HK 12 Theorie

Zeit: Freitag 16:30–19:00 Raum: TU MA041

Gruppenbericht HK 12.1 Fr 16:30 TU MA041

Signal of confinement in SU(2) propagators — •Kurt Langfeld, Gunnar Schulze, Wolfgang Lutz, and Hugo Reinhardt — Institute for Theoretical Physics, University of Tuebingen, D-72076 Tuebingen

Recently, a tight relation was established [1] between the Gribov-Zwanziger horizon criterion for confinement and the vortex picture, using the Maximal Center Gauge. On the basis of these findings, we show that the Maximal Center Gauge disentangles the confining degrees of freedom from the gluon and ghost fields; the latter fields appear in Landau gauge. The gluon-, ghost- and center field propagators are studied. It is shown that the ghost form factor is finite in the IR limit while the center fields act as confiners. Finally, the investigation of the low lying eigenmodes of a chirally improved Dirac operator reveals an intimate relation between the center fields and spontaneous chiral symmetry breaking.

[1] Gattnar, Langfeld, Reinhardt, Phys. Rev. Lett. 93, 061601 (2004)

HK 12.2 Fr 17:00 TU MA041

The infrared behaviour of QCD propagators at non-vanishing temperatures and densities — •D. Nickel[1], R. Alkofer[2], B. Grüter[2], A. Maas[1], W. Schleifenbaum[1], and J. Wambach[1] — [1]Institute for Nuclear Physics, Technical University Darmstadt — [2]Institute of Theoretical Physics, Tübingen University

The propagators of QCD, and especially their infrared behavior, contain important information about the phase structure of matter. In our work [1,2,3] we investigate these with a truncated system of Dyson-Schwinger equations in Landau gauge.

We present for the Yang-Mills propagators analytical and numerical results at non-vanishing temperatures. These are in quantitative and qualitative agreement with corresponding lattice results. It turns out that the chromomagnetic sector stays confining even at infinite temperatures.

For the quark propagator at finite chemical potentials we explore the chirally broken and unbroken phase, as well as the superconducting 2SC and CFL phase. The pressure difference between both phases is approximately determined. This method bridges the gap between weak coupling investigations at high densities and densities of the order of nuclear saturation.

[1] A. Maas et al., Eur. Phys. J. **C37** (2004) 335.
[2] B. Grüter et al., arXiv:hep-ph/0408282.
[3] W. Schleifenbaum et al., arXiv:hep-ph/0411052.

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HK 12.3 Fr 17:15 TU MA041

Topologically non-trivial QCD field configurations on the lattice — •Stefan Solbrig[1], Christof Gattringer[1], Hugo Reinhardt[2], Jochen Gattnar[2], Kurt Langfeld[2], Torsten Tok[2], and Andreas Schäfer[1] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg — [2]Institut für Theoretische Physik, Auf der Morgenstelle 14, 72076 Tübingen

Gluon field configurations with non-trivial topology play a crucial role in QCD. Instantons are clearly related to chiral symmetry breaking and center vortices are strongly correlated with confinement. We present evidence, that there is a deep connection between these two classes of objects. We use the chirally improved lattice Dirac operator to compute eigenvectors and eigenvalues of various lattice gauge field configurations. Removing the vortices from thermalized configurations also removes the topological content of the gauge field. As a consistency check, we apply random changes to raw configurations.

(Supported by BMBF)

HK 12.4 Fr 17:30 TU MA041

Nuclear Lattice Simulations with Chiral Effective Field Theory — •B. Borasoy[1], D. Lee[1], and T. Schaefer[2] — [1]Helmholtz-Institut für Strahlen- und Kernphysik (Theorie), Universität Bonn, Germany — [2]Physics Department, North Carolina State University, Raleigh, USA

We study nuclear and neutron matter by combining chiral effective field theory with non-perturbative lattice methods and treating nucleons and pions as point particles on a lattice. This allows us to probe larger volumes, lower temperatures, and greater nuclear densities than in lattice QCD. 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 a realistic simulation of many-body nuclear phenomena is obtained with no free parameters, a systematic expansion, and a clear theoretical connection to QCD. Results for hot neutron matter at temperatures 20 to 40 MeV and densities below twice nuclear matter density are presented.

Financial support of the DFG, DOE and NSF is gratefully acknowledged.

[1] D. Lee, B. Borasoy and T. Schaefer, Phys. Rev. C70 (2004) 014007.

HK 12.5 Fr 17:45 TU MA041

Automated Generation of Feynman Rules for Lattice Chiral Perturbation Theory — •Georg von Hippel[1,2], Buḡra Borasoy[3], Alistair Hart[4], Ron Horgan[2], and Randy Lewis[1] — [1]Department of Physics, University of Regina, Regina, SK, S4S 0A2, Canada — [2]DAMTP, CMS, University of Cambridge, Cambridge CB3 0WA, U.K. — [3]Helmholtz-Institut für Strahlen- und Kernphysik (Theorie), Universität Bonn, Nußallee 14-16, 53115 Bonn, Germany — [4]School of Physics, University of Edinburgh, King's Buildings, Edinburgh EH9 3JZ, U.K.

We present an algorithm to systematically and efficiently generate Feynman rules for chiral perturbation theory on a lattice, which is based on a similar algorithm implemented by some of the authors for the case of improved actions in lattice QCD [1]. A program written in Python performs the perturbative expansion of the lattice action and generates the vertices and propagators, which then can be output in either a human-readable format or as data files that can serve as input for programs to perform automated numerical evaluations of lattice Feynman diagrams. A FORTRAN library is presented as an example of the latter approach. We expect this automated approach to significantly facilitate future calculations in lattice-regularized χPT.

[1] A. Hart, G.M. von Hippel, R.R. Horgan, L.C. Storoni, Automatically generating Feynman rules for improved lattice field theories, submitted to J.Comp.Phys.

HK 12.6 Fr 18:00 TU MA041

Quark mass dependence of nucleon properties and lattice QCD — •Massimiliano Procura, Thomas R. Hemmert, Bernhard U. Musch, and Wolfram Weise — Institute for Theoretical Physics (T39), TU München, Germany

We present an updated analysis of the quark mass dependence of the nucleon mass M_N [1,2] and the nucleon axial-vector coupling constant g_A [2], comparing two different formulations of $SU(2)$ Baryon Chiral Effective Field Theory, with [3] and without [4] explicit $\Delta(1232)$ degrees of freedom. We perform an interpolation of these nucleon properties between their physical values and sets of fully dynamical two-flavor lattice QCD data. We obtain good interpolation functions already at the one-loop level. The inclusion of $\Delta(1232)$ as an explicit degree of freedom turns out to be not essential for the nucleon mass, but crucial for g_A. Our study represents a first step towards a systematic approach for chiral extrapolation of lattice results for nucleon observables.

Work supported in part by DFG and BMBF.

[1] M. Procura, T.R. Hemmert and W. Weise, Phys. Rev. D69 (2004).
[2] M. Procura, T.R. Hemmert, B.U. Musch and W. Weise, in preparation.
[3] V. Bernhard, T.R. Hemmert and U.-G. Meißner, Phys. Lett. B565 (2003).
[4] T. Becher and H. Leutwyler, Eur. Phys. J. C9 (1999).

HK 12.7 Fr 18:15 TU MA041

A Nucleon in a Tiny Box — •Harald W. Griesshammer — T39, Technischen Universität München, D-85747 Garching

Chiral Perturbation Theory techniques are used to compute the nucleon mass-shift due to finite-volume and temperature effects. We interpolate between the infinite-volume limit and very small volumes (the "ϵ-régime" $1/\Lambda_\chi \ll L \sim \beta \ll 1/m_\pi$ as first discussed by Gasser and Leutwyler). This first extension to nucleons can be used to extrapolate lattice results from temporal and spatial sizes smaller than the pion cloud and avoids the numerically costly simulation of Physics well under theoretical control. Based on the two leading orders, we discuss the convergence of the expansion as a function of the lattice size and quark masses. An extraction of the experimentally ill-determined low-energy coefficients c_2, c_3 of the chiral Lagrangean from lattice simulations at small volumes and a “magic” ratio $\beta = 1.22262L$ is possible. Further observables are commented on.

HK 12.8 Fr 18:30 TU MA041

Quarkmass Dependence of Baryon Magnetic Moments — •Tobias A. Gail and Thomas R. Hemmert — Technische Universität München

We discuss the chiral extrapolation of recent lattice data [1] for the nucleon magnetic moment using relativistic p^4 ChPT.

For the three moments of the $N\Delta$ transition the established nonrelativistic [2] and a new relativistic calculation using infrared regularization adapted for spin $\frac{3}{2}$ fields are discussed in the context of lattice data [3] and recent experimental results.

[1] M.Göckeler et al. (QCDSF Collaboration), hep-lat/0303019

[2] G.C.Gellas, T.R.Hemmert, C.N.Ktorides, G.I.Poulis, Phys.Rev.D60:054022,1999

[3] C.Alexandrou et al., Phys.Rev.D69:114506,2004

HK 12.9 Fr 18:45 TU MA041

Volume Dependence of the pion mass from Renormalization Group flows. — •Bertram Klein[1], Jens Braun[2], and Hans-Juergen Pirner[2] — [1]GSI, Planckstr.1, 64291 Darmstadt — [2]Institut fuer Theoretische Physik, Universitaet Heidelberg, Philosophenweg 19, 69120 Heidelberg

We investigate finite volume effects on the pion mass and the pion decay constant. An understanding of such effects is necessary in order to interpret results from lattice QCD and extrapolate reliably from finite lattice volumes to infinite volume.

We consider the quark-meson-model in a finite 3+1 dimensional volume. In order to break chiral symmetry in the finite volume, we introduce a small current quark mass. In the corresponding effective potential for the meson fields, the chiral O(4) symmetry is broken explicitly, and the sigma and pion fields are treated individually. Using the proper-time renormalization group (RG), we derive renormalization group flow equations in the finite volume and solve these equations in the local potential approximation.

We calculate the volume dependence of pion mass and pion decay constant and investigate the influence of different boundary conditions for the quark fields on the result.

We compare our results with results from chiral perturbation theory in finite volume and with results from lattice QCD.