TEMPLATE FOR A WORKSHOP SCIENTIFIC REPORT

TITLE

Write here the title of the workshop

DATE

Write here the date of the workshop (es. 7-11 September 2009)

ORGANIZERS

Write here the Surname, Name, Affiliation and Country of the Organizer
[es D. Binosi (ECT*, Italy)]
Organizer 2
Organizer 3
….
Organizer n

NUMBER OF PARTICIPANTS

Es. 55

MAIN TOPICS

Es.

[The general theme of the workshop concerned techniques for gauge-invariant calculations of off-shell Green's functions in non-Abelian gauge theories such as Quantum Chromodynamics (QCD), and their relationship to other approaches to QCD, including lattice simulations and phenomenology. Of critical interest was the infrared behavior of such gauge theories, where all non-perturbative phenomena (confinement, chiral symmetry breakdown, non-integral topological charge) have their roots. We especially hoped that the lattice and the continuum communities would find at the Workshop, and later explore, new ways of this most difficult problem of non-perturbative QCD.]

The main topics were

- Main topic 1
- Main topic 2
- …
- Main topic n

SPEAKERS:

Write here the Name Surname Affiliation and Country of each participant
Es.
[C, Aguilar (Federal Univ. of ABC, Brazil)]
Participant 2
Participant 3
…
Participant n

SCIENTIFIC REPORT:

Es.

[Non-Abelian gauge theories have been at the centre stage of elementary particle physics for the last four decades, since the establishment of electroweak gauge theory and, a few years later, QCD, the theory describing strong interactions. Unlike quantum electrodynamics, which yields with spectacular success to perturbation theory and Feynman-diagram techniques, only the ultraviolet (high-energy) regime of QCD is amenable to a perturbative treatment, due to

the characteristic property of asymptotic freedom. The infrared sector of QCD, on the other hand, is the host of several non-perturbative phenomena, which most famously encompass quark confinement and dynamical mass generation, and powerful methods must be employed for their quantitative treatment.

The basic building blocks of QCD are the Green's (correlation) functions of the fundamental physical degrees of freedom, gluons and quarks, and of the unphysical ghosts. Even though it is well-known that these quantities are not physical, since they depend on the gauge-fixing scheme and parameters used to quantize the theory, it is widely believed that reliable information on their non-perturbative structure is essential for unravelling the infrared dynamics of QC. In addition to their relevance for phenomenology, the QCD Green's functions encode information on confinement, albeit in a rather subtle way.

The two basic non-perturbative tools that permit the exploration of the infrared domain of QCD are (i) the lattice, where space-time is discretized and the quantities of interest are evaluated numerically, and (ii) the infinite set of integral equations governing the dynamics of the QCD Green's functions, known as Schwinger-Dyson equations (SDE). While the lattice calculations are limited by the lattice size used, the problem of the Gribov copies, and the extrapolation of the numerical results to the continuous limit, the fundamental conceptual difficulty in treating the SDE resides in the need for a self-consistent truncation scheme, i.e., one that does not compromise the gauge-invariance of the quantities studied.

These two methods are actively applied in all the areas which were covered by the workshop; in fact about half the attendees of QCD-TNT worked in continuum theory and half in lattice simulations. The multiple QCD competing themes addressed in the workshop can be summarized as follows.

- Does the QCD gluon have a dynamical mass, coming from solving Schwinger-Dyson equations (sometimes called the "decoupling" solution) for the gauge propagator and ghost and yielding finite gauge and ghost dressing functions at zero momentum? Or do the gauge and ghost propagators of the equations show a power-law behavior for small momentum, including a ghost dressing function diverging at zero momentum (called the "scaling" solution)?
- Is the Gribov-Zwanziger (GZ) picture, emphasizing the Landau gauge and gauge copies of the gauge potential, consistent with either or neither of the above views? How is the GZ picture realized non-perturbatively?
- What do lattice simulations say about the previous two topics?

In addition to these main themes there were a number of other subjects covered in the Workshop, represented by one or a few speakers each, including:

- Continuum and lattice studies of the Coulomb gauge; three-dimensional QCD and the functional Schrodinger equation; five-dimensional QCD simulations; calculations and lattice simulations in QCD at finite temperature and density; fermions and chiral symmetry breaking in QCD; the role of calorons or other topological solitons; glueballs; the AdS/CFT view of QCD; and QCD phenomenology.]

RESULT AND HIGHLIGHTS

Es.

[The Workshop was a very useful opportunity to balance the aforementioned competing views, and this was in fact perceived by all the participants.

Notwithstanding the fact that consensus on the decoupling vs scaling issue (first three topics above) has not been achieved, and that at the Workshop there were dissenters, it is fair to say the participants were leaning toward the decoupling picture of a massive gluon and non-singular ghost dressing function, and that lattice simulations probing the region of near-zero propagator momentum are largely in support of this picture.

The GZ scenario is currently in a confused state, with different authors making different claims at the Workshop. In view of the growing support from lattice simulations of the decoupling" picture, some are trying to incorporate a massive gluon into the original GZ effective action,

with varying degrees of success. Others claim that a confinement criterion due to Kugo and Ojima is wrong and needs to be revised; the revision would favour the "decoupling" scenario. Yet others claim that this revision is incorrect. It appears now that lattice simulations support the revision rather quantitatively; on the other hand claims were made that this agreement may be coincidental.

The Coulomb gauge picture of QCD is in an interesting state of evolution. It is now apparent both in the continuum and on the lattice that Coulomb gauge gluon propagators are very different from those of either the Landau gauge or the Pinch Technique; these Landau or PT propagators support the center vortex picture. Most Workshop practitioners of the Coulomb gauge are strong supporters of the center vortex picture, so the question is how to reconcile Coulomb gauge and center vortices. Some interesting proposals that might do this were made, but they need more work.

A complete and detailed discussion of the results of the fourth topic above, would be too lengthy; we will simply say that taken as a whole they seem to be consistent with the emerging majority view of the work presented for the main three topics.]

	Monday 7	**Tuesday 8**	**Wednesday 9**	**Thursday 10**	**Friday 11**
09:15	**J. Greensite** Aspects of Confinement in Coulomb Gauge	**J M Cornwall** Open issues in confinement, for the lattice and for center vortices	**V. Zakharov** Topological solutions in dual formulation of Yang-Mills theories	**J-P. Blaizot**	**W. Weise** Symmetry breaking patterns in QCD: chiral and deconfinement transitions
09:50	**Y. Simonov** Confinement, deconfinement and chiral symmetry breaking in QCD	**Ph de Forcrand** Confinement in (4+1) dimensions	**A. Szczepaniak** Gluon properties in magnetically confining vacuum	**M. D'Elia** Magnetic monopoles in the deconfined phase of Yang-Mills theories	**G. W. Semenoff** Large representation Polyakov loop in hot Yang-Mills theory
10:25	**M. Lavelle** Infrared problems and a response	**K. Langfeld** A fresh look at the confinement mechanism	**S. Olejnik** Vacuum structure and Casimir scaling in Yang-Mills theories	**S. Hands** Lattice study of dense two color matter	**C. Ratti** The role of monopoles in a gluon plasma
11:00	Coffee break @ ECT* garden				
11:30	**T. Mendes** Numerical test of the Gribov-Zwanziger scenario in landau gauge	**H. Suganuma** Lattice QCD Analysis for Gluons	**P. Minkowski** QCD as basic field theory: diffculties to build new bridges from perturbative regions to simple properties of hadrons	**P. Nair** The Hamiltonian approach to Yang-Mills (2+1): An update and corrections to string tension	**E-M. Ilgenfritz** Multidyon picture for confinement and deconfinement
12:05	**J. Papavassiliou** Gluon masses without seagull divergences	**L. Giusti** On the Banks-Casher relation with Wilson fermions	**H. Reinhardt** Hamiltonian approach to Yang-Mills theory in Coulomb gauge	**O. Philipsen** Screened perturbation theory for 3D Yang-Mills and hot QCD	**D. Antonov** Shear viscosity of the gluon plasma in the stochastic-vacuum approach
13:00	Lunch @ ECT* Canteen				
14:30	**M. Creutz** Gluon masses without seagull divergences	**D. Binosi** On the dynamics of the Kugo-Ojima function	**T-W. Chiu** Topological quantum fluctuations in the QCD vacuum	**A. C. Aguilar** Non-perturbative QCD effective charges	**V. Sauli** General method of solution of Schwinger-Dyson equations in Minkowski space
15:05	**O. Pene** Gluon masses without seagull divergences	**J Gracey** The static potential in the Gribov-Zwanziger Lagrangian	**P. Tandy** How much meson physics can one tie to DCSB	**D. Dudal** Aspects of the Gribov-Zwanziger framework	**P. Bicudo** Schwinger-Dyson equations and the quark-antiquark static potential
15:40	**J. Rodriguez-Quintero** A ghost story (II): Ghost, gluons and the gluon condensate beyond the IR of QCD	**K-I. Kondo** Gribov-Zwanziger horizon condition, ghost and gluon propagators and Kugo-Ojima confinement criterion	**A. Cucchieri** Simulating linear covariant gauges on the lattice: a new approach	**N. Vandersickel** A candidate for the scalar glueball operator within the refined Gribov-Zwanziger framework	**A. Ilderton** Physical charges in QED and QCD
16:15	Coffee break @ ECT* garden				
16:45	**A. Natale** QCD phenomenology with infrared finite SDE solutions	**R. Ferrari** Beyond renormalization: an essay on nonlinear sigma model, massive YM and Electroweak Model	**O. Oliveira** The lattice infrared Landau gauge gluon propagator: from finite volume to the infinite volume	**D. Mehta** Lattice Landau Gauge and algebraic geometry	**V. Mathieu** Gluon mass and glueball spectrum
17:20	**H. Forkel** Hadrons as holograms	**A. Quadri** The Electroweak model based on the nonlinearly realized gauge group	**J. Skullerud** Gluons and deconfinement at high density	**M. Trusov** New developments of Dirac orbital approach in the low-energy QCD	**R. Millo** Effective action for low-energy quantum field fluctuations
20:00	Dinner @ ECT*	Dinner @ La Baracca	Dinner @ Patelli	Soc. dinner @ Orso Grigio	Pizza @ Alla Mostra