz (DESY Hamburg), Federico Farchioni (Univ. Münster), Istvan Montvay (DESY Hamburg)

The quark mass dependence in QCD for light dynamical quarks ($\frac{1}{4}m_s \leq m_{ud} \leq \frac{2}{3}m_s$) has been studied. We observed the behaviour predicted by chiral perturbation theory and give some numerical estimates for the Gasser-Leutwyler low energy constants L_5 and L_8.
The computations were done on 16^4 and $16^3 \times 32$ lattices at $\beta = 5.1$ and different values of the hopping parameter κ ($0.160 \leq \kappa \leq 0.170$). We used the Two-Step Multi-Boson (TSMB) algorithm for Wilson-fermions. The pion masses and decay constants were measured as well as the PCAC-quark masses. For taking into account the breaking of chiral symmetry due to the type of dynamical fermions so-called Wilson-chiral perturbation theory was applied. Additional valence quark masses have been added to the analysis, which are described by partially quenched chiral perturbation theory.
Altough we showed that it is possible to reach quark masses which are light enough to show the right low energy behaviour with Wilson-fermions, we also see some limitations of this approach. A possible way out of this may be the extension to twisted-mass Wilson-fermions. First attempts in this direction have been done in a larger collaboration together with DESY Zeuthen.

Picking up the gauntlet: Meeting the challenge of light quarks with hybrid calculations

Presented by: Wolfram Schroers

Wolfram Schroers, R. Edwards, G. Fleming, Ph. Hagler, J. W. Negele, K. Orginos, A. V. Pochinsky, D. B. Renner, D. Richards

A major challenge of contemporary lattice research consists of the need to employ light fermions in a numerical calculation. Although Ginsparg-Wilson fermions are practical for light valence quarks, their cost for light dynamical sea quarks is presently prohibitive. Hence, we investigate if the Asqtad discretization - as used by the MILC collaboration - provides a means to meet this challenge.

Heavy Quarkonia Results from CLEO

Presented by: Kamal Seth (CLEO-c collaboration)

CLEO Analysis Coordinator: Daniel Cronin-Hennessy

CLEO has accumulated over 5 pb^{-1} of e^+e^- collision data in the vicinity of the Υ(1S,2S,3S) resonances at the Cornell Electron-Positron Storage Ring (CESR). This represents about factor 10 increase in the largest previous data samples. CLEO will present recent results from the resonance and Upsilon(4S) data. Among these results will be the first new particle observation in 20 years from the $b\bar{b}$ system (Υ1D), observation of the η_c', the first observation of a non-dipion $b\bar{b}$ hadronic transition, and a search for the production of the X(3872) in two-photon fusion and initial state radiation processes.

Is there an Aoki phase in quenched QCD?

Presented by: Stephen Sharpe
Stephen Sharpe, Maarten Golterman, Robert Singleton Jr.

We study the question of whether there is an Aoki phase—a phase in which parity and possibly flavor are spontaneously broken—in quenched QCD with one and two flavors of Wilson fermions. We use quenched chiral perturbation theory including terms up to quadratic in the lattice spacing, generalizing the corresponding unquenched analysis of Sharpe and Singleton. The issue is interesting both as it requires understanding quenched chiral perturbation theory at a non-perturbative level, and, as discussed by Golterman and Shamir, because the presence of an Aoki phase has implications for simulations with domain-wall and overlap fermions. We argue that such a phase is present, with properties similar to, though not identical with, those of the unquenched case.

Remarks on the discretization of physical momenta in lattice QCD

Presented by: Nazario Tantalo
Nazario Tantalo

The adoption of two distinct boundary conditions for two fermions species on a finite lattice allows to deal with arbitrary relative momentum between the two particle species, in spite of the momentum quantization rule due to a limited physical box size. In order to prove the physical significance of this topological momentum, I will present numerical results checking in the continuum limit the validity of the expected energy-momentum dispersion relations.

Light hadron spectrum, quark masses and renormalization constants, with two flavors of dynamical quarks

Presented by: Cecilia Tarantino
Cecilia Tarantino, Damir Becirevic, Philippe Boucaud, Vicente Gimenez, Vittorio Lubicz, Guido Martinelli, Federico Mescia, Silvano Simula

We present the preliminary results of an unquenched study of the light hadron spectrum, quark masses and renormalization constants. Numerical simulations are carried out with two flavors of dynamical quarks, using the plaquette gluon action and the Wilson quark action at $\beta = 5.8$. At each of four sea quark masses, corresponding to $m_{PS}/m_V \sim= 0.5 \div 0.8$, we generate 4500 trajectories using the preconditioned Hybrid Monte Carlo algorithm. Finite volume effects are investigated emplying $16^3 \times 48$ and $24^3 \times 48$ lattices.

The Omega- and the strange quark mass

Presented by: Doug Toussaint
Doug Toussaint, C.T.H. Davies

Ω^- propagators have been calculated on the MILC collaboration's archive of three flavor improved staggered quark lattices. The strange quark mass can be adjusted to fix the Ω^-

mass, which gives a check on computations of the strange quark mass based on the kaon mass. Although not as accurate, the Ω^- mass gives results for the strange quark mass in good agreement with those starting from the kaon mass.

Exploratory Spectrum Calculations using Overlap Valence Quarks on a Staggered Sea

Presented by: Robert Tweedie

Robert Tweedie, UKQCD Collaboration, Richard Kenway, Ken Bowler, Chris Maynard

We present recent exploratory results for the hadron mass spectrum using mixed actions. We use improved staggered sea quarks and HYP-smeared Overlap valence quarks. We obtain good signals on O(10) configs at one lattice spacing and two different sea quark masses.

First results for dynamical Wilson twisted mass fermions at full twist

Presented by: Carsten Urbach

Carsten Urbach, F. Farchioni, R. Frezzotti, K. Jansen, I. Montvay, G.C. Rossi, E. Scholz, A. Shindler, N. Ukita, I. Wetzorke

We study lattice QCD with dynamical twisted mass Wilson fermions at a twisting angle of $\pi/2$ (full twist), which are O(a) improved without involving a clover term. We present first results and experiences for simulations with dynamical fermions with the objective of a scaling study for full QCD. We discuss improvements of the Hybrid Monte Carlo algorithm with even-odd preconditioning and with the Hasenbusch trick for two quark flavours. In this work we concentrate on determining the critical hopping parameter, a prerequisite to extract O(a) improved quark and hadron masses as well as decay constants that will be used for the scaling test.

Staggered Chiral Perturbation Theory at Next-to-leading Order

Presented by: Ruth S. Van de Water

Ruth S. Van de Water, Stephen R. Sharpe

We study taste and Lorentz symmetry violation for staggered fermions at nonzero lattice spacing using staggered chiral perturbation theory. Previous work has considered the lowest order staggered chiral Lagrangian in a combined expansion in which the quark mass, m, and the square of the lattice spacing, a^2, are of comparable size. This has been used to determine the 1-loop corrections to the lattice pseudo-Goldstone boson mass and decay constant. We extend the staggered chiral Lagrangian to $\mathcal{O}(a^2p^2)$, $\mathcal{O}(a^4)$ and $\mathcal{O}(a^2m)$, the order necessary to allow a full next-to-leading order calculation of the masses and decay constants including analytic terms. We calculate the contributions to these quantities which break the SO(4) taste symmetry that remains at $\mathcal{O}(a^2)$ down to the discrete lattice symmetry group. We find a number of predictions for such quantities: given the SO(4) breaking splittings between masses, we can predict the corresponding splittings between decay constants and the violations of rotational symmetry in the dispersion relations. These results hold also for theories in which the $\sqrt[4]{\mathrm{Det}}$ trick has been used, assuming that the effective theory is still valid. Testing them will therefore provide evidence for or against the validity of this trick.

Applying Chiral Perturbation Theory to Twisted Mass Lattice QCD

Presented by: Jackson Wu
Jackson Wy, Stephen R. Sharpe

The twisted mass formulation of lattice QCD has been proposed to combat the problem of exceptional configurations in simulations with Wilson fermions. Moreover, it has been recently shown that, for maximal twisting (i.e. a twisting angle of $pi/2$), $O(a)$ improvement is automatic for appropriately chosen quantities - there is no need to improve either the action or the operators. We have explored twisted mass LQCD using chiral perturbation theory, including discretization effects up to $O(a^2)$, and working at next-to-leading order in the chiral expansion. Working at this order allows us to study the impact of the flavor breaking induced by the twisted mass. In particular we have studied the vacuum structure (where we see how the Aoki phase transitions are smoothed out by twisting), and calculated the functional form of pion masses and decay constants on the quark mass, twisting angle and lattice spacing. These forms can be used to carry out the combined chiral and continuum extrapolation that will be needed in this approach, and give explicit examples of quantities that both are and are not automatically improved at maximal twisting.

Two-particle wave function in four dimensional Ising model

Presented by: Takeshi Yamazaki
Takeshi Yamazaki

I calculate two-particle wave function with non-zero relative momentum in four dimensional Ising model, which contains an unstable state. I present the wave functions corresponding to two-particle and unstable states obtained by the diagonalization method, and calculate scattering phase shift from the wave function by the finite volume method. I also compare it with that obtained from two-particle energy.

2 Weak matrix elements

Nucleon decay matrix elements

Presented by: Yasumichi Aoki
Yasumichi Aoki, [RBC collaboration]

We report on the hadronic matrix elements of nucleon decay with the three quark operators in effective Hamiltonians of GUT. Domain-wall fermions are employed to reduce the systematic uncertainties from chiral symmetry breaking and scaling violation. Non-perturbative renormalization is applied. Dynamical quark effects are discussed.

$Re(A_2)$, $Re(A_0)$ and $N_f = 3$ RG evolution

Presented by: Keunsu Choi
Keunsu Choi, Weonjong Lee, Stephen Sharpe

We present results of ReA_0 and ReA_2 calculated using improved staggered fermions on the lattice of $16^3 \times 64$ at $\beta = 6.0$. These results are obtained using leading order chiral perturbation in quenched QCD. A subtleness on the RG evolution with $N_f = 3$ is resolved and the results will be presented.

Quenched Approximation to $\Delta S = 1$ K Decay

Presented by: Norman H. Christ
Norman H. Christ
The importance of explicit quark loops in the amplitudes contributing to $\Delta S = 1$ K meson decays raises potential ambiguities when these amplitudes are evaluated in the quenched approximation. Using the factorization of these amplitudes into short- and long-distance parts provided by the standard low-energy effective weak Hamiltonian, we argue that the quenched approximation can be conventionally justified if it is applied to the long- distance portion of each amplitude. The result is a reasonably well-motived definition of the quenched approximation that will be compared to the approximation employed in the earlier RBC and CP-PACS calculations of these quantities.

The Kaon B-parameter from Two Flavour Dynamical Domain Wall Fermions.

Presented by: Chris Dawson
Chris Dawson
We report on the calculation of the kaon B-parameter using two dynamical flavours of domain wall fermions. Our analysis is based on three ensembles of configurations, each consisting of about 5,000 HMC trajectories, with a lattice spacing of approximately 1.7 GeV for $16^3 \times 32 \times 12$ lattices; dynamical quark masses range from approximately the strange quark mass to half of that. Both degenerate and non-degenerate quark masses are used for the kaons.

Towards a determination of the lowest moments of generalized parton distributions in full QCD

Presented by: Pleiter, Dirk
Pleiter Dirk
Precise calculation of structure functions and the lowest moments of the generalized parton distributions on the lattice would have a significant impact on understanding the structure of the nucleon. Current lattice techniques and compute power allow for simulations of full QCD closer to the chiral and continuum limit and therefore render reliable computations possible. Such calculations provide information, e.g., on the spatial distribution of charge and magnetization in the nucleon. We will present results from the QCDSF collaboration for generalized parton distribution functions focusing on most recent results from full QCD with non-perturbatively $O(a)$-improved Wilson fermions.

B_K for improved staggered quarks

Presented by: Elvira Gamiz
Elvira Gamiz, Sara Collins, Christine Davies, Junko Shigemitsu, Matthew Wingate
We compare calculations of B_K with improved staggered quarks (HYP, Asqtad) and demon-

strate the improved scaling behaviour that this gives rise to over old calculations with naive quarks. This allows the calculation of B_K on the MILC dynamical configurations and we hope to show results for his also.

Axial and tensor charge of the nucleon with dynamical fermions

Presented by: Meinulf Goeckeler

Meinulf Goeckeler, P. Haegler, R. Horsley, D. Pleiter, P.E.L. Rakow, A. Schaefer, G. Schierholz, J.M. Zanotti

We present results for the axial and tensor charge of the nucleon (and the corresponding form factors) obtained from simulations with $N_f = 2$ non-perturbatively $O(a)$ improved Wilson fermions. The renormalization of the corresponding two-quark operators is performed non-perturbatively. We discuss the quark-mass dependence of the results as well as the finite-size effects and compare with predictions from chiral perturbation theory.

Semileptonic Hyperon Decays on the Lattice: an Exploratory Study

Presented by: Diego Guadagnoli

Diego Guadagnoli, Guido Martinelli, Silvano Simula

We present preliminary results of an exploratory lattice study of the vector form factor $f_1(q^2 = 0)$ for the semileptonic hyperon decay $\Sigma^- \to N\ l\ \nu$. This study is based on the method applied in hep-ph/0403217 for the extraction of $f^+(0)$ for the decay $K^0 \to \pi^-\ l\ \nu$. The main task is to test the method against hyperons to understand what level of precision can be reached and the significance that $SU(3)$-breaking effects could have on the determination of V_{us}.

$\Delta I = 3/2\ k \to \pi\pi$ Decay with physical final state

Presented by: Changhoan Kim

Changhoan Kim

We present a calculation of the on-shell $\Delta I = 3/2\ K \to \pi\pi$ matrix element. We achieve a physical $\pi\pi$ final state with non-zero relative momentum by imposing anti-periodic boundary condition on the pion. By calculating the matrix element with varying strange quark mass, we can interpolate to the on-shell matrix element. Then, using the Lüscher and Lellouch formula and applying the NPR technique for renormalization, we can extract physical matrix element from the lattice calculation down to a pion mass of $358MeV$. This work is done at $a^{-1} = 1.31(4)GeV$ in a $16^3 \times 32$ volume where we assign each pion $257MeV$ momentum by anti-periodic boundary conditions.

Quenching effects in strong penguin contributions to ε'/ε

Presented by: John Laiho

John Laiho

We discuss some of the difficulties involved in the calculation of the left-right, strong penguin contributions (i.e. Q_6) to ϵ'/ϵ within the quenched approximation. As pointed out by

Golterman and Pallante, there are additional effective operators that appear in the quenched chiral perturbation theory needed to make contact with $K \to \pi\pi$ amplitudes at physical kinematics. They have also proposed a method for determining the leading order low-energy constant, α_q^{NS}, associated with the new operators. We show that their method has difficulties due to power divergent contributions and propose a new method to obtain this constant from the lattice which does not suffer from this problem. Using this alternative method we obtain α_q^{NS}.

Analysis of ϵ'/ϵ using staggered fermions

Presented by: Weonjong Lee

Weonjong Lee, T. Bhattacharya, G.T. Fleming, G. Kilcup, R. Gupta, S. Sharpe

We present most updated results of $Re(\epsilon'/\epsilon)$, size of the direct CP violation in neutral Kaon system, calculated using improved staggered fermions on the lattice of $16^3 \times 614$ at $\beta = 6.0$. These results are obtained using leading order chiral perturbation in quenched QCD. The systematics related to the quenched approximation is analyzed quantitatively. The results are compared with experiments.

Baryon magnetic moments in the external field method

Presented by: Frank Lee

Frank Lee, R. Kelly, L. Zhou, W. Wilcox

We present a calculation of the magnetic moment in the octet and decuplet sectors using the external field method and standard Wilson gauge and fermion actions. Progressively small static magnetic fields are introduced on a 24^4 lattice at beta=6.0 and the pion mass is probed down to about 500 MeV. Magnetic moments are extracted from the linear response of the masses to the external field. The results are chirally extrapolated and compared with other calculations and experiment.

Kaon weak matrix elements for direct and indirect CP violation in the standard model and beyond with Neuberger quarks

Presented by: Laurent Lellouch

Laurent Lellouch, Federico Berruto, Nicolas Garron, Christian Hoelbling, Joseph Howard, Silvia Necco, Claudio Rebbi, Noam Shoresh

I will present results for electroweak penguin contributions to direct CP violation and for possible new physics contributions to indirect CP violation in $K \to \pi\pi$ decays. The relevant matrix elements are obtained with Neuberger fermions on quenched gauge configurations generated with the Wilson plaquette action at $\beta = 6.0$ on an $18^3 \times 64$ lattice.

A First Look at $N_f = 3$ Dynamical DWF Simulations

Presented by: Robert D. Mawhinney (for the RBC Collaboration)

Robert D. Mawhinney (for the RBC Collaboration)

The RBC collaboration has done a preliminary simulation of full QCD with 3 degenerate flavors of domain wall fermions and the DBW2 gauge action. About 1,500 trajectories have been accumulated for a $16^3 \times 32$ lattice with $L_s = 8$, with a lattice spacing of $a^{-1} \approx 2$ GeV. Basic hadronic results from this simulation will be presented, as well as the residual mass.

The $K \to \pi$ vector form factor on the lattice

Presented by: Federico Mescia

Federico Mescia

We present a quenched lattice study of the form factors $f_+(q^2)$ and $f_0(q^2)$ of the matrix elements $\langle \pi | \bar{s}\gamma_\mu u | K \rangle$. We focus on the second-order SU(3)-breaking quantity $[1 - f_+(0)]$, which is necessary to extract $|V_{us}|$ from $K_{\ell 3}$ decays. For this quantity we show that it is possible to reach the percent precision which is the required one for a significant determination of $|V_{us}|$.

Kaon Matrix Elements in Domain-Wall QCD with DBW2 Gauge Action

Presented by: Jun Noaki

Jun Noaki, RBC Collaboraiton

We are calculating the decay constants, kaon B-parameter B_K, $\Delta I = 1/2$ rule and ϵ'/ϵ using the quenched DBW2 gauge action with domain-wall fermions. For the first two quantities, we carry two kinds of simulations with different lattice scales, $1/a \approx 2.0$ and 3.0 GeV. In this talk, we discuss some of the technical details of the calculation, potential systematic errors coming from chiral symmetry breaking and scale dependences and consistency with previous work as well as presenting some preliminary results.

Nucleon structure with domain wall fermions

Presented by: Shigemi Ohta (RBCK Collaboration)

Shigemi Ohta (RBCK Collaboration), Kostas Orginos

We report the status of RBCK calculations on nucleon structure with quenched and dynamical domain wall fermions. The quenched results for the moments of structure functions $\langle x \rangle_q$, d_1, and $\langle 1 \rangle_{\delta q}$ from 1.3 GeV cutoff lattices are complete with non perturbative renormalization (NPR) and final. The dynamical results with two degenerate dynamical quark flavors from 1.7 GeV cutoff lattices are without NPR while the axial charge result is naturally renormalized and is complete.

Precision computation of B_K in quenched lattice QCD

Presented by: Carlos Pena

Carlos Pena, Petros Dimopoulos, Jochen Heitger, Stefan Sint, Anastassios Vladikas

The results of a precision computation of B_K with Wilson fermions are presented. Simulations are performed at different lattice spacings, enabling continuum limit extrapolations. Two different twisted mass QCD regularisations are considered for the computation of bare matrix elements. In both cases the relevant four-fermion operator renormalises multiplicatively. In one regularisation it is possible to perform the computation directly at the physical kaon mass value, thus avoiding extrapolations in the mass. Nonperturbative renormalisation is carried out using available Schrödinger Functional results.

Magnetic and Electric dipole form factors of nucleons with DWQ

Presented by: Amarjit Soni
Amarjit Soni, Federico Berruto, Tom Blum, Kostas Orginos

Attempts at extracting nucleon form-factors with DWQ are discussed. Our main target is the electric dipole moment of the neutron arising due to the theta-term in the QCD gauge action. However, given that the methodology for lattice calculation is much the same we use the opportunity to extract nucleon magnetic and electric form factors. We plan to use both quenched and dynamical ($N_f = 2$) domain-wall quarks. Theoretical and computational issues will be clarified and some preliminary numerical results presented.

Sea quark effects in B_K from $N_f = 2$ clover-improved Wilson fermions

Presented by: Abdullah Shams Bin Tariq
Abdullah Shams Bin Tariq, Jonathan M. Flynn, Federico Mescia

We report calculations of the parameter B_K appearing in the $\Delta S = 2$ neutral kaon mixing matrix element, whose uncertainty limits the power of unitarity triangle constraints for testing the standard model or looking for new physics. We use two flavours of dynamical clover-improved Wilson lattice fermions and look for dependence on the dynamical quark mass at fixed lattice spacing. We see some evidence for dynamical quark effects and in particular B_K decreases as the sea quark masses are reduced towards the up/down quark mass.

Recent results on moments of parton distribution functions

Presented by: Ines Wetzorke
Ines Wetzorke, ZeRo Collaboration, XLF Collaboration

We report on recent results for the pion and nucleon matrix element of the twist-2 operator corresponding to the average momentum of non-singlet quark densities. We discuss the chiral extrapolation to physical quark masses, finite size effects for the nucleon matrix element and present first results for the non-perturbative renormalization from full dynamical simulations.

Correlation functions at small quark masses with overlap fermions

Presented by: Hartmut Wittig
Hartmut Wittig, Leonardo Giusti, Pilar Hernandez, Mikko Laine, Carlos Pena, Peter Weisz, Jan Wennekers

We report on our activities in computing correlation functions at small quark masses, using overlap fermions. The aim is to develop efficient numerical techniques that allow for the determination of low-energy constants, such as F_π and the quark condensate, to be determined by matching correlation functions to the expressions of ChPT, preferably in the ϵ-regime. Large statistical fluctuations, caused by local "bumps" in wavefunctions associated with low modes of the Dirac operator, render precise calculations of correlation functions for small quark masses extremely difficult. Using a technique called "low-mode averaging" we are able to reduce significantly statistical fluctuations in the computation of 2-point functions. We present results for the pion decay constant and describe our experience in applying the same technique to the calculation of 3-point functions.

Generalised Parton Distributions from Quenched and Dynamical QCD

Presented by: James Zanotti
James Zanotti, M. Göckeler, P. Hägler, R. Horsley, D. Pleiter, P. Rakow, A. Schäfer, G. Schierholz
Generalised parton distributions provide information on the longitudinal and transverse distributions of partons in the fast moving nucleon. Here we present the latest results from the QCDSF collaboration for (moments of) structure functions and form factors in both quenched and full QCD using $\mathcal{O}(a)$-improved Wilson fermions. In particular, we focus on the latest results for the lowest three moments of the GPD's $H(x, \xi, \Delta^2)$ and $\widetilde{H}(x, \xi, \Delta^2)$.

3 Heavy quark physics

The B_c mass from unquenched Lattice QCD

Presented by: Ian Allison
Ian Allison

In the light of renewed theoretical interest, and in anticipation of new experimental studies of the B_c meson system, we perform a precise unquenched calculation of its ground state mass using $2+1$ flavour (improved staggered) dynamical configurations from the MILC collaboration. Lattice NRQCD and the Fermilab formalism are used to describe the b and c quarks respectively. This complements previous successful studies of the Υ system using NRQCD and the ψ system using the Fermilab approach, made using the same configurations.

Staggered Chiral Perturbation Theory with Heavy-Light Mesons

Presented by: Christopher Aubin
Christopher Aubin, C. Bernard

We merge heavy quark effective theory with staggered chiral perturbation theory to calculate heavy-light meson (B and D meson) quantities. This results in an additional taste-symmetry breaking potential involving the heavy-light mesons with 16 new undetermined parameters. Although this potential violates the taste symmetry at $O(a^2)$, its terms do not contribute to the one-loop calculation of important quantities such as decay constants, form factors, and B parameters, although they would contribute at higher order. We show results for the B meson decay constant in the partially quenched, full QCD and quenched cases, and discuss the calculation of the form factors for $B(D) \to \pi(K)\ell\nu$ decays.

First Results from CLEO-c Results

Presented by: David Cinabro (CLEO-c collaboration)
CLEO Analysis Coordinator: Daniel Cronin-Hennessy(i.e. TBD)

Initial running of the CLEO-c detector has provided the world's largest sample of $\psi(3770)$ decays. Using this data we have reconstructed D mesons decaying to hadronic final states and have used them to tag events with a charm-anti-charm meson pair. CLEO presents preliminary results from our charm energy data which will include measurements of the D meson decay constant, $D\overline{D}$ production cross section and the status of a variety of exclusive semileptonic measurements.

The heavy quark self energy from moving NRQCD on the lattice

Presented by: Alex Dougall
Alex Dougall, Christine T. H. Davies, Kerryann M. Foley, G. Peter Lepage

We present results for the heavy quark self-energy in moving NRQCD to one-loop in perturbation theory. Results for the energy shift, mass and velocity renormalisations are discussed and compared with non-perturbative results. We show that the velocity renormalisation is small, which is required by reparameterisation invariance.

Signal at subleading order in lattice-HQET

Presented by: Stephan Durr
Stephan Durr, Andreas Juttner, Juri Rolf, Rainer Sommer

We discuss the correlators needed at subleading order in HQET to compute the decay constant F_B beyond the static limit. Based on our implementation in the Schrödinger functional we will focus on the signal-to-noise ratios and briefly comment on further applications.

Moving NRQCD: B mesons at large momentum

Presented by: Kerryann Foley
Kerryann Foley, G.P. Lepage, C.T.H. Davies, A. Dougall

We briefly review moving NRQCD formalism and its appropriateness for lattice calculations of heavy meson decays, such as $B \to \pi l \nu$, at large recoil. We include a discussion on the optimal frame choice for different systems and present new simulation results for the kinetic mass and velocity renormalizations as well as showing that the decay constant is determined correctly at large momenta.

Heavy-light decay constants using clover valence quarks and three flavors of dynamical improved staggered quarks

Presented by: Steven Gottlieb
Steven Gottlieb, C. Bernard, T. Burch, S. Datta, D. DeTar, E. B. Gregory, U. M. Heller, J. Osborn, R. Sugar, D. Toussaint

The MILC Collaboration, starting some time ago, began a large scale calculation of heavy-light meson decay constants using clover valence quarks on ensembles of three flavor configurations. For the coarse configurations, with $a = 0.12$ fm, eight combinations of dynamical light and strange quarks have been used. For the fine configurations, with $a = 0.09$ fm, three combinations of quark masses are used. Since we last reported on this calculation, statistics have been increased on the fine ensembles, and, more importantly, the perturbative renormalization of the axial-vector current has been calculated by M. Nobes. Thus, results for f_B, f_{B_s}, f_D and f_{D_s} can be calculated in MeV, in addition to ratios that were calculated previously.

B Leptonic Decays and $B-\bar{B}$ Mixing with 2+1 Flavors of Dynamical Quarks

Presented by: Alan Gray
Alan Gray, Christine T.H. Davies, Emel Gulez, G. Peter Lepage, Junko Shigemitsu, Matthew Wingate

Calculations of B leptonic decays and $B-\bar{B}$ mixing using NRQCD heavy and Asqtad light valence quarks on the MILC dynamical configurations are described. Smearing has been implemented to substantially reduce the statistical errors of the matrix elements needed for the determination of f_B. Preliminary chiral extrapolations have been done. The four fermion matrix elements needed for the determination of $f_B^2 B_B$ have been calculated and preliminary fits have been successful.

Matching of the Heavy-Light Currents with NRQCD Heavy and Improved Naive Light Quarks

Presented by: Emel Gulez
Emel Gulez, Junko Shigemitsu, Matt Wingate

One-loop matching of heavy-light currents is carried out for a highly improved lattice action, including the effects of mixings with dimension 4 $\mathcal{O}(1/M)$ and $\mathcal{O}(a)$ operators. We use the NRQCD action for heavy quarks, the Asqtad improved naive action for light quarks, and the Symanzik improved glue action. The results have been used for calculating decay rates and semileptonic form factors for B, B_S and D_S.

Non-perturbative tests of HQET in small-volume quenched QCD

Presented by: Jochen Heitger
Jochen Heitger, Andreas Juettner, Rainer Sommer, Jan Wennekers

We quantitatively investigate the heavy quark mass dependence of current matrix elements and energies, which are derived from relativistic heavy-light meson correlation functions and calculated over a wide range of quark masses in the continuum limit of small-volume quenched lattice QCD. These observables, as functions of the heavy quark mass, allow for a precise comparison with the predictions of the heavy quark effective theory (HQET). We are able to verify that the large quark mass behaviour of our quantities is described by the effective theory and to obtain non-perturbative estimates on the size of the $1/m$–corrections to the static theory. The latter are also of practical relevance in our recent strategy to solve renormalization problems in HQET non-perturbatively by a matching to QCD in finite volume.

Charmed meson spectrum and decay constants with the one-loop $O(a)$ improved relativistic heavy quark action.

Presented by: Yasuhisa Kayaba
Yasuhisa Kayaba, S. Aoki, O. Baer, M. Fukugita, K.-I. Ishikawa, N. Ishizuka, Y. Iwasaki, K. Kanaya, T. Kaneko, Y. Kuramashi, M. Okawa, Y. Taniguchi, A. Ukawa, T. Yoshie

Employing a relativistic heavy quark action and axial vector currents pertubratively improved at $O(g^2a)$, we calculate the charmed meson spectrum and decay constants in Lattice QCD with a renormalization-group improved gauge action as well as the plaquette gauge action.
We check the validity of the heavy quark formulation in quenched simulations at a fixed lattice spacing $a \sim 0.1$ fm: It is shown that the continuum dispersion relation for energy and a space-time interchange symmetry for decay constants are satisfied within expected systematic errors.
Preliminary results from simulations with two flavors of dynamical quarks are also reported.

Excited B mesons from the lattice

Presented by: Jonna Koponen
Jonna Koponen, A.M. Green, C. McNeile, C. Michael, G. Thompson

The energies of different angular momentum states of a heavy-light meson were measured on a lattice in [1]. We have now repeated this study using several different lattices, quenched and unquenched, that have different physical lattice sizes, clover coefficients and quark–gluon couplings. The heavy quark is taken to be infinitely heavy, whereas the light quark mass is approximately that of the strange quark. By interpolating and extrapolating in the light quark mass we can thus compare the lattice results with B and B_s meson experiments. Most interesting is the lowest P-wave B_s state, since it is possible that it lies below the BK threshold and hence is very narrow. Unfortunately, there are no experimental results on P-wave B or B_s mesons available at present.
The new measurements confirm the earlier calculated energy spectrum [2]. From some theoretical considerations [3] it is expected that, for higher angular momentum states, the multiplets should be inverted compared with the Coulomb spectrum, *i.e.* nL$-$ should lie higher than nL+. Here nL+($-$) means that the light quark spin couples to angular momentum L giving the total $j = L \pm 1/2$ and n is the principal quantum number. Experimentally this inversion is not seen for P-waves, and now the lattice measurements show that there is no inversion in the D-wave states either. In fact, the 1D+ and 1D$-$ states seem to be nearly degenerate, *i.e.* the spin-orbit splitting is very small.
In addition to the energy spectrum, we measured earlier also vector (charge) and scalar (matter) radial distributions of the light quark in the S-wave states of a heavy-light meson on a lattice [4]. Now we are extending the study of radial distributions to P-wave states and we hope to be able to present some preliminary results at the conference.

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Non-perturbative determination of heavy quark action coefficients

Presented by: Huey-WEn Lin
Huey-WEn Lin

We propose to determine the coefficients in the Fermilab heavy quark action by matching the finite-volume, off-shell, gauge-fixed propagator and vertex functions with those determined in the exact, relativistic theory. The matching, relativistic amplitudes may be determined either from short-distance perturbation theory or from finite-volume step-scaling recursion. This method will be illustrated by tree-level matching, and preliminary non-perturbative off-shell amplitudes will be shown.

Heavy meson chiral perturbation theory in finite volume

Presented by: C.-J. David Lin
C.-J. David Lin, Daniel Arndt

We study finite volume effects in heavy-light meson systems using heavy-light chiral perturbation. It is shown that volume effects can be amplified in the heavy-quark mass, as well as the light-quark mass extrapolations/interpolations. As an explicit example, we calculate finite volume effects in the $B_{B_{(s)}}$ paramter, $f_{B_{(s)}}$ and the SU(3) ratios in full, quenched and partially-quenched QCD.

The charm quark mass with dynamical fermions

Presented by: C.M, Maynard
C.M Maynard, UKQCD collaboration, A. Dougall, C. Mcneile

We compute the charm quark mass in lattice QCD and compare different formulations of the heavy quark, and quenched data to that with dynamical sea quarks. We take the continuum limit of the quenched data by extrapolating from three different lattice spacings, and compare to data with two flavours of dynamical sea quarks with a mass around the strange at the coarsest lattice spacing.

Phenomenology of static-light mesons from unquenched lattice QCD calculations.

Presented by: Craig McNeile
Craig McNeile, Chris Michael, Gavin Thompson

I present results for the static-light meson from unquenched lattice QCD. The unquenched gauge configurations were generated using the non-perturbatively improved clover action. At the fixed lattice spacing of 0.1fm the lightest sea quark mass used is a third of the strange quark mass. A comparison is made between heavy-light chiral perturbation theory and the f_B^{static} decay constant. The mass of the bottom quark is reported.

The B_{B} parameter in the static approximation without mixings, from tm-Wilson fermions

Presented by: Michele Della Morte
Michele Della Morte
We start from the recent proposal by R. Frezzotti and G. Rossi to chirally improve Wilson fermions in such a way that mixings among operators of different chirality can be excluded. The method, which is based on the use of tmQCD with several replica of valence quarks, is extended here to static-light systems. The operators relevant for the computation of the B_{B} parameter (in the static approximation) are considered. In this case the same renormalization pattern as for Ginsparg-Wilson fermions is obtained by a simple modification of the discretization of the valence quarks action.

Semileptonic $D \to \pi/K$ and $B \to \pi/D$ decays in three flavor lattice QCD

Presented by: Masataka Okamoto
Masataka Okamoto, C. Aubin, C. Bernard, C. DeTar, M. Di Pierro, A. X. El-Khadra, S. Gottlieb, E. B. Gregory, U. M. Heller, A. S. Kronfeld, P. B. Mackenzie, D. Menscher, M. B. Oktay, J. Osborn, J. N. Simone, R. Sugar, D. Toussaint
We present our results for semileptonic $D \to \pi$ and $D \to K$ decay form factors in three flavor unquenched lattice QCD using the MILC gauge configurations. Simulations are carried out with the Asqtad improved staggered light quark action with masses ranging from $3m_s/4$ to $m_s/8$. We perform chiral extrapolations using the staggered chiral perturbation theory. The results are then compared to experimental ones. We also report preliminary unquenched results for semileptonic $B \to \pi$ and $B \to D$ decays and compare to previous quenched results.

Model independent determination of $|V_{ub}|$ from $B \to \pi l \nu$ decay

Presented by: Tetsuya Onogi
Tetsuya Onogi, Masaru Fukunaga
We determine the CKM matrix element $|V_{ub}|$ using with lattice results, dispersive bounds, and experimental data. The lattice calculation of the $B \to \pi l \nu$ form factor is limited to large q^2 regime, Therefore, although the B factory experiment can measure the decay rate for all q^2, only a partial result has been used for the determination of $|V_{ub}|$. With the help of the statistical distributions of the dispersive bound proposed by Lellouch, we carry out a "global fit" using the lattice data and CLEO results for all kinematic range. We show that the accuracy of $|V_{ub}|$ can be improved by this method.

The residual mass in lattice Heavy Quark Effective Theory to the third order

Presented by: Francesco Di Renzo
Francesco Di Renzo, Luigi Scorzato

As it is well known, a lattice determination of the b-quark mass can be obtained in the framework of Heavy Quark Effective Theory (HQET). One possible procedure goes as follows. By matching the QCD propagator to its lattice HQET counterpart one can relate the pole mass to the binding energy and the physical mass of an hadron, *i.e.* the B meson. Since the relation between the pole and the $\overline{\mathrm{MS}}$ mass is known, the latter can be obtained. A delicate (again, well known) point is that in the computation of the lattice HQET propagator a linearly divergent contribution arises, which cancels both a similar divergence in the binding energy and a renormalon ambiguity in the definition of the pole mass. This (mass) contribution is known as the residual mass. Its computation to α_s^3 order in the quenched approximation greatly improved the final error for the b-quark mass. Now the computation has been at the same order extended to the $N_f = 2$ (unquenched) case. We discuss the impact on an unquenched determination of the b-quark mass.

Preliminary results for f_B on a dynamical anisotropic lattice

Presented by: Sinéad Ryan
Sinéad Ryan, Keisuke J. Juge, Richard Morrin, Alan O Cais, Mike Peardon, Jon-Ivar Skullerud

A (very) preliminary determination of f_B on dynamical lattices is described. The heavy quark is simulated in the static approximation and an improved Wilson formulation is used for the light quark. Improved all-to-all static-light propagators are compared to point sources for this calculation.

Semileptonic B Decays with Nf=2+1 Dynamical Quarks

Presented by: Junko Shigemitsu
Junko Shigemitsu, C.Davies, A.Dougall, K.Foley, E.Gamiz, A.Gray, E.Gulez, P.Lepage, M.Wingate

Semileptonic, $B \to \pi\, l\overline{\nu}$, decays are studied on the MILC dynamical configurations using NRQCD heavy and Asqtad light quarks. We work with light valence quark masses ranging between m_s and $m_s/8$. Preliminary simple linear chiral extrapolations have been carried out for form factors $f_\parallel$ and $f_\perp$ at fixed E_π. The chirally extrapolated results for the form factors $f_+(q^2)$ and $f_0(q^2)$ are then well fit by the Becirevic-Kaidalov (BK) parametrization. The form factor $f_+(q^2)$ exhibits a pole at the physical M_{B^*} and the BK fit is also consistent with the soft pion relation for f_0.

The determination of decay constants f_{D_s} and f_D in $2+1$ flavor lattice QCD

Presented by: James N. Simone
James N. Simone, C. Aubin, C. Bernard, C. DeTar, M. Di Pierro, A.X. El-Khadra, S. Gottlieb, E.B. Gregory, U.M. Heller, A.S. Kronfeld, P.B. Mackenzie, D. Menscher, M. Okamoto, M.B. Oktay, J. Osborn, R. Sugar, D. Toussaint

We study leptonic decay constants f_{D_s} and f_D in $2+1$ flavor lattice QCD using the MILC collaboration's Asqtad action gauge configurations. We use tadpole-improved clover charm quarks in the Fermilab interpretation and improved staggered light valence quarks. We compute decay constants in the partially quenched theory where valence quark masses and sea quark masses are permitted to be unequal. These results are fit using the expansion for the heavy-light decay constants from Staggered Chiral Perturbation Theory. We use the low energy constants determined in the partially quenched theory to recover the chiral behavior of the decay constant in full QCD.

Charmonium Spectrum from Quenched QCD with Overlap Fermions

Presented by: Sonali Tamhankar
Sonali Tamhankar, Andrei Alexandru, Ying Chen, Shao-Jing Dong, Terrence Draper, Ivan Horváth, Frank X. Lee, Keh-Fei Liu, Nilmani Mathur, Jianbo Zhang

We present preliminary results for charmonium spectrum using overlap fermions, in particular for hyperfine splitting. Simulations are performed on $16^3 \times 72$ lattices, with Wilson gauge action at $\beta = 6.3345$.

4 Non-zero temperature and density

Progress on the finite density calculation with canonical ensemble

Presented by: Andrei Alexandru
Andrei Alexandru, Keh-Fei Liu, Ivan Horvath, Manfried Faber

We will be talking about an implementation of the canonical ensemble approach to the finite density problem. We will also discuss measuring observables using the canonical partition function and present some preliminary results with different baryon numbers on a small volume.

New ideas in finite density QCD

Presented by: Vicente Azcoiti
Vicente Azcoiti, Giuseppe Di Carlo, Angelo Galante, Victor Laliena

We introduce a new approach to analyze the phase diagram of QCD at finite chemical potential and temperature, based on the definition of a generalized QCD action. Several details of the method will be discussed, with particular emphasis on the advantages respect to the imaginary chemical potential approach.

Spinodal Decomposition in SU(3) Lattice Gauge Theory

Presented by: A. Bazavov
A. Bazavov, B.A. Berg, A. Velytsky

We consider model A dynamics for a quench from the disordered (confined) into the ordered (deconfined) phase of $SU(3)$ lattice gauge theory. For $4 \times L^3$ lattices the exponential growth factors of low-lying structure function modes are found to depend on the spatial volume L^3. Due to a competition between differently ordered vacuum domains, model A dynamics cannot equilibrate the continuum limit of the system in any finite (physical) time. We investigate the influence of this effect on the gluonic energy density.

The lattice QCD simulation of the quark-gluon mixed condensate $g\langle\bar{q}\sigma_{\mu\nu}G_{\mu\nu}q\rangle$ at finite temperature and the phase transition of QCD

Presented by: Takumi Doi
Takumi Doi, Noriyoshi Ishii, Makoto Oka, Hideo Suganuma

The thermal effects on the quark-gluon mixed condensate $g\langle\bar{q}\sigma_{\mu\nu}G_{\mu\nu}q\rangle$ are investigated using the $\mathrm{SU}(3)_c$ lattice QCD with the Kogut-Susskind fermion at the quenched level. We emphasize that the mixed condensate is an alternative chiral order parameter which characterizes different aspect of the QCD vacuum from the standard quark condensate $\langle\bar{q}q\rangle$, and is suitable to study the chiral structure of the QCD vacuum. In addition, the mixed condensate plays an important role in various quark hadron physics, especially in the baryon sector such as the N-Δ splitting. It is also pointed out that the mixed condensate is a key quantity for the prediction on the parity of the recently discovered penta-quark baryon, $\Theta^+(1540)$. In this talk, we present the evaluation of the mixed condensate $g\langle\bar{q}\sigma_{\mu\nu}G_{\mu\nu}q\rangle$ as well as quark condensate $\langle\bar{q}q\rangle$ at finite temperature. Comparing the thermal behavior of the two different condensates and of the Polyakov loop, we also discuss the vacuum structure of QCD near the phase transition temperature.

Fluctuations in the vicinity of the phase transition line for two flavor QCD

Presented by: Shinji Ejiri
Shinji Ejiri, C.R. Allton, M. Doering, S.J. Hands, O. Kaczmarek, F. Karsch, E. Laermann, K. Redlich, C. Schmidt

Thermal fluctuations near the critical temperature T_c provide important information for the understanding of the properties of the QCD phase transition at high temperature and density. The fluctuation of the baryon number is expected to diverge at the endpoint of the first order chiral phase transition line. The electric charge fluctuation in heavy-ion collisions is one of the most promising experimental observables to identify the critical endpoint. We study the susceptibilities of quark number, iso-spin number and electric charge in numerical simulations of lattice QCD at high temperature and density. The simulation of QCD at non-zero baryon density has been known to be difficult. However, studies based on a Taylor expansion with respect to chemical potential μ_q turned out to be an efficient technique to investigate the low density regime, interesting for heavy-ion collisions. We discuss the equation of state for 2 flavor QCD at non-zero temperature and density. Derivatives of $\ln Z$ with respect to μ_q are calculated up to sixth order. From this Taylor series, the susceptibilities are estimated as functions of temperature and μ_q. Moreover, we comment on the hadron resonance gas model, which explains well our simulation results below T_c.

Deconfinement and chiral restoration in hot and dense matter

Presented by: Kenji Fukushima
Kenji Fukushima, Yoshitaka Hatta

We argue that the chiral phase transition at zero quark mass and the deconfinement transition at infinite quark mass are continuously connected in the quark mass and temperature plane. This gives a simple interpretation on the coincidence of the pseudo-critical temperature observed in lattice QCD. We show the results in a model study to discuss the dynamical mechanism behind the simultaneous phase transitions. We suggest several lattice measurements at finite temperature and density based on our scenario and model study.
[References] K. Fukushima, Phys. Lett. B553, 38 (2003). K. Fukushima, Phys. Rev. D68, 045004 (2003). Y. Hatta and K. Fukushima, Phys. Rev. D69, 097502 (2004). K. Fukushima, hep-ph/0310121 to appear in Phys. Lett. B. Y. Hatta and K. Fukushima, hep-ph/0311267

Testing new strategies in finite density

Presented by: Angelo Galante
Angelo Galante, Vicente Azcoiti, Giuseppe Di Carlo, Victor Laliena

A new approach for non-zero chemical potential simulations is tested in the Gross-Neveu model where the critical line is reconstructed in a large μ/T interval. Preliminary results for $N_f = 4$ QCD are also presented.

Study of the chiral transition in $N_f = 2$ QCD

Presented by: Adriano Di Giacomo
Adriano Di Giacomo, Massimo D'Elia, Claudio Pica

The order of the chiral transition for $N_f = 2$ is an interesting probe of the QCD vacuum. A strategy is developed to investigate the order of the transition using finite size scaling and its relation to color confinement. The results of the analysis will be presented in a separate talk.

Finite temperature 2-color QCD for real and imaginary chemical potential

Presented by: Pietro Giudice
Pietro Giudice, Alessandro Papa

We study 2-color QCD in (3+1)D at finite temperature T and for *both* real ($\mu = \mu_R$) and imaginary ($\mu = i\mu_I$) values of the chemical potential for baryon density. We discuss the structure of the phase diagram on the T-μ_R and T-μ_I planes and verify the applicability of the method of analytical continuation.

QCD at small baryon number

Presented by: Slavo Kratochvila
Slavo Kratochvila, Philippe de Forcrand

We consider the difficulties of finite density QCD from a different angle: the canonical formalism. We present results for small baryon numbers, where the sign problem can be controlled, in particular by supplementing the mu=0 sampling with imaginary mu ensembles. We initiate the thermodynamic study of few-nucleon systems.

strong coupling analysis of diquark condensation

Presented by: Victor Laliena

Victor Laliena, Vicente Azcoiti, Giuseppe Di Carlo, Angelo Galante

The phenomenon of diquark condensation at non-zero baryon density and zero temperature is analyzed in the strong coupling limit of lattice QCD. The results indicate that there is attraction in the quark-quark channel also at strong coupling, and that the attraction is more effective at high baryon density, but for infinite coupling it is not enough to produce diquark condensation. It is argued that the absence of diquark condensation is not a peculiarity of the strong coupling limit, but persists at sufficiently large finite couplings.

Nuclear Lattice Simulations with Chiral Effective Field Theory

Presented by: Dean Lee

Dean Lee, Bugra Borasoy, Thomas Schaefer

We study nuclear and neutron matter by combining chiral effective field theory with non-perturbative lattice methods. In our approach nucleons and pions are treated as point particles on a lattice. This allows us to probe larger volumes, lower temperatures, and greater nuclear densities. The low energy interactions of these particles are governed by chiral effective theory and operator coefficients are determined by fitting to zero temperature few-body scattering data. The leading dependence on the lattice spacing can be understood from the renormalization group and absorbed by renormalizing operator coefficients. In this way we have a realistic simulation of many-body nuclear phenomena with no free parameters, a systematic expansion, and a clear theoretical connection to QCD. We present results for hot neutron matter at temperatures 20 to 40 MeV and densities below twice nuclear matter density.

A Noisy Hybrid Monte Carlo Algorithm for Finite Density

Presented by: Keh-Fei Liu

Keh-Fei Liu

A Noisy Hybrid Monte Carlo (NHMC) algorithm for the finite density in the canonical ensemble approach is discussed. It may overcome the sign and overlap problems in the grand canonical ensemble approach with the chemical potential and the fluctuation problem in the Noisy Monte Carlo algorithm.

QCD at Finite Temperature and Density with Staggered and Wilson Quarks

Presented by: Xiang-Qian Luo

Xiang-Qian Luo

At sufficiently high temperature T or chemical potential μ, QCD is expected to undergo phase transition from quark confinement to new forms of matter. We present results for phase structure on the (μ, T) plane for lattice QCD with Kogut-Susskind Fermions from Lagrangian Monte Carlo simulations, and Wilson fermions from strong coupling Hamiltonian analysis.

3-d lattice SU(3) free energy to four loops

Presented by: Andrea Mantovi
Andrea Mantovi, Francesco Di Renzo, Vincenzo Miccio, York Schroder, Christian Torrero

The free energy density is a good observable to study the deconfinement phase transition. One would like to follow its evolution across the phase transition in order to connect the confinement region to the quark gluon plasma phase. Dimensional reduction is a strategy to bridge the gap between the two phases. In a continuum scheme ($\overline{\mathrm{MS}}$) one can match the full theory to a $3d$ $SU(3)$ gauge theory coupled to a Higgs field in the adjoint representation. The latter can then in turn be matched to the $3d$ $SU(3)$ pure gauge theory, which captures the ultrasoft degrees of freedom and can be simulated on the lattice. The lattice measurements can be incorporated in the reduction setup by computing the $3d$ lattice $SU(3)$ free energy in perturbation theory to four loops (the $3d$ theory is superrenormalizable and so all divergences can be computed perturbatively). We report on this computation. We discuss how to deal properly with the logarithmic infrared divergence one encounters at four loop.

Density profiles of the lowest eigenvalues of the Dirac operator for two color QCD at nonzero chemical potential compared to matrix models

Presented by: Harald Markum
Harald Markum, Gernot Akemann, Elmar Bittner, Maria-Paola Lombardo, Rainer Pullirsch

We investigate the eigenvalue spectrum of the staggered Dirac matrix in full QCD with two colors and finite chemical potential. The profiles of the lowest eigenvalues in the complex plane are compared to results of a matrix model at weak and strong non-Hermiticity.

Finite temperature QCD with two flavors of dynamical quarks on $24^3 \times 10$ lattice

Presented by: Yoshifumi Nakamura
Yoshifumi Nakamura, V.G. Bornyakov, M.N. Chernodub, Y. Mori, S.M. Morozov, M.I. Polikarpov, G. Schierholz, A.A. Slavnov, H. Stueben , T. Suzuki

We present results obtained in QCD with two flavors of non-perturbatively improved Wilson fermions at finite temperature on $16^3 \times 8$ and $24^3 \times 10$ lattices.
We determine the transition temperature in the range of quark masses $0.6 < m_\pi/m_\rho < 0.8$ at lattice spacing $a \sim 0.1$ fm and extrapolate the transition temperature to the continuum and to the chiral limits.

Eigenvalue correlations in QCD with a chemical potential

Presented by: James C. Osborn
James C. Osborn

I will present a new Random Matrix Model for QCD with a chemical potential that is based on the symmetries of the Dirac operator and can be solved exactly for all eigenvalue correlations for any number of flavors. In the microscopic limit of small energy levels the results should be an accurate description of QCD. This new model can also be scaled so that all physical observables remain at their $\mu = 0$ values until the first order chiral restoration transition is reached. This gives a more realistic model for the QCD phase diagram than previous RMM. I will also mention what the phase diagram looks like for different numbers of flavors.

Numerical test of Polyakov loop models in high-temperature SU(2)

Presented by: Alessandro Papa
Alessandro Papa, Roberto Fiore, Pietro Giudice

We study the compatibility of mean-field theory models for the Polyakov loop in the deconfined phase of SU(N) pure gauge theories with numerical data obtained for the case of SU(2), in the temperature range $T_c \div 4T_c$.

Cut-off effects in meson correlators and spectral functions

Presented by: Peter Petreczky
Peter Petreczky, Tom Blum

Recent lattice calculations of meson spectral functions at zero and finite temperature in quenched QCD with Wilson fermions show large lattice artifacts at high energies (doubler peaks). The origin of these artifacts is not yet known. Therefore we have performed calculations of the meson spectral function on quenched, 2+1 flavor $a^2 - tad$, and two flavor domain wall fermion lattices using tree-level clover, HYP-smeared tree-level clover, and domain wall fermion valence quarks at several lattice spacings. We find lattice artifacts at high energy for all fermion actions mentioned above. We also the discuss the problem of extracting excited state meson properties from the spectral function of point-point correlation functions. We find that with HYP- smeared Wilson fermions one can avoid exceptional configurations, making this formulation convenient for detailed study of finite temperature meson spectral functions in the limit of small quark masses.

Free energy of a static quark anti-quark pair and the renormalized Polyakov loop in three flavor QCD

Presented by: Konstantin Petrov
Konstantin Petrov, Peter Petreczky

We study the free energy of a static quark anti-quark pair at finite temperature in three flavor QCD with degenerate quark masses using $N_\tau = 4$ and 6 lattices with Asqtad staggered fermion action. The static free energy was calculated for different values of the quark mass and the entropy contribution at large distances has been extracted. We also calculate the renormalized Polyakov loop.

The order of the chiral transition in $N_f = 2$ QCD

Presented by: Claudio Pica
Claudio Pica, Massimo D'Elia, Adriano Di Giacomo

An in-depth numerical investigation has been performed with KS fermions on lattices with $N_t = 4$ and $N_s = 12, 16, 20, 24, 32$ and quark masses am_q ranging from 0.01335 to 0.35. The specific heat and a number of susceptibilities have been measured and compared with the expectation of an $O(4)$ second order and a first order phase transition. A second order $O(4)$ is excluded, whilst data are consistent with a first order.

Hadron screening masses at finite baryonic density

Presented by: Irina Pushkina
Irina Pushkina, QCD-TARO Collaboration

We report on studies of the effects of chemical potential on the pseudoscalar and vector meson screening masses with Kogut-Susskind fermions. To get an insight into the behavior of a system at finite density, we expand the masses in the vicinity of zero chemical potential at finite temperature, and explore their changes through the response to the chemical potential at $\mu = 0$. Such technique allows to perform the numerical simulations with standard methods.
We investigate derivatives with respect to both the isoscalar ($\mu_S = \mu_u = \mu_d$) and isovector ($\mu_V = \mu_u = -\mu_d$) chemical potential. The results indicate a rapid mass increase at $T > T_c$ at finite isoscalar chemical potential. We also observed one distinguished feature in the case of the pseudoscalar meson at finite isovector chemical potential at temperature $140 - 200 MeV$. The manifestation of medium effects is discussed.

N=(1,1) Super Yang-Mills in (1+1) Dimensions at Finite Temperature

Presented by: Nathan Salwen
Nathan Salwen, J.R. Hiller, Yiannis Prestos, Stephen Pinsky

We present a formulation of $\mathcal{N} = (1,1)$ super Yang–Mills theory in 1+1 dimensions at finite temperature. The partition function is constructed by finding a numerical approximation to the entire spectrum. We solve numerically for the spectrum using Supersymmetric Discrete Light-Cone Quantization (SDLCQ) in the large-N_c approximation and calculate the density of states. We find that the density of states grows exponentially and theory has a Hagedorn temperature which we extract. We use the density of density of state to also calculate a standard set of thermodynamic functions below the Hadedorn temperature. In this temperature range there is some non-trivial behavior of the thermodynamic function because the transition between the region where the thermodynamic functions are dominated by the massless states and the regions where the massive state become dominant.

The finite temperature transition for 3-flavour lattice QCD at finite isospin density.

Presented by: D. K. Sinclair
D. K. Sinclair, J. B. Kogut

We simulate 3-flavour lattice QCD at small isospin chemical potential μ_I, in the neighbourhood of the finite temperature transition. This yields the μ_I dependence of the transition β and hence temperature. It is argued that this also predicts the dependence of the transition temperature on quark-number chemical potential μ. A Binder cumulant analysis gives preliminary evidence for the expected critical endpoint for quark mass just above its critical value $m_c(0)$.

Detecting chiral singularities in strongly coupled QCD at finite temperature

Presented by: Costas Strouthos
Costas Strouthos, Shailesh Chandrasekharan

We study the difficulties associated with detecting Goldstone boson effects in strongly coupled QCD at fixed nonzero temperature. We show that the behavior of the chiral condensate, the pion mass and the pion decay constant are all consistent with the predictions of chiral perturbation theory. The values of the quark masses that we need to demonstrate this are much smaller than those being used in dynamical QCD simulations.

Three-flavor QCD at high temperatures

Presented by: Robert Sugar
Robert Sugar, The MILC Collaboration:, C. Bernard, T. Burch, C. DeTar, Steven Gottlieb, E.B. Gregory, U.M. Heller, J. Osborn, R. Sugar, D. Tousaint

We present an update of our study of three-flavor QCD using improved staggered quarks. Simulations are being carried out on lattices with four, six and eight time slices for three degenerate quarks, and for degenerate up and down quarks with the strange quark mass fixed at approximately its physical value. New results include quark number susceptibilities associated with fluctuations in the isospin, hypercharge and baryon number densities, and their correlations. They also include data from very high temperature simulations in the range T/T_C between 2 and 10.

Heavy Quark Potentials and the Critical Endpoint of QCD at Physical Quark Masses

Presented by: Anna I. Toth
Toth Anna I., Z. Fodor, S. D. Katz, K. K. Szabo

A critical endpoint is expected in QCD on the temperature (T) versus baryonic chemical potential (μ) plane. Using a recently proposed lattice method for $\mu \neq 0$ we study dynamical QCD with $n_f = 2 + 1$ staggered quarks of physical masses on $L_t = 4$ lattices. With the help of the behaviour of the Lee-Yang zeroes we locate the critical endpoint. Heavy quark potentials are also determined as a function of the chemical potential.

The QCD Phase Diagram at Non-zero Baryon and Isospin Chemical Potentials

Presented by: D. Toublan
D. Toublan, B. Klein, J.J.M. Verbaarschot

In heavy ion collision experiments as well as in neutron stars, both baryon and isospin chemical potentials are different from zero. In particular, the regime of small isospin chemical potential is phenomenologically important. Using a random matrix model, we find that the phase diagram at non-zero temperature and baryon chemical potential is greatly altered by an arbitrarily small isospin chemical potential: There are two first order phase transitions at low temperature, two critical endpoints, and two crossovers at high temperature. As a consequence, in the region of the phase diagram explored by RHIC epxeriments, there are *two* crossovers that separate the hadronic phase from the quark-gluon plasma phase at high temperature.

Charmonium properties at finite temperature on quenched anisotropic lattices

Presented by: Takashi Umeda
Takashi Umeda, Hideo Matsufuru

We study charmonium properties near the deconfining transition, below and above T_c up to $1.8T_c$, on quenched anisotropic lattices. We extract the information of spectral functions at those temperatures using the maximum entropy method and the constrained curve fitting, which are used in complementary manner to keep reliability in the results. We also calculate the color singlet and averaged free energy from the Polyakov loop correlations and evaluate the charmonium spectrum from the potential model approach. Based on these data, we discuss the relation between signals of QGP formation and the charmonium properties.

Model A Dynamics and the Deconfining Phase Transition

Presented by: Alexander Velytsky
Alexander Velytsky, B.A. Berg, H. Meyer-Ortmanns

We consider model A dynamics for a quench from the disordered (confined) to the ordered (deconfined) QCD phase. The linear theory of spinodal decompositions is compared with data from an effective spin model. Further, the quench leads to competing vacuum domains, which are difficult to equilibrate. From a hysteresis study, we find a dynamics dominated by spinodal decompositions and evidence that some effects survive for the physically relevant case of a quench through a cross-over regions. But finite size corrections turn out to be large and are difficult to control.

The Lattice NJL Model at Non-zero Baryon and Isospin Densities

Presented by: David N. Walters
David N. Walters, Simon Hands

We investigate of the chiral symmetry restoring transition in the Nambu – Jona-Lasinio model with both non-zero baryon chemical potential ($\mu_B \neq 0$) and isospin chemical potential ($\mu_I \neq 0$). These scales are ordered $\mu_I \ll \mu_B$, which is phenomenologically relevant to the

physics of compact stars.
With non-zero isospin chemical potential, the model is thought to suffer from a "sign problem." We proceed in two ways:

(i) we perform "quenched" simulations in which μ_I is made non-zero only during the measurement of chiral observables;

(ii) we perform full simulations with imaginary isospin chemical potential and analytically continue results to real μ_I.

Exploring Lattice Methods for Cold Fermionic Atoms

Presented by: Matthew Wingate
Matthew Wingate

There has been a surge of experimental effort recently in cooling trapped fermionic atoms to quantum degeneracy. By varying an external magnetic field, interactions between atoms can be made arbitrarily strong. When the S wave scattering length becomes comparable to and larger than the interparticle spacing, standard perturbative analysis break down. In this case the system exhibits a type of universality, and J-W. Chen and D.B. Kaplan recently showed that they can be studied from first principles using lattice field theory. This poster will show results of exploratory simulations. The HMC algorithm is employed and tested, the existence of a continuum limit is checked, finite size effects are explored, and the pairing condensate is studied as a function of the external source strength.

5 Improvement and Renormalization

Perturbative determination of the parameters of an anisotropic quark action

Presented by: Justin Foley
Justin Foley, Alan O' Cais, Mike Peardon, Sinead M. Ryan

The parameters of a 3+1 anisotropic quark action with Symanzik-improved glue are determined to one-loop in perturbation theory. A comparison with the non-perturbative determinations of these parameters is discussed.

Three-loop Strong Coupling Constant

Presented by: Quentin Mason
Quentin Mason, Christine Davies, Kerryann Foley, Peter Lepage, Howard Trottier

We show results from our lattice perturbation theory program at three-loop order. Combined with the MILC configurations this gives unquenched $2 + 1$ results for the strong coupling constant determined from several Wilson loops and Creutz ratios, the mean-link and the static potential.

Anisotropic lattice with nonperturbative accuracy

Presented by: Hideo Matsufuru
Hideo Matsufuru, Hidenori Fukaya, Masanori Okawa, Tetsuya Onogi, Takashi Umeda

We present our study on the nonperturbative calibration of the the anisotropic lattice QCD for precision computations of heavy-light matrix elements.
In the quenched approximation, we determine the nonperturbative anisotropic parameter of the gauge action with less than 1% accuracy using the Sommer scale measured by the Lüscher-Weisz algorithm or smearing technique. We also study the nonperturbative O(a)-improvement of the quark action. We show that using the mass from the temporal and spatial directions the leading anisotropic parameter can be determined with less than 1% accuracy and the Ward-Takahashi identities can determine the O(a)-improvement coefficients with 10% accuracies.

Two and three loop computations of renormalization constants for lattice QCD

Presented by: Vincenzo Miccio
Vincenzo Miccio, Francesco Di Renzo, Andrea Mantovi, Luigi Scorzato, Christian Torrero

Renormalization constants (and improvement coefficients) can be computed by means of Numerical Stochastic Perturbation Theory to two/three loops in lattice perturbation theory, both in the quenched approximation and in the full (unquenched) theory. As a case of study we report on the computation of the renormalization constant of the propagator both for Wilson and for overlap fermions. For Wilson fermions both quenched and unquenched ($N_f = 2$ and $N_f = 3$) computations are available and one can compare them with non perturbative determinations. For overlap fermions at the moment a two loop computation for the quenched case is possible. We also report on the status of the computation of other quantities (*i.e.* currents) and discuss how computations for other fermionic regularizations are feasible.

Lattice artefacts in SU(3) lattice gauge theory with a mixed fundamental and adjoint plaquette action.

Presented by: Silvia Necco
Silvia Necco, Martin Hasenbusch

We study the SU(3) lattice gauge model in 3+1 dimensions. We consider a pure gauge action with plaquette terms in the fundamental and adjoint representation. In particular, we investigate whether a negative adjoint coupling leeds to reduced lattice artefacts compared with the standard Wilson action. This choice of the adjoint coupling is motivated by the presence of a line of first order phase transitions at positive values of the adjoint coupling. To this end, we computed the deconfinement temperature T_c the static potential and the mass of the lightest glueball 0^{++}. We measured these quantities by implementing variance reduced estimators that have been proposed recently. We determine the scaling behavior of $T_c/\sqrt{\sigma}$ and $m_{0^{++}}/T_c$ and observe that in particular discretization effects in $m_{0^{++}}/T_c$ can be considerably reduced with respect to the Wilson action.

NLO anomalous dimension of parity-odd 4 fermion operators in the Schroedinger Functional Scheme

Presented by: Filippo Palombi
Filippo Palombi, Carlos Pena, Stefan Sint

Renormalization constants for the $\Delta F = 2$ parity-odd four fermion operators are computed in various Schroedinger Functional schemes and lattice regularizations with Wilson quarks at one loop order in perturbation theory. Our results are used in the calculation of the NLO anomalous dimension, through matching with continuous schemes. They also enable a comparison of the two-loop perturbative RG running to the previously obtained non-perturbative one in the region of small renormalized coupling.

Automating the Schrödinger functional

Presented by: Paolo Ribeca
Paolo Ribeca

We discuss how to establish a general framework to automate perturbative lattice computations in the Schrödinger functional. Algorithmic and software issues are presented too.

One-loop renormalisation of the second moment of GPD with Wilson fermions

Presented by: Arwed Schiller
Arwed Schiller, M. Göckeler, H. Perlt, A. Schäfer

We calculate the non-forward matrix elements needed for the second moment of unpolarized and polarized generalized parton distributions in one-loop lattice perturbation theory using Wilson fermions. For representations of the hypercubic group commonly used in simulations we determine the sets of all possible mixing operators. For those representations the one-loop mixing matrices of renormalisation factors are found. Due to non-vanishing contributions of external partial derivatives the number of contributing operators might increase significantly compared to forward matrix elements. Tadpole improvement is used to remove large lattice artifacts. In case of mixed symmetries (with two equal Lorentz indices out of three) the mixing is non-negligible. In addition those operators also mix with lower dimensional operators. Therefore, a renormalisation of measured operators in those representations has to be performed with great care.

Wilson tmQCD towards the chiral limit

Presented by: A. Shindler
A. Shindler, XLF collaboration

We report on recent quenched results at low quark masses using the Wilson tmQCD formulation. We discuss the chiral extrapolation and the continuum limit for several physical quantities like meson masses and decay constants.

Scaling study of step scaling function with improved gauge actions in SU(3) gauge theory

Presented by: Shinji Takeda

Shinji TAKEDA, S. Aoki , M. Fukugita , K-I. Ishikawa, T. Ishikawa , N. Ishizuka, Y. Iwasaki , K. Kanaya , T. Kaneko, Y. Kuramashi , M. Okawa, Y. Taniguchi , A. Ukawa, T. Yoshié

We study the scaling behavior of a step scaling function for the SU(3) gauge coupling, employing improved gauge actions. We confirm that the step scaling functions from the improved gauge actions agree with previous results obtained from the plaquette action in the continuum limit at both weak and strong coupling. We also investigate how different choices of the boundary counter terms for the improved gauge actions affect the scaling behavior. In the extrapolation to the continuum limit, we observe that cut off dependence becomes moderate for the Iwasaki action, if the scaling violations are perturbatively removed from the results. We also measure a low energy scale ratio with the Iwasaki action, and confirm its universality.

Schrödinger functional formalism with overlap Dirac operator

Presented by: Y. Taniguchi

Y. Taniguchi, M. Lüscher

We present a Schrödinger functional formalism with the overlap Dirac operator. By making use of a projection the system is given to satisfy the Dirichlet boundary condition in temporal direction without any non-locality problem of the Dirac operator. At tree level the system well reproduces the continuum eigenvalue and propagators in $a \to 0$ limit. The SF formalism with the domain-wall fermion will also be presented.

One-loop determination of mass dependent $O(a)$ improvement coefficients for the heavy-light vector and axial vector currents with relativistic heavy and domain-wall light quarks

Presented by: Norikazu Yamada

Norikazu YAMADA, Sinya AOKI, Yoshinobu KURAMASHI

We determine the mass dependent $O(a)$ improvement coefficients for the heavy-light vector and axial vector currents consisting of the relativistic heavy and the domain-wall light quarks. The calculation is carried out perturbatively at the one loop level to remove the systematic error of $O(\alpha_s(am_Q)^n)ap)$ as well as $O(\alpha_s(am_Q)^n)$ ($n \geq 0$). We present the results as a function of heavy quark mass and domain-wall height for three types of gauge actions.

6 Chiral fermions

Improved Domain Wall Implementation for Chiral Fermions

Presented by: Richard C. Brower

Richard C. Brower, Hartmut Neff, Kostas Orginos

A new class of domain wall fermions is defined that interpolates between Shamir's and

Borici's form without increasing the number of Dirac applications per CG iteration. This class represents a full (real) Mobius transformation of the overlap kernel. By implementing a new version of Red/Black precondition and tuning the scaling parameter for the kernel convergence is improved. At fixed value of chiral symmetry violations measured by the residual mass (m_{res}, the number of lattice sites (L_s) in the fifth dimension are substantially reduced resulting in a factor of 2 or better improvement for typical parameters on quenched Wilson lattices with $\beta = 6.0$.

QCD, Chiral Symmetry Breaking and the Random Lattice

Presented by: Saul Cohen
Saul Cohen
According to the Nielsen-Ninomiya No-Go theorem, the doubling of fermions on the lattice cannot be suppressed in a chiral theory. Whereas Wilson and staggered fermions suppress doublers with explicit breaking of chiral symmetry, the random lattice does so by spontaneous chiral symmetry breaking even in the free theory. I present results for meson masses, the chiral condensate and fermionic eigenvalues from simulations of quenched QCD on random lattices in four dimensions, focusing on chiral symmetry breaking.

SU(N) chiral gauge theories on the lattice

Presented by: Maarten Golterman
Maarten Golterman, Yigal Shamir
We describe how an SU(N) chiral gauge theory can be put on the lattice using non-perturbative gauge fixing. In particular, we explain how the Gribov problem is dealt with. Our construction is local, avoids doublers, and weak-coupling perturbation theory applies at the critical point which defines the continuum limit of our lattice chiral gauge theory.

Structure functions from overlap fermions

Presented by: Martin Grtler
Martin Grtler, Roger Horsley, Tony Kennedy, Paul Rakow, Gerrit Schierholz, Thomas Streuer
I present results from the QCDSF-UKQCD overlap fermion project obtained on a $16^3 \times 32$ lattice (1/a=2.1 GeV). This comprises a calculation of quark masses, moments of the nonsinglet unpolarised nucleon structure function and the non-perturbative determination of renormalisation factors.

Comparative study of overlap and staggered fermions in the Schwinger model

Presented by: Christian Hoelbling
Christian Hoelbling, Stephan Durr
We perform a comparative study of staggered and overlap fermions in the Schwinger model for $N_f = 0, 1, 2$. The staggered $N_f = 1$ ensemble was obtained using the square root of the staggered determinant. We find, that naive staggered fermions fail near the chiral

limit, while APE/HYP improved staggered fermions give correct physical results down to very small fermion masses. As a possible cause of this phenomenon, we observe that the infrared spectrum of the APE/HYP improved staggered dirac operator develops a twofold near degeneracy and a qualitative similarity to the infrared spectrum of the overlap operator.

Meson spectroscopy with overlap quarks

Presented by: Joseph Howard
Joseph Howard, Federico Berruto, Nicolas Garron, Christian Hoelbling, Laurent Lellouch, Silvia Necco, Claudio Rebbi, Noam Shoresh

A simulation of quenched QCD with the overlap Dirac operator has been completed for 100 Wilson gauge configurations at $\beta = 6$ on an $18^3 \times 64$ lattice. The analysis of many mesonic observables has been completed. This poster will focus on techniques used to determine the optimum correlator fitting window, on the observation of quenched chiral logs, and on the use of extended sink operators to improve the prediction of the meson spectrum.

Formulation of chiral gauge theories

Presented by: Werner Kerler
Werner Kerler

A general formulation of chiral gauge theories is presented, in which restrictions of the Dirac operators are removed and which reveals considerably more freedom in the structure of the chiral projections. Two forms of the correlation functions are introduced which both apply also in the presence of zero modes and for any value of the index. The decomposition of the total sets of bases into equivalence classes is analyzed. The properties under gauge transformations and CP transformations are derived.

Domain Wall Fermions at Strong Coupling

Presented by: Ludmila Levkova
Ludmila Levkova, Robert Mawhinney

The Domain-Wall formulation of chiral fermions works well at relatively small lattice spacings, *e.g.* at $1/a = 2$ GeV. However, this approach becomes increasingly problematic at stronger gauge coupling where the roughness of the gauge field leads to increased explicit chiral symmetry breaking. This problem becomes especially severe for sufficiently strong coupling where the underlying 4-dimensional Wilson theory is in the Aoki phase. These strong coupling difficulties interfere with the study of QCD thermodynamics and decrease the range of couplings available for scaling studies. We review our attempts to find a suitable modification of the gauge and/or the fermion action which would allow the Domain-Wall method to work reliably at stronger coupling.

Rough Gauge Fields, Smearing and Domain Wall Fermions

Presented by: Meifeng Lin
Meifeng Lin

At a fixed lattice spacing, as determined by say m_ρ, adding additional fermion flavors to a dynamical simulation produces rougher gauge field configurations at the lattice scale. For domain wall fermions, these rough configurations lead to larger residual chiral symmetry breaking and larger values for the residual masses, $m_{\rm res}$. We discuss ongoing attempts to reduce chiral symmetry breaking for $N_f = 3$ dynamical domain wall fermion simulations by different smoothing choices for the gauge fields. We also compare various models which attempt to explain the features seen in measurements of $m_{\rm res}$.

Effects of low lying fermion modes in the ϵ-regime

Presented by: Kenji Ogawa
Kenji Ogawa, Shoji Hashimoto

We investigate the effects of low lying fermion modes on the QCD partition function in the ϵ-regime. Using the overlap-Dirac operator we calculate several tens of low lying fermion eigenvalues on the quenched lattice. The Leutwyler-Smilga's theoretical relations derived from the fermion mass dependence of the QCD partition function is compared with the numerical results. The fermion determinant is incorporated using the truncated determinant approximation.

Comparison between overlap and twisted mass fermions towards the chiral limit

Presented by: Mauro Papinutto
Mauro Papinutto, XLF Collaboration

We compare results for meson masses and decay constants obtained at fixed value of the lattice spacing ($\beta = 5.85$) with overlap and twisted mass fermions. Twisted mass simulations have been performed on three different volumes in order to investigate possible finite volume effects. A comparison of the computational costs is discussed.

Structure functions and g_A from overlap fermions

Presented by: Thomas Streuer
Thomas Streuer, M. Guertler, R. Horsley, A. Kennedy, P. Rakow, G. Schierholz

We present results for moments of structure functions and for the nucleon axial charge in quenched QCD. We use overlap fermions and the Luscher-Weisz gauge action at lattice spacing a=0.01fm.

Dynamical overlap fermions, results with HMC algorithm

Presented by: Kalman Szabo
Kalman Szabo, Zoltan Fodor, Sandor Katz

We present first, exploratory results of a hybrid Monte-Carlo algorithm for dynamical, $n_f = 2$, four-dimensional QCD with overlap fermions. The fermionic force requires careful treatment near the borders of topological sectors. As expected, the computational requirements are typically two orders of magnitude larger for the dynamical overlap formalism than for the more conventional (Wilson or staggered) formulations.

Non-compact QED_3 with an extra four-fermion term

Presented by: Ioannis Tziligakis
Ioannis Tziligakis, Costas Strouthos, John Kogut

We present preliminary results of the three dimensional non-compact QED with a weak four-fermion term in the lattice action. According to Dyson-Schwinger studies and numerical simulations of QED_3 (without an extra four-fermion term) chiral symmetry is broken for $N_f \leq N_{fc}$ $(2 \leq N_{fc} \leq 4)$ and the dimensionless condensate is expected to be very small (≤ 0.005). The small four-fermion coupling provides the framework for an improved algorithm, which allows us to simulate the chiral limit of massless fermions and expose delicate effects.

Comparative study of overlap and staggered fermions in QCD

Presented by: Urs Wenger
Urs Wenger, Stephan Durr, Christian Hoelbling

We perform a comparative study of the infrared properties of overlap and staggered fermions in QCD. We observe that the infrared spectrum of the APE/HYP improved staggered Dirac operator develops a fourfold near-degeneracy and is in qualitative agreement with the infrared spectrum of the overlap operator. The near-degeneracy allows us to identify the zeromodes of the staggered operator and we find that the number of zeromodes is in line with the topological index of the overlap operator.

7 Topology and confinement

Analyticity in theta and infinite volume limit of the topological susceptibility in SU(3) gauge theory

Presented by: B. Alles
B. Alles, M. D'Elia, A. Di Giacomo

The large volume limit of the topological susceptibility in SU(3) gauge theory is investigated on the lattice, to establish an upper limit on parity violating terms.

A stability surprise at finite temperature

Presented by: Pierre van Baal
Pierre van Baal, E.-M. Ilgenfritz B. Martemyanov M. Muller-Preussker

It was found that for cooling of SU(2) lattice Monte Carlo configurations generated at finite temperature in the confined phase, the end product can give a stable configuration with constant magnetic field. The stability depends on the value of the Polyakov loop. We discuss the context in which these so-called Dirac Sheet configurations were studied and give a precise explanation in terms of marginal stability.

Instanton constituents at finite and zero temperature from cooling

Presented by: Falk Bruckmann
Falk Bruckmann, Ernst-Michael Ilgenfritz, Boris Martemyanov, Pierre van Baal

Finite temperature instantons in the background of a non-trivial Polyakov loop are known to consist of magnetic monopoles. This constituent picture can be studied on the lattice by the method of cooling. We apply cooling with overimproved actions to obtain higher charge instantons (in SU(2)). Their constituents reveal interesting overlap effects, extending as well as confirming analytic results. We also investigate to what extent fractional charge constituents survive at zero temperature. The emphasis is on localisation properties, in the light of the chiral zero modes recently found in dynamical configurations at zero temperature.

Thick vortices in SU(2) lattice gauge theory

Presented by: Srinath Cheluvaraja
Srinath Cheluvaraja

Three dimensional $SU(2)$ lattice gauge theory is studied after eliminating thin monopoles and the smallest thick monopoles. Kinematically this constraint allows the formation of thick vortex loops which produce $Z(2)$ fluctuations at longer length scales. The thick vortex loops are identified in a three dimensional simulation. A condensate of thick vortices persists even after the thin vortices have all disappeared. The thick vortices decouple at a slightly lower temperature (higher β) than the thin vortices and drive a phase transition.

External fields and color confinement

Presented by: Leonardo Cosmai
Leonardo Cosmai, Paolo Cea

U(1), SU(2), and SU(3) lattice gauge theories in presence of external fields are investigated both in (3+1) and in (2+1) dimensions. The (free) energy of gauge systems has been measured. While the phase transition in compact U(1) is not influended by the strength of an external constant magnetic field, the deconfinement temperature for SU(2) and SU(3) gauge systems in a constant abelian chromomagnetic field decreases when the strength of the applied field increases. On the other hand an abelian monopole field does not modify the deconfinement temperature. The dependence of the deconfinement temperature on the strength of an external constant chromomagnetic field seems to be a peculiar feature for non abelian gauge theories.

Are magnetic monopoles hadrons?

Presented by: Michael Creutz
Michael Creutz

The charges of magnetic monopoles are constrained to a multiple of 2π over the elementary unit electric charge. In the standard model, quarks have fractional charge, raising the question of whether the basic magnetic monople unit is a multiple of $2\pi/e$ or three times that. A simple lattice construction shows how a magnetic monopole of the lower strength is possible if it interacts with gluonic fields as well. Such a monopole is thus a hadron. This is consistent with the construction of magnetic monopoles in grand unified theories.

Chiral transition and deconfinement in $N_f = 2$ QCD

Presented by: M. D'Elia

M. D'Elia, L. Del Debbio, A. Di Giacomo, B. Lucini, G. Paffuti, C. Pica

The transition is studied by use of a disorder parameter detecting condensation of magnetic monopoles in the vacuum. The deconfining transition is found to coincide with the chiral transition and the susceptibility ρ, related to the disorder parameter, is consistent with a first order phase transition.

Topological susceptibility with three flavors of staggered quarks

Presented by: Carleton DeTar

Carleton DeTar, C. Aubin, C. Bernard, Brian Billeter, Steven Gottlieb, E.B. Gregory, U.M. Heller, J.E. Hetrick, J. Osborn, R. Sugar, D. Toussaint

As one test of the validity of the staggered-fermion fourth-root determinant trick, we examine the suppression of the topological susceptibility of the QCD vacuum in the limit of small quark mass. The suppression is sensitive to the number of light sea quark flavors. Our study is done in the presence of 2+1 flavors of dynamical quarks in the improved staggered fermion formulation. Variance-reduction techniques provide better control of statistical errors. New results from staggered chiral perturbation theory account for taste-breaking effects in the low-quark mass behavior of the susceptibility, thereby reducing scaling violations from this source. Measurements over a range of quark masses at two lattice spacings permit a rough extrapolation to zero lattice spacing to remove the remaining lattice artifacts.

Improved Measure of Local Chirality

Presented by: Terrence Draper

Terrence Draper, Andrei Alexandru , Ying Chen , Shao-Jing Dong , Ivan Horvath , Frank X. Lee , Keh-Fei Liu , Nilmani Mathur , Harry B. Thacker , Sonali Tamhankar , Jianbo Zhang

It has become popular to probe the structure of the QCD vacuum indirectly by using fermion eigenmodes, because this provides a natural way to filter out UV fluctuations. The double-peaking in the distribution of the local chiral orientation parameter (X) has been offered as evidence, by some, in support of a particular model of the vacuum. Here we caution that the X-distribution peaking varies significantly with various versions of the definition of X. Furthermore, these distributions vary little from those resulting from a random reshuffling of the fields (which destroys any QCD-induced space-time coherence); that is, the double-peaking is largely a kinematical effect. We propose a new universal definition of the X parameter whose distribution is uniform for randomly reshuffled fields. Any deviations from uniformity for actual data can then be directly attributable to QCD-induced dynamics. We find that the familiar double peak disappears.

Theta vacuum effects on the pseudoscalar condensates and the η' meson in 2-dimensional lattice QED

Presented by: Hidenori Fukaya
Hidenori Fukaya, Tetsuya Onogi

We study the pseudoscalar condensates and the η' meson correlators of the two-flavor massive Schwinger model in the non-zero theta vacuum. We find that the pseudoscalar condensates are non-zero in each topological sector and they cause long-range correlations of the η' meson. The relation between the pseudoscalar condensates and the long-range correlation is well understood by the clustering decomposition. Moreover, it is clear that the fluctuation of the "disconnected" diagram originates from the pseudoscalar condensates in each topological sector. We also find that even in $\theta = 0$ case the cancellation of the long-range correlation is nontrivial and requires accurate contributions from higher topological sectors.

Topological susceptibility in the SU(3) Yang-Mills theory

Presented by: Leonardo Giusti
Leonardo Giusti, Luigi Del Debbio Claudio Pica

We compute the topological susceptibility for the SU(3) gauge theory by using the formula for the topological charge density operator suggested by Neuberger's fermions. The continuum limit is reached by extrapolating numerical data obtained for several values of the lattice spacing.

Scaling dimension of low lying eigenmodes and topological charge density

Presented by: James E. Hetrick
James E. Hetrick, MILC Collaboration

As a quantitative measure of localization, the inverse participation ratio of low lying Dirac eigenmodes and topological charge density is calculated on quenched lattices over a wide range of lattice spacings and volumes. Since different topological objects (instantons, vorticies, monopoles, and artifacts) have different co-dimension, scaling analysis provides information on the amount of each present and their correlation with the localization of low lying eigenmodes.

SU(3) calorons and their constituents

Presented by: E.-M. Ilgenfritz
E.-M. Ilgenfritz:q!, D. Peschka, M. Müller-Preussker

Generic caloron solutions for SU(3) with nontrivial asymptotic holonomy can be separated in up to three dyonic constituents. In order to explore the parameter space of classical solutions, a systematic cooling study has produced large ensembles of $|Q| = 1$ and higher charge calorons on finite asymmetric lattices. Whereas there are no strict solutions for unit charge, such configurations appear metastable, while higher charge calorons are remarkably stable and static in Euclidean time. For $|Q| = 1$ the structure is closely related to the known KvBLL solutions for SU(3) although full dissociation is a rare case. Non-selfdual $Q = 0$

stable solutions consisting of constituents have also been found. The diagnostics makes use of the clover-improved Dirac operator, improved field strength and the eigenvalues of the local holonomy $P(\vec{x})$. The latter seem to be suitable to search for dyons not only in classical configurations.

String Breaking in QCD with Dynamical Wilson Fermions

Presented by: Thomas Lippert
Thomas Lippert, H. Neff, G. Bali, Th. Dssel, K. Schilling

We present first results of the simulation of the “breaking” of the static quark-antiquark string into a static-light meson-antimeson system in full QCD with $N_f = 2$ dynamical Wilson fermions. Our investigation is based on $24^3 \times 40$ TχL configurations. The all-to-all light quark propagators occuring in the transition element and in the static-light meson correlator are computed by means of the truncated eigenmode approximation with orthogonal eigenvectors of the hermitian Wilson-Dirac matrix Q. By combination of various improvement methods we obtain the corresponding two-by-two mixing system with so far unprecedented accuracy. We observe level splitting as a signal for string breaking induced by sea quarks.

Confinement from Instantons or Merons

Presented by: J. W. Negele
J. W. Negele, F. Lenz, M. Thies

In contrast to ensembles of singular gauge instantons, which are well known to fail to produce confinement, it is shown that effective theories based on ensembles of merons or regular gauge instantons do produce confinement. Furthermore, when the scale is set by the string tension, the action density and topological susceptibility are comparable to those arising in lattice QCD.

Calorons and constituent monopoles - a progress report

Presented by: Daniel Nogradi
Daniel Nogradi, Falk Bruckmann, Pierre van Baal

The effect of a background Polyakov loop on topological excitations is investigated in finite temperature gauge theory. In SU(n) gauge theory a non-trivial value leads to the splitting of a charge k instanton into kn constituent monopoles as individual lumps of fractional topological charge. Of these, k lumps will support a chiral fermion zero-mode. This will be illustrated through the exact solutions for the gauge field and the zero-modes, both with overlapping and well-separeted constituents. These monopole degrees of freedom are expected to play a dynamical role in the confined phase of QCD, as supported by lattice studies and a recent semiclassical analysis.

Polyakov Loops, $Z(N)$ Symmetry, and Sine-Law Scaling

Presented by: Michael C. Ogilvie
Michael C. Ogilvie, Peter N. Meisinger

We construct an effective action for Polyakov loops using the eigenvalues of the Polyakov loops as the fundamental variables. We assume $Z(N)$ symmetry in the confined phase, a finite difference in energy densities between the confined and deconfined phases as $T \to 0$, and a smooth connection to perturbation theory for large T. The low-temperature phase consists of $N-1$ fields fluctuating around an explicitly $Z(N)$ symmetric background. In the low-temperature phase, the effective action yields non-zero string tensions for all representations with non-trivial N-ality. Mixing occurs naturally between representations of the same N-ality. Sine-law scaling emerges as a special case, associated with nearest-neighbor interactions between Polyakov loop eigenvalues.

Topology and string tension in SU(N) theories, at zero and finite temperatures

Presented by: H. Panagopoulos
H. Panagopoulos, L. Del Debbio, E. Vicari

We present some high statistics results for the string tension and topological susceptibility in SU(N) gauge theories, at zero and finite temperature. The nature and location of the finite temperature phase transition is further investigated.

A numerical study of a confined $Q\bar{Q}$ system in compact U(1) lattice gauge theory in 4D

Presented by: Marco Panero
Marco Panero

We present a numerical study about the confining regime of compact U(1) lattice gauge theory in 4D. To address the problem, we exploit the duality properties of the theory. The main features of this method are presented, and its possible advantages and limits with respect to alternative techniques are briefly discussed. In Monte Carlo simulations, we focus our attention onto the case when a pair of static external charges is present. Some results are shown, concerning different observables which are of interest in order to understand the confinement mechanism, like the profile of the electric field induced by the static charges, and the ratios between Polyakov loop correlation functions at different distances.

Quark and Gluon Confinement in Coulomb gauge

Presented by: H. Reinhardt
H. Reinhardt, C. Feuchter

The Yang-Mills Schrödinger equation is solved in Coulomb gauge for the vacuum by the variational principle using an ansatz for the wave functional, which is strongly peaked at the Gribov horizon. A coupled set of Schwinger-Dyson equations for the gluon and ghost propagators in the Yang-Mills vacuum as well as for the curvature of gauge orbit space is derived and solved in 1-loop approximation. We find a gluon propagator, which is infrared suppressed and an infrared singular ghost propagator, which yields a confinement potential, which rises almost linearly.

$\mathbf{CP}^{N-1}$ Model with the Theta Term and Maximum Entropy Method

Presented by: Yasuhiko Shinno
Yasuhiko Shinno, Masahiro Imachi, Hiroshi Yoneyama

We have studied the behavior of the free energy density $f(\theta)$ of the CP^{N-1} model with a θ term in order to investigate the phase structure in θ space. The importance sampling method cannot be implemented directly because of the θ term which causes the sign problem.

The sign problem may be evaded by calculating $f(\theta)$ by Fourier-transforming the topological charge distribution $P(Q)$. This method works well at moderate volumes and in the strong coupling region. In the weak coupling region and at large volumes, however, errors of $P(Q)$ disturb the behavior of $f(\theta)$. This is called flattening. In order to deal with flattening, we have used the maximum entropy method (MEM) to calculate $f(\theta)$.

In our previous study, we applied the MEM to mock data of the Gaussian $P(Q)$ with noise in order to investigate whether the MEM is effective.

In this talk, we apply the MEM to CP^{N-1} data which are simulated by use of the fixed point action. We present the result of $f(\theta)$ and discuss whether the MEM could be applied to flattening for Monte Carlo data.

The gluon and ghost propagator and the influence of Gribov copies

Presented by: Andre Sternbeck
Andre Sternbeck, E.-M. Ilgenfritz, M. Mueller-Preussker

The dependence of the gluon and ghost propagator in pure $SU(3)$ gauge theory on the choice of Gribov copies in Lorentz gauge is studied. Simulations were performed on lattice sizes $8^4 - 24^4$ at $\beta = 5.8$, 6.0 and 6.2. In the infrared region the ghost propagator is clearly affected by the Gribov noise, while the influence on the gluon propagator is small. The data are fitted to the scaling behavior expected from the Dyson-Schwinger approach to extract the critical exponent.

Coherent Long Range Structure of Topological Charge Fluctuations in CP(N-1) Sigma Models

Presented by: H. B. Thacker
H. B. Thacker, S. Ahmad, J. Lenaghan

Local topological charge structure in the 2D CP(N-1) sigma models is studied using the overlap Dirac operator. For the same Monte Carlo configurations, topological charge distributions obtained from the overlap Dirac operator are compared with those obtained from the ultralocal definition of $q(x0$ in terms of the log of the plaquette. The efficacy of the overlap approach in revealing long-range topological structure is clearly demonstrated. Long-range coherence of topological charge along locally 1D regions in 2D space-time is observed. By recalling the analogy between the gauge field A_μ in 2D U(1) gauge theory and the Chern-Simons 3-form $A_{\mu\nu\lambda}$ in 4D Yang-Mills theory, we argue that our CP(N-1) results are precisely analogous to the recent discovery of coherent 3D sheets of topological charge in 4D QCD. In both theories, coherent regions of topological charge form along surfaces of codimension 1.

The interface tension in SU(N) lattice gauge theory.

Presented by: Michele Vettorazzo
Michele Vettorazzo, Philippe de Forcrand

We propose a new method to measure the order-order interface tension in the 4d SU(N) lattice gauge theory. We measure this quantity for N=3 and 4. In particular, for the N=4 case, we focus on the ratio of the k-tensions between different ordered phases. In the N=3 case, our results differ noticeably from earlier results in the literature.

Topology and staggered fermion action improvement

Presented by: Kit Yan Wong
Kit Yan Wong, R.M. Woloshyn

It is conventional wisdom that staggered fermions do not feel gauge field topology. However, the response of staggered fermion eigenmodes to the topology of the gauge field can depend quite sensitively on the way in which the staggered fermion action is improved. We study this issue focusing on a FatAsq action, i.e., an a-squared improved (Asq) action constructed using unitarized fat links.

MEM Study of True Flattening of Free Energy and the Theta Term

Presented by: Hiroshi Yoneyama
Hiroshi Yoneyama, Masahiro Imachi, Yasuhiko Shinno

We study lattice field theory with the θ term. When simulated, it suffers from the sign problem. This appears as fictitious flattening of the free energy $f(\theta)$. In order to deal with the flattening phenomenon of $f(\theta)$, we employ the maximum entropy method (MEM) . In our previous study, we used , as mock data, the Gaussian topological charge distribution $P(Q)$ with noise, and found that $f(\theta)$ could show smooth behavior. In this poster, we report the result of the MEM analysis, where such mock data are used that "true" flattening of $f(\theta)$ occurs . This is regarded as a toy model for studying whether the MEM could correctly detect a first order phase transition in θ space. We discuss how the MEM distinguish fictitious and true flattening.

8 Spin and Higgs models

A finite temperature investigation of the Georgi-Glashow model in 3D

Presented by: Andrea Barresi
Andrea Barresi, Biagio Lucini, Luigi Del Debbio

We study the $SU(2)$ gauge theory with scalar matter in the adjoint representation in 3D at zero and finite temperature. At zero temperature we check the scaling behaviour through some observables like the glueball and the Higgs masses. At non zero temperature we find evidence for a finite temperature phase transition both in the symmetric and in the broken phase; such transitions are consistent with the universality class of Ising 2D, in agreement with the analytical investigation of Kogan et al.

Simulations of CP(N-1) Models for Large N

Presented by: Bernard B. Beard
Bernard B. Beard

We discuss simulations of CP(N-1) models via dimensional reduction of discrete SU(N) quantum spin models. These models can be simulated with an efficient loop cluster algorithm in continuous euclidean time, effective even for very large N. Efforts to extract the mass gap of the CP(N-1) model are complicated by the volume dependence of the correlation length ξ. The dependence on volume L^d persists for $\xi >> L$.

Finite Size Scaling, Fisher Zeroes and $\mathcal{N}$=4 Super Yang-Mills

Presented by: P.R. Crompton
P.R. Crompton, W. Janke

We investigate critical slowing down in the local updating continuous-time Quantum Monte Carlo method by relating the finite size scaling of Fisher Zeroes to the dynamically generated mass gap, via the scaling of their respective critical exponents. As we discuss, the nonlinear sigma model representation derived through the hamiltonian of our lattice model can be used to give a effective treatment of conformal $\mathcal{N}$=4 SYM. We now present scaling relations from our spin chain analysis of this system to include quantum corrections, and discuss the connection with the continuum limit and recent 2-loop results. The prospects of extending this approach to calculating higher twist parton distributions are also discussed.

Study of CP(N-1) θ-Vacua by Cluster Simulation of SU(N) Quantum Spin Ladders

Presented by: Michele Pepe
Michele Pepe, B. B. Beard, S. Riederer, U.-J. Wiese

D-theory provides an alternative lattice regularization of the (1+1)-d $CP(N-1)$ quantum field theory. In this formulation the continuous classical $CP(N-1)$ fields emerge from the *dimensional* reduction of *discrete* $SU(N)$ quantum spins. In analogy to Haldane's conjecture, ladders consisting of an even number of transversely coupled spin chains lead to a $CP(N-1)$ model with vacuum angle $\theta = 0$, while an odd number of chains yields $\theta = \pi$. In contrast to the standard formulation, in D-theory no sign problem arises at $\theta = \pi$, and an efficient loop-cluster algorithm is used to investigate the θ-vacuum effects. At $\theta = \pi$ there is a first order phase transition with spontaneous breaking of charge conjugation symmetry for $CP(N-1)$ models with $N > 2$.

QED in 2+1 dimensions with Fermi and Gap anisotropies

Presented by: Iorwerth Owain Thomas
Iorwerth Owain Thomas, PhD Supervisor: Prof. Simon Hands

QED in 2+1 dimensions has long been studied as a model field theory which exhibits both asymptotic freedom and non-trivial IR behaviour. There is also a trend towards viewing it as a candidate low energy effective theory for the pseudogap phase of high temperature superconductors. One feature of these theories is their lack of isotropy in the x and y directions (a common feature of Dirac theories in condensed matter systems). A model motivated by this work is outlined, and some initial, tentative results are given regarding its phase structure with respect to the relative anisotropies in the x and y directions.

The scaling equation of state of the three-dimensional O(N) universality class

Presented by: Francesco Parisen Toldin
Francesco Parisen Toldin, Agostino Butti, Andrea Pelissetto, Ettore Vicari

We determine the critical equation of state of the three-dimensional O(N) universality class, for $N = 4$, 5, 6, 32, 64. The $N = 4$ is relevant for the chiral phase transition in QCD with two flavors, the $N = 5$ model is relevant for the $SO(5)$ theory of high-T_c superconductivity, while the $N = 6$ model is relevant for the chiral phase transition in QCD with two flavors and two colors. We first consider the small-field expansion of the effective potential (Helmholtz free energy). Then, we apply a systematic approximation scheme based on polynomial parametric representations that are valid in the whole critical regime, satisfy the correct analytic properties (Griffiths' analyticity), take into account the Goldstone singularities at the coexistence curve, and match the small-field expansion of the effective potential. From the approximate representations of the equation of state, we obtain estimates of several universal amplitude ratios. We also compare our approximate solutions with those obtained in the large-N expansion, up to order $1/N$, finding good agreement for $N >\sim 32$.

9 Machines and algorithms

APENet: LQCD clusters a' la APE

Presented by: Roberto Ammendola
Roberto Ammendola, Marco Guagnelli, Giuseppe Mazza, Filippo Palombi, Roberto Petronzio, Davide Rossetti, Andrea Salamon, Piero Vicini

In this paper we present APENet, a new high speed, low latency, 3-dimensional interconnect architecture optimized for PC clusters running LQCD-like numerical applications. The hardware implementation is based on a single PCI-X 133MHz network interface card hosting six independent bi-directional channels with a peak bandwidth of 676 MB/s each direction and measured latency less than 10μs. The internal packet switching capabilities of the network card allows up to three couple of links simultaneously active. The current software environment, based on Linux, is made of a low-level library and an high-level application library. An MPI implementation and a standard Linux network device driver are being actively developed. We also discuss preliminary benchmarks results showing exciting performances similar or better then those found in high-end commercial network systems. At the present a 16 nodes APENET-based cluster is being assembled while installation of a larger system (more than 100 nodes) will be completed in a few months.

The Multigrid Algorithm for GW Fermions

Presented by: Artan Borici
Artan Borici
In this talk we show that the multigrid algorithm for Ginsparg-Wilson fermions is capable to accelerate inversions by an order of magnitude.

Improving algorithms to compute all elements of the lattice quark propagator: II

Presented by: Alan O Cais
Alan O Cais, Keisuke Jimmy Juge, Mike Peardon, Sinead Ryan , Jonivar Skullerud
We present a new exact algorithm for estimating all elements of the quark propagator. The advantage of the method is that the exact all-to-all propagator is reproduced in a large but finite but number of inversions. The efficacy of the algorithm is tested in Monte Carlo simulations of Wilson quarks in quenched QCD. Applications that are difficult to probe with point propagators are discussed.

Exact 2+1 flavour fermion simulations

Presented by: M. A. Clark
M. A. Clark, A. D. Kennedy
We consider the rational hybrid monte carlo algortihm for performing exact 2+1 flavour fermion simulations. The specific cases of asqtad and domain wall fermions are considered. We find that in both cases the naive performance is similar to conventional HMC.

Dynamical overlap simulations using HMC.

Presented by: Nigel Cundy
Nigel Cundy, Th. Lippert, S. Krieg, A. Frommer, K. Schaefer, J. van den Eshof

We apply the Hybrid Monte Carlo method to overlap fermions. We give the fermionic force for the molecular dynamics update, and discuss how the computation of the force can be accelerated using relaxation and preconditioning techniques. We present early results on a small dynamical chiral ensemble.

Cutoff-effects in the spectrum of dynamical Wilson fermions

Presented by: Roland Hoffmann
Roland Hoffmann, Michele Della Morte, Francesco Knechtli, Ulli Wolff

We investigated the low-lying eigenvalues of the improved Wilson-Dirac operator in the Schrödinger functional with two dynamical quark flavors. At a lattice spacing of approximately 0.1 fm we found more very small eigenvalues than in the quenched case. These cause problems with the HMC algorithm and through a simulation at a finer lattice spacing we were able to establish their nature as cutoff-effects.

Comparing iterative methods for overlap and twisted mass fermions

Presented by: Karl Jansen
Karl Jansen, for the XLF collaboration

We discuss various iterative methods to obtain the fermion propagator with both overlap and twisted mass fermions. We do so at two values of the bare quark mass and two different volumes. For overlap fermions we also compare the efficiency of various methods for calculating the topological index.

The Chroma Software System for Lattice QCD

Presented by: Balint Joo
Balint Joo, Robert G. Edwards

We describe aspects of the Chroma software system for Lattice QCD calculations. Chroma is an open source C++ based software system developed as part of the U.S. SciDAC initiative with collaboration from UKQCD. The Chroma system uses othe SciDAC packages such as QDP++ for lattice wide data parallel operations, QMP for communications, QIO for binary I/O and the publicly available libxml2 library for XML input and output. It also interfaces with output from the BAGEL assembler generator for optimised Lattice Fermion kernels on some architectures. Chroma has been run on workstations, clusters, IBM Pseries hardware and QCDOC developmentmachines. As a case study we describe its use in computations involving the overlap fermion matrix.

Improving algorithms to compute all elements of the lattice quark propagator: I

Presented by: Keisuke Jimmy Juge

Keisuke Jimmy Juge, Alan O'Cais, Michael Peardon, Sinead Ryan, Jon-ivar Skullerud

We present a new exact algorithm for estimating all elements of the quark propagator. The advantage of the method is that the exact all-to-all propagator is reproduced in a large but finite number of inversions. The efficacy of the algorithm is tested in Monte Carlo simulations of Wilson quarks in quenched QCD. Applications that are difficult to probe with point propagators are discussed.

The Status of User Software on QCDOC

Presented by: Chulwoo Jung (for the QCDOC collaboration)

Chulwoo Jung for the QCDOC collaboration

The current status of QCDOC application software and the user environment is summarized. The performance of optimized routines used in the evolution of ASQTAD improved staggered fermions is discussed. Also, an update on QMP and other SciDAC software is presented.

Accelerating Fermionic Molecular Dynamics

Presented by: A D Kennedy

A D Kennedy, M A Clark

We consider how to accelerate fermionic Molecular Dynamics algorithms by introducing n pseudofermion fields coupled with the nth root of the fermionic kernel. This reduces the maximum pseudofermionic force, and thus allows a larger Molecular Dynamics integration step size without hitting an instability in the integrator. The nth roots may be computed efficiently using Chebyshev rational approximations, and to this end we briefly review the theory of optimal polynomial and rational Chebyshev approximations.

Accelerating inversions of the overlap operator

Presented by: Stefan Krieg

Stefan Krieg, N. Cundy, J. van den Eshof, A. Frommer, Th. Lippert, K. Schaefer

We present relaxation and preconditioning techniques which accelerate the inversion of the overlap operator by a factor of four on small lattices, with larger gains as the lattice size increases. These can be used in both propagator calculations and dynamical simulations.

Higgs Search at LHC by neural networks

Presented by: Dr. Mostafa Mjahed

Dr. Mostafa Mjahed

As is well known, the discovery of the Standard Model Higgs boson is the first motivation for the LHC. Its search should be complicated by the presence of huge backgrounds [1].

Our aim here is to use a neural network classifier as a tool for a better discrimination between signal and background. We will analyze the Higgs mass range *140-200 GeV*. At this mass range, the dominant mechanism for Higgs production is gluon-gluon fusion. Usual ways to reduce background are lepton isolation, what motivated us to study the decay into four muons.

Events were produced at LHC energies (M_H= *140-200 GeV*), using the Lund Monte Carlo generator Pythia 5.7 [2]. Higgs boson events ($pp \rightarrow HX \rightarrow 4\mu X$) and the most relevant background are considered. The most discriminant variables, as the transverse momentum of the four muons, the invariant masses of the four different muons pairs, the four muons invariant mass, the hadron multiplicity and other new variables, are used.

The results show that the optimized neural network (NN) [3] allows to achieve a good discrimination between background events and Higgs boson events. Its performances are higher than those obtained by the linear discriminant classifier [4]. Efficiencies and purities of the neural network are in average *1* to *5 %* higher. In addition, NN can support a high degree of parallelism and could be used for an on line analysis of the experimental data (as triggering)

[1] D. Froidevaux, in Proc of Large Hadron Collider Workshop, eds G. Jarlskob and D. Rein, CERN 90-10, ECFA 90-133, Vol II, p444

[2] T. Sjostrand, M. Bengtsson, Comp. Phys. Comm. 82 (1994)74.

[3] J. A. Freeman, M. Skapura, Neural Networks, Addison - Wesley, 1991.

[4] M. S. Srivastava, E. M. Carter, Applied multivariate statistics, North Holland, Amsterdam, 1983.

Stout links: an analytic gauge-link smearing algorithm.

Presented by: Mike Peardon
Mike Peardon, Colin Morningstar

An analytic method of smearing link variables in lattice QCD (the stout link) is presented. The differentiability of the scheme with respect to the underlying link variables permits the use of molecular-dynamics-based configuration generation algorithms. Some preliminary tests of the properties of stout links and their updating are presented.

Domain Wall Fermion Inverter on Pentium 4

Presented by: Andrew Pochinsky
Andrew Pochinsky

A highly optimized domain wall fermion inverter has been developed as part of the SciDAC lattice initiative. By designing the code to minimize memory bus traffic, it achieves high cache reuse and performance in excess of 2 GFlops for out of L2 cache problem sizes on a GigE cluster with 2.66 GHz Xeon processors. The code uses the SciDAC QMP communication library.

QCD on the BlueGene/L supercomputer

Presented by: Pavlos Vranas
Pavlos Vranas, G. Bhanot, D. Chen, A. Gara

The considerations and performance of QCD on IBM's BlueGene/L supercomputer will be presented.

10 Theoretical Developments

Higher loop results for the plaquette, using the clover and overlap actions

Presented by: A. Athinodorou
A. Athinodorou, H. Panagopoulos, A. Tsapalis

We calculate the perturbative value of the free energy in QCD on the lattice. This quantity is directly related to the average plaquette. Our calculation is done to 3 loops using the clover action for fermions; the results are presented for arbitrary values of the clover coefficient, and for a wide range of fermion masses. In addition, we calculate the 2 loop result for the same quantity, using the overlap action.

Lattice Supersymmetry via Twisting

Presented by: Simon Catterall
Simon Catterall, Sofiane Ghadab

We describe a technique for obtaining lattice actions for supersymmetric theories which retain an exact supersymmetry. This approach starts from a result in topological field theory that continuum theories with extended supersymmetry may be rewritten in terms of a new set of variables in such a way as to expose a nilpotent, scalar supercharge Q. This change of variables is termed *twisting*. Furthermore, the action written in these twisted variables is typically Q-exact. Provided the algebra can be maintained after discretization this twisted supersymmetry will then be retained in the lattice model. We give explicit examples of this construction for the case of one and two-dimensional nonlinear sigma models with $N = 2$ supersymmetry. The resultant actions are local, free of doubles and approach their continuum counterparts as $a \to 0$.

Exact supersymmetry on the lattice: the Wess-Zumino model

Presented by: Alessandra Feo
Alessandra Feo, Marisa Bonini

It is shown that the lattice Wess-Zumino model written in terms of Ginsparg-Wilson fermions is invariant under a generalized supersymmetry transformation which is determined by an iterative procedure in the coupling constant. This transformation is non-linear in the scalar fields and depends on the superpotential parameters. The implications of this lattice invariance are discussed.

Lattice Study of the O(3) Supersymmetric Sigma Model

Presented by: Sofiane Ghadab
Sofiane Ghadab, Simon Catterall

We present preliminary numerical results from a lattice study of the two-dimensional O(3) non-linear sigma model. In the continuum this model possesses $N = 2$ supersymmetry. The lattice formulation we use retains an exact (twisted) supersymmetry except for a soft breaking associated with a Wilson mass term needed to remove the doubles. Our numerical results show that the partition function is independent of coupling as predicted by supersymmety. We also show evidence for the appearance of a coupling constant independent chiral condensate in the model. This condensate arises from instanton effects and corresponds to the usual chiral anomaly in two dimensions. We also show results for the supersymmetric Ward identities.

Twisted N=2 exact SUSY on the lattice for BF and Wess-Zumino models with noncommutativity

Presented by: Issaku Kanamori
Issaku Kanamori, Alessandro D'Adda, Noboru Kawamoto, Kazuhiro Nagata

We formulate exact supersymmetric models on a lattice. We introduce noncommutativity to ensure the Leibniz rule. With the help of superspace formalism, we give supertransformations which keep the N=2 twisted SUSY algebra exactly. The action is given as a product of (anti)chiral superfields on the lattice. We present BF and Wess-Zumino models as explicit examples of our formulation. Both models have exact N=2 twisted SUSY in 2 dimensional space at a finite lattice spacing. In component fields, the action has supercharge exact form.

Twisted Superspace and Dirac-Kähler Fermions on a Lattice

Presented by: Noboru Kawamoto
Noboru Kawamoto, Alessandro D'Adda , Issaku Kanamori , Kazuhiro Nagata

We propose a new formulation which realizes exact twisted supersymmetry for all the super charges on a lattice by twisted superspace formalism. We show explicit examples of N=D=2 twisted supersymmetry for N=2 SUSY invariant BF and Wess-Zumino models. We introduce mild lattice noncommutativity to preserve Leibnitz rule on the lattice. The formulation is based on the twisted superspace formalism for twisted N=D=2 supersymmetry which we proposed recently. We found that the twisting procedure in the quantization of topoligical field theory is essentially the Dirac-Kähler fermion mechanism. It is thus natural to recognize that the superspace describes semilocally scattered fermions and bosons within a double size square lattice.

Properties of the large N phase transition

Presented by: Joe Kiskis
Joe Kiskis, Rajamani Narayanan, Herbert Neuberger

Data on the latent heat of the large N phase transition are presented.

The locality problem for two tastes of staggered fermions

Presented by: F. Knechtli
F. Knechtli, B. Bunk, M. Della Morte, K. Jansen

We address the locality problem arising in simulations, which take the square root of the staggered fermion determinant as a Boltzmann weight to reduce the number of dynamical quark tastes from four to two. We study analytically and numerically the square root of the staggered fermion operator as a candidate to define a two taste theory from first principles. Although it has the correct weight, this operator is non-local in the continuum limit. Our work serves as a warning that fundamental properties of field theories might be violated when employing blindly the square root trick. The question, whether a local operator reproducing the square root of the staggered fermion determinant exists, is left open.

Universality in the Gross-Neveu model

Presented by: Tomasz Korzec
Tomasz Korzec

We calculate a universal quantity in the large-N limit of the continuum Gross-Neveu model as well as in its discretized versions with Wilson- and with staggered-fermions and compare the results with each other. First steps towards a high precision Monte-Carlo study at finite N are presented.

Effects of large field cutoffs on perturbative series in scalar and gauge models

Presented by: Yannick Meurice
Yannick Meurice, Li Li

A common challenge for quantum field theorists consists in finding accurate methods in regimes where existing expansions break down. In the RG language, this amounts to find acceptable interpolations for the RG flow in intermediate regions between fixed points. In a $SU(3)$ pure gauge theory near $\beta \simeq 6$, weak and strong coupling expansions break down and MC seems to be the only reliable method. In the case of scalar field theory, the weak coupling expansion is unable to reproduce the exponential suppression of the large field configurations operating at strong coupling, but we have shown that this problem can be solved by introducing a large field cutoff ϕ_{max}. One is then considering a slightly different problem, however a judicious choice of ϕ_{max} can be used to reduce or eliminate the discrepancy. This optimization procedure can be approximately performed using the strong coupling expansion and naturally bridges the gap between the weak and strong coupling expansions.

At this conference, we report recent attempts to extend this procedure for $SU(3)$ LGT. We compare gauge invariant and gauge dependent (in the Landau gauge) criteria to sort the configurations into "large-field" and "small-field" configurations. We discuss the effects of discarding the large field configurations on the perturbative coefficients of the Wilson loop and related quantities. We discuss approximate optimizations based on strong coupling expansions.

N=D=2 Twisted Supersymmetry on a Lattice

Presented by: Kazuhiro Nagata
Kazuhiro Nagata, Alessandro D'Adda, Issaku Kanamori, Noboru Kawamoto

We construct an exact $\mathcal{N}=2$ twisted supersymmetry on a $2D$ lattice. In order to maintain an exact Leibniz rule on the lattice, we developed a 'non-commutative' twisted superspace formulation with which all four supercharges of the algebra can be realized exactly on the lattice. The explicit construction of $\mathcal{N}=2$ twisted SUSY algebra on the lattice and its super invariant action is presented.

A Topology Conserving Gauge Action for QCD

Presented by: S. Shcheredin
S. Shcheredin, W. Bietenholz K. Jansen K.-I. Nagai S. Necco L. Scorzato

We report on first QCD applications of a lattice gauge action, which tends to keep the Monte Carlo history in a single topological sector. Such actions were proposed by M. Lüscher and first applied in d=2 by Fukaya and Onogi. If the charge is stable throughout the history, much computing time for the index evaluation can be saved. It also allows us to cumulate a large number of configurations in the same sector, which is required for simulations in the epsilon regime of chiral perturbation theory. We describe a local HMC algorithm which is suitable to simulate this action, and present first results, depending on the parameter which suppresses topological changes.

Staggered Fermion, its Symmetry and Ichimatsu-Patterned Lattice

Presented by: Hiroto So
Hiroto So, Katsumi Itoh, Mitsuhiro Kato, Michika Murata, Hideyuki Sawanaka

We formulate a single component staggered fermion by SO(2D) Clifford Algebra in a D-dimensional lattice. Symmetries, (i) discrete chiral symmetry and (ii) rotational symmetry can be understood by the formulation. The single staggered Majorana fermion corresponds to a fermi field on a cell in an Ichimatsu-patterned lattice gauge theory. Therefore, we can obtain scalar operators inside the cell by the rotation.

Density matrix renormalization group approach to a two dimensional bosonic model

Presented by: Takanori Sugihara
Takanori Sugihara

Density matrix renormalization group (DMRG) is applied to a (1+1)-dimensional $\lambda\phi^4$ model. Spontaneous breakdown of discrete Z_2 symmetry is studied numerically using vacuum wavefunctions. We obtain the critical coupling $(\lambda/\mu^2)_c = 59.89 \pm 0.01$ and the critical exponent $\beta = 0.1264 \pm 0.0073$, which are consistent with the Monte Carlo and the exact results, respectively. The results are based on extrapolation to the continuum limit with lattice sizes $L = 250, 500$, and 1000. We show that the lattice size $L = 500$ is sufficiently close to the the limit $L \to \infty$. (JHEP05(2004)007)

A Lattice Formulation of Super Yang-Mills Theories with Exact Supersymmetry

Presented by: Fumihiko Sugino
Fumihiko Sugino

We construct SU(N) super Yang-Mills theories with extended supersymmetry on hypercubic lattices of various dimensions keeping one or two supercharges exactly.

It is based on topological field theory formulation for the super Yang-Mills theories. Gauge fields are represented by ordinary unitary link variables, and the exact supercharges on the lattice are nilpotent up to gauge transformations. In particular, the lattice models are free from the vacuum degeneracy problem, which was encountered in earlier approaches. Thus, we do not need to introduce any supersymmetry breaking terms, and the exact supersymmetry is preserved wholly in the process of taking the continuum limit.

Among the models, we show that the desired continuum theories are obtained without any fine tuning of parameters for the cases $\mathcal{N} = 2, 4, 8$ in two-dimensions. We also investigate the cases $\mathcal{N} = 4, 8$ in three dimensions, and comment on $\mathcal{N} = 4$ in four dimensions.

Simulation Results for the Photon in a Non-commutative Spacetime

Presented by: Jan Volkholz
Jan Volkholz, Wolfgang Bietenholz, Frank Hofheinz, Jun Nishimura, Yoshiaki Susaki

We present preliminary simulation results for QED in a non-commutative 4d space, which is discretized to a fuzzy lattice. The numerical treatment of this system becomes feasible after its dimensional reduction, i.e. its mapping on a twisted Eguchi-Kawai matrix model. In this formulation we investigate the (complex) Wilson loops and in particular the Creutz ratios. This is an ongoing project which aims at non-perturbative predictions for the photon, which can be confronted with phenomenology in order to verify the possible existence of noncommutativity in nature.

Effective string excitation energies

Presented by: Peter Weisz
Peter Weisz, Martin Luescher

We present some new analytic results concerning excitation energies of effective string theories which possibly describe flux tubes joining widely separated static quarks and antiquarks.

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