# T 707 QCD III

Zeit: Mittwoch 14:00–16:15 Raum: TU H2037

T 707.1 Mi 14:00 TU H2037

**Limiting Particle Kinematics in Multiparticle Production at Very High Energies.** — •Luebbo von Lindern — Ackerstrasse 35, D-26121 Oldenburg (Oldb.)

Plotting balanced pseudorapidities = $\gamma$(cms)x pseudorapidity versus the ratio of secondary particle(lab-)energies to the primary energy $\gamma$(cms)in appropriate scales, the limiting kinematic features of multipaticle production can uniquely be displayed (1). Their underlying approximations and some symmetry properties for large particle numbers/jet are discussed. These apply to colliding beam multijets and classical cosmic ray jets as well. Some related statistical aspects have been discussed in another context by J.D. Bjorken, Phys.Rev. D vol.45, 1992, p.101 and vol.47, 1993, p.4077. 1. L. von Lindern, Thesis LMU, Munich 1961

T 707.2 Mi 14:15 TU H2037

**Das Phasendiagramm des Gross-Neveu-Modells: Exaktes Ergebnis und Parallelen zur Festkörperphysik** — •Konrad Urlichs, Oliver Schnetz und Michael Thies — Institut für Theoretische Physik III, Staudtstraße 7, 91058 Erlangen

Das Gross-Neveu-Modell in 1+1 Dimensionen ist die wohl einfachste wechselwirkende Quantenfeldtheorie für Fermionen die sich formulieren lässt. Dennoch zeigt das Modell ein erstaunlich komplexes Phasenverhalten bei endlicher Dichte und Temperatur: Eine Phase in der die chirale Symmetrie durch eine dynamisch erzeugten Fermionmasse spontan gebrochen wird, eine chiral symmetrische Phase und eine Phase in der auch die Translationssymmetrie durch die Bildung eines Baryonenkristalls (Kink-Antikink-Kristall) gebrochen wird. Im large-N Limes ist die wechselwirkende Theorie äquivalent zu einer Theorie unabhängiger Teilchen in einem externen Potential. Dies entspricht der Hartree-Fock-Näherung die im large-N Limes exakt wird. Die Hartree-Fock-Gleichungen sind durch eine Abbildung auf die Lamé-Gleichung analytisch lösbar. Wir identifizieren den Mechanismus der Brechung der Translationssymmetrie als die relativistische Version des Overhauser-Effekts aus der Vielteilchenphysik: Das System bricht jede Symmetrie, die die Bildung eines Gaps an der Fermikante und die damit verbundene Absenkung der Gesamtenergie ermöglicht. Interessant ist, dass das mathematisch identische Phasendiagramm auch in der Festkörperphysik auftaucht, wo es die Eigenschaften des Peierls-Fröhlich-Modells und ferromagnetischen Supraleitern beschreibt.

T 707.3 Mi 14:30 TU H2037

**Nonperturbative $g^6$-Contribution to Free Energy of Hot QCD** — •Boris Kastening — Inst. f. Theoretische Physik, FU Berlin, Arnimallee 14, 14195 Berlin

The small-coupling expansion of the free energy density of hot QCD has the form $f = T^4[c_0+c_2g^2+c_3g^3+(c_4'\ln g+c_4)g^4+c_5g^5+(c_6'\ln g+c_6)g^6+\cdots]$. While $c_0$ through $c_6'$ may be computed within perturbation theory, $c_6$ receives both perturbative and nonperturbative contributions, $c_6 = c_6^{\rm p}+c_6^{\rm np}$. Working within the three-dimensional pure gauge theory that describes the magnetostatic modes of hot four-dimensional non-Abelian gauge theory, we determine $c_6^{\rm np}$. Infrared divergences are regularized by introducing a mass into gauge and ghost propagators and taking the massless limit after resummation of the corresponding perturbative series through four loops. $c_6^{\rm np}$ turns out to be of the same order of magnitude which is expected for $c_6$, if agreement is assumed between the small-$g$ expansion of $f$ and lattice results within their expected common range of validity.

T 707.4 Mi 14:45 TU H2037

**Finite Temperature Phase Transition from SU(3) Vortex Structures** — •Kurt Langfeld, Markus Quandt, and Hugo Reinhardt — Institute for Theoretical Physics, University of Tuebingen, D-72076 Tuebingen

The deconfinement transition at finite temperatures is investigated by using SU(3) lattice gauge simulations. Two different definitions of the underlying vortex structures are studied: Vortices arising from center projection after fixing to (i) the Laplacian Center Gauge and (ii) the Maximal Center Gauge. It is shown that the vortex configurations reproduce the deconfinement temperature. In addition, the vortex structures correctly reflect the first order nature of the transition. This observation falls into place with the findings in SU(2) gauge theory where vortex percolation explains the second order nature of the transition.

T 707.5 Mi 15:00 TU H2037

**Factorisation, Parton Entanglement and the Drell-Yan Process** — •Andre Utermann[1], Daniel Boer[2], Arnd Brandenburg[3], and Otto Nachtmann[1] — [1]Institut für Theoretische Physik, Universität Heidelberg — [2]Department of Physics and Astronomy, Vrije Universiteit Amsterdam — [3]DESY Hamburg

We discuss the angular distribution of the lepton pair in the Drell-Yan process, hadron + hadron $\to \gamma^* + X \to l^+ + l^- + X$. This process gives information on the spin-density matrix $\rho^{(q,\bar{q})}$ of the annihilating quark-antiquark pair in $q+\bar{q} \to l^+ + l^-$. There is strong experimental evidence that even for unpolarised initial hadrons $\rho^{(q,\bar{q})}$ is nontrivial, and therefore the quark-antiquark system is polarised. We discuss the possibilities of a general $\rho^{(q,\bar{q})}$ –which could be entangled– and a factorising $\rho^{(q,\bar{q})}$. We argue that instantons may lead to a nontrivial $\rho^{(q,\bar{q})}$ of the type indicated by experiments.

T 707.6 Mi 15:15 TU H2037

**Center vortices and Dirac eigenmodes in SU(2) lattice gauge theory** — •Torsten Tok[1], Jochen Gattnar[1], Christof Gattringer[2], Kurt Langfeld[1], Hugo Reinhardt[1], Andreas Schäfer[2], and Stefan Solbrig[2] — [1]Institut für Theoretische Physik, Universität Tübingen, 72076 Tübingen — [2]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg

We study the interplay between Dirac eigenmodes and center vortices in SU(2) lattice gauge theory. In particular we focus on vortex-removed configurations and compare them to an ensemble of configurations with random changes of the link variables. We show that removing the vortices destroys all zero modes and the near zero modes are no longer coupled to topological structures. The Dirac spectrum for vortex-removed configurations in many respects resembles a free spectrum thus leading to a vanishing chiral condensate. Configurations with random changes leave the topological features of the Dirac eigensystem intact.

T 707.7 Mi 15:30 TU H2037

**Center vortex model for SU(3) Yang-Mills theory – the 't Hooft loop operator** — •Markus Quandt[1], Hugo Reinhardt[1], and Michael Engelhardt[2] — [1]Institut für Theoretische Physik, Universität Tübingen, 72076 Tübingen, Germany — [2]Physics Department, New Mexico State University, Las Cruces, NM 88003, USA

We study the *'t Hooft loop operator* in the center vortex model for the infrared sector of $SU(3)$ Yang-Mills theory. This model is based on the assumption that the vortex world-surfaces, which are the relevant degrees of freedom in this regime, can be viewed as random surfaces in Euclidean space-time. The 't Hooft loop is a vortex creation operator which implements *twisted boundary conditions* on a spacetime torus.

Our mesurements of the free energy of large spatial 't Hooft loops confirm a temperature dependence dual to the usual Wilson loop: We find an area law with a *dual string tension* $\tilde{\sigma}(T)$ for $T > T_c$, and a perimeter law, $\tilde{\sigma} = 0$, in the confinement phase below $T_c$. As we approach the critical temperature from above, we also observe a weak discontinuity in the free energy, $\sqrt{\Delta\tilde{\sigma}} \approx 34\,\mathrm{MeV}$, which is an indication of a weak first order phase transition for the gauge group $G = SU(3)$. Our findings are in good agreement with recent lattice calculations.

T 707.8 Mi 15:45 TU H2037

**Automated Generation of Feynman Rules for Improved Lattice Actions** — •Georg von Hippel[1,2], Alistair Hart[3], Ron Horgan[2], and Laurent Storoni[2] — [1]Department of Physics, University of Regina, Regina, SK, S4S 0A2, Canada — [2]DAMTP, CMS, University of Cambridge, Cambridge CB3 0WA, U.K. — [3]School of Physics, University of Edinburgh, King's Buildings, Edinburgh EH9 3JZ, U.K.

Deriving the Feynman rules for lattice perturbation theory from improved actions and operators is a necessary, but tedious and complicated, task. It is therefore suitable for automation. We describe a flexible algorithm for generating Feynman rules for a wide range of lattice field theories including gluons, relativistic fermions and heavy quarks [1]. This algorithm has been successfully used to compute perturbative tadpole improvement factors in pure gauge theory [2] and decay constants for heavy quarkonia in NRQCD [3]. We also present an efficient implementation of this in a freely available, multi-platform language called Python.

[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.
[2] A.Hart, R.R. Horgan, L.C. Storoni, Perturbation theory vs. simulation for tadpole improvement factors in pure gauge theories, Phys.Rev. D70 (2004) 034501, hep-lat/0402033.
[3] A. Gray, A. Hart, G.M. von Hippel, R.R. Horgan, S-wave QCD/NRQCD matching for the vector annihilation current at $\mathcal{O}(\alpha_s v^2)$, in preparation.

T 707.9 Mi 16:00 TU H2037

**From laser produced Debye layers in plasma to a theory of nuclear forces and quark-gluon plasmas** — •Heinrich Hora — Department of Theoretical Physics, University of New South Wales, Sydney 2052, Australia

The electric double layer at the surface of plasma plume at laser irradiation of targets has the thickness of the Debye sheath acting as a work function to the electrons in the plasma given by its temperature. The electrostatic energy in the Debye layer results in surface tension of and is the reason for the smooth plasma plumes and causes a surface wave stabilization against Rayleigh-Taylor instabilities. Generalizing to the electron gas in a metal, the Debye layer is defined by the Fermi-Dirac quantum energy instead of temperature and leads to a quantum theory of surface tension of metals in agreement with measurements. Taking these conditions for the Fermi energy of the hadrons in a nucleus, a quasi-Debye layer results in the thickness of the charge decay in the nuclear surface as measured by Hofstadter. The energy of the surface tension is always smaller than energy of the confined hadrons in a nucleus but due to a difference in the exponent of the radial dependence it turns out that the surface energy just compensates the confinement energy at the measured values of the radii of the large nuclei. The confinement energy is then dominated by the Fermi energy of the hadrons with a small correction by the Coulomb energy and other minor parts [1]. When compressing the nuclei to about six times higher energy, the Fermi energy of the hadrons changes into the relativistic branch where no longer a nucleation is possible and the soup of particles does not depend on their mass permitting the quark gluon plasma as well as a neutron ensemble assumed in neutron stars.

[1] H. Hora, *Plasma Model for Surface Tension of Nuclei and the Phase Transiton to the Quark Plasma*, CERN-PS/DL-Note-91/05, August 1991; H. Hora and G.H. Miley eds., *Edward Teller Lectures: Lasers and Inertial Fusion Energy*, Imperial College Press, London 2004, p. 103, ISBN 1-86094-468-X , paperback ISBN 0-646-44226-0