

30 years of strong interactions: a three-day meeting in honor of Joseph Cugnon and Hans-Jürgen Pirner

mercredi 6 avril 2011 - vendredi 8 avril 2011

Sol Cress

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QCD / 0

Transverse-Momentum Distributions and spherical symmetry

Auteur: Cédric Lorcé¹

¹ *Johannes Gutenberg-Universität Mainz*

Parton distributions, quark models, spherical symmetry

QCD / 1

Structure of the gauge invariant quark Green's function in QCD2

Auteur: Hagop Sazdjian¹

¹ *IPN, Université Paris-Sud 11, Orsay*

Auteur correspondant sazdjian@ipno.in2p3.fr

Study of QCD2 with gauge invariant quark Green's functions

In honour of Joseph Cugnon / 2

The Liège Intra Nuclear Cascade, a versatile and long term developing tool for Intermediate Energy Reactions

Auteur: Alain BOUDARD¹

¹ *CEA-IRFU/SPhN*

Auteur correspondant alain.boudard@cea.fr

We will describe the Liège Intra Nuclear Cascade created and developed by Joseph Cugnon till the eighties.

In honour of Hans-Jürgen Pirner / 3

Pion in deep inelastic scattering

Auteur: Bogdan Povh¹

¹ *Max-Planck-Institut für Kernphysik*

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The forward neutron production in the ep collisions at 300 GeV CM measured by the H1 and ZEUS Collaborations at DESY has been used to estimate the total probability for the proton fluctuation into $n\pi^+$ and $p\pi^0$. The probability found is on the order of the 25%. This number is compared with the numbers obtained for the probability of quark fluctuation into π^+ and π^0 from several alternative DIS

processes (Gottfried sum rule, polarized structure function) and the axial-vector coupling constant, where the pion fluctuation is believed to play an important role. The probability for this fluctuation is about 36%. The experimental results are discussed in frame of the SU2 quark model.

Heavy-ion collisions / 4

A Fixed Target Experiment at the LHC: a precision version of RHIC ?

Auteur: Jean-Philippe Lansberg¹

Co-auteurs: Frédéric Fleuret²; Stanley Brodsky³

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We discuss a number of arguments strongly supporting the conception of a multi-purpose fixed-target experiment with the proton or lead-ion LHC beam.

In honour of Hans-Jürgen Pirner / 5

Finite-Volume effects in QCD and functional RG methods

Auteur: Bertram Klein¹

¹ *Technische Universität München*

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Quantum Chromodynamics at finite temperature and density is currently a subject of great interest, due to both advances in experimental heavy-ion collisions and theoretical improvement of our understanding in recent years. Simulations of the theory on finite space-time lattices provide important theoretical advances. But in particular for investigating QCD phase transitions, large quark masses and finite volumes in the simulations need to be taken into account. The investigation of finite-volume effects in QCD has a long tradition in the framework of chiral perturbation theory and random matrix theory and can provide useful tools for the analysis. With regard to a description the chiral phase transition in QCD, it is very important to correctly take into account the effects of long-range fluctuations such as pions as the Goldstone bosons of spontaneous chiral symmetry breaking. It is natural to employ Renormalization Group methods for this purpose. Together with Prof. Pirner, we have initiated work in this direction with functional Renormalization Group methods, and with steadily improving results from QCD lattice simulations there has been increased interest in the investigation of finite-volume effects. These effects have implications for the chiral phase transition in QCD and the interpretation of lattice simulation results. I will give an overview over recent developments.

In honour of Hans-Jürgen Pirner / 6

High-Energy Scattering in the Lab and in the Early Universe

Auteur: Frank Steffen¹

¹ *MPI of Physics*

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My talk consists of two parts. In the first part, the loop-loop correlation model (LLCM) is presented which has been developed in collaboration with Hans-Juergen Pirner. This model allows for a or a unified description of static color dipole potentials, confining QCD strings, and hadronic high-energy reactions and shows saturation effects that manifest S-matrix unitarity at ultra-high energies. In the second part, thermal QCD reactions in the hot early Universe are discussed in a supersymmetric setting. Those reactions provide possible explanations for the origin of dark matter.

In honour of Hans-Jürgen Pirner / 9

Phase Structure of Strongly Interacting Theories and Finite-Size Effects

Auteur: Jens Braun¹

¹ *Theoretisch-Physikalisches Institut*

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Strongly-interacting theories of fermions are of great interest both experimentally and theoretically. While heavy-ion collision experiments provide us with information on hot and dense QCD, experiments with ultracold trapped atoms provide an accessible and controllable system where quantum many-body phenomena can be studied experimentally in great detail. Our theoretical understanding of these theories have improved in recent years. However, finite-size effects in these systems are not yet fully understood. During my time as a graduate student, Prof. Pirner already encouraged me to look into these problems, in particular with respect to heavy-ion collision experiments. In the present talk, I review some aspects of finite-size effects and the role that they are playing in strongly-interacting fermionic theories.

QCD / 10

Associated production of one particle and a Drell-Yan pair

Auteur: Federico Alberto Ceccopieri¹

¹ *IFPA, université Liège*

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We discuss the collinear factorization formula for the associated production of one particle and a Drell-Yan pair in hadronic collisions. We outline possible applications of the results to different research areas.

Astroparticles / 11

Ultra-High energy cosmics-rays and first LHC data

Auteur: David d'Enterria¹

¹ CERN**Auteur correspondant** dde@cern.ch

The determination of the primary energy and mass of ultra-high-energy cosmic-rays (UHECR) generating extensive air-showers in the Earth's atmosphere, relies on the detailed modeling of hadronic multiparticle production at center-of-mass (c.m.) collision energies up to two orders of magnitude higher than those studied at particle colliders. The first Large Hadron Collider (LHC) data have extended by more than a factor of three the c.m. energies in which we have direct proton-proton measurements available to compare to hadronic models. In this work we compare LHC results on inclusive particle production at energies $\sqrt{s} = 0.9, 2.36, \text{ and } 7 \text{ TeV}$ to predictions of various hadronic Monte Carlo (MC) models used commonly in cosmic-ray physics. While reasonable overall agreement is found for some of the MC, none of them reproduces consistently the \sqrt{s} evolution of all the observables. We discuss implications of the new LHC data for the description of cosmic-ray interactions at the highest energies.

In honour of Joseph Cugnon / 12

Perspectives and future for intranuclear-cascade and nuclear-de-excitation models

Auteur: Davide Mancusi¹¹ University of Liège

Intranuclear-cascade models (INC) are a precious tool for the description of hadron-nucleus reactions between ~ 0.1 and a few GeV, as it has been proved by extensive comparisons and benchmarks. The development of such models is however still active and is motivated at the same time by fundamental questions and applications. Moreover, INC models provide an accurate understanding of the entrance channel of hadron-induced nuclear reactions: we can thus use them as a solid starting point for the study of nuclear de-excitation.

I will begin by discussing the open theoretical challenges posed by INC models. I will then focus on the Liège Intranuclear Cascade model (INCL) and outline the most important extensions that are planned for the near future (high energies, exotic nuclei, nucleus-nucleus reactions...). The usefulness of INC models in the context of nuclear-de-excitation studies will be demonstrated by a few interesting examples.

QCD / 13

The structure of Yang-Mills spectrum for arbitrary semisimple gauge algebras

Auteur: Fabien Buisseret¹¹ University of Mons**Auteur correspondant** fabien.buisseret@umons.ac.be

Pure Yang-Mills theory is confining for any simple gauge algebra, although the case of $\text{su}(3)$, i.e. pure gauge QCD, has logically been the most studied one so far. As for QCD, glueballs are expected to be present in the low-energy spectrum of Yang-Mills theory with an arbitrary simple gauge algebra. In this talk, the general structure of this spectrum will be discussed within a quasigluon picture, where glueballs are seen as bound states of a given number of quasigluons interacting via an instantaneous potential. Such a framework has already proved to be successful in describing the pure gauge $\text{su}(3)$ lattice data, both qualitatively and quantitatively. The qualitative features of the low-lying glueball

spectrum will be shown to be common to all algebras, excepted the lightest $C=-$ glueballs that only exist when the gauge algebra is $su(N>2)$. The special case of the gauge algebra $su(N)$ at large N will be discussed and compared to recent lattice data.

Heavy-ion collisions / 14

A minimal quasiparticle approach for the QGP and its large- N_c limits.

Auteur: Gwendolyn Lacroix¹

Co-auteur: Fabien Buisseret ¹

¹ UMONS

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Nowadays, Quark-Gluon Plasma (QGP) is a very active research field both theoretically and experimentally. QGP is a QCD state of matter obtained at large enough temperatures and/or baryonic densities and characterized by a deconfinement of quarks and gluons (i.e. quarks and gluons can move quasi freely). We propose here a quasiparticle approach to describe QGP. We use an ideal-gas framework in which quark and gluon masses depend on temperature. Our model is minimal in the sense that we use thermal quasiparticle masses (quarks and gluons) computed from perturbative techniques with standard two-loop running coupling constant and we do not allow any extra ansatz concerning the temperature-dependence of the running coupling. We show that it is able to reproduce the most recent equations of state computed on the lattice for temperatures typically higher than 2 times the critical temperature (T_c). This approach is expected to be relevant well above T_c , in temperature range in which is reasonable to neglect interactions between quasiparticles. We also compute this equation of state for a generic gauge theory with gauge groups $SU(N_c)$ and $SO(2N_c)$ in order to study the accuracy of various inequivalent large- N_c limits and the large- N_c equivalence between the groups $SU(N_c)$ and $SO(2N_c)$.

QCD / 15

The quantum N-body problem and the auxiliary field method

Auteur: Claude Semay¹

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Approximate analytical energy formulas for N-body semirelativistic Hamiltonians with one- and two-body interactions are obtained within the framework of the auxiliary field method. We first review the method in the case of nonrelativistic two-body problems. A general procedure is then given for N-body systems and applied to the case of baryons in the large- N_c limit.

Neutrino physics / 16

Why neutrinos are different

Auteur: jean-marie frere¹

¹ *ULB, Brussels, Physth*

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We show that the supposed Majorana nature of neutrinos is intimately linked to the presence of large mixing angles between families. This follows simply from Lorentz invariance in an extended (6-dimensional model).

The approach predicts in addition an “Inverted Hierarchy” between neutrino masses, mitigated however by a large “pseudo-Dirac” compensation, which limits the rate of neutrinoless nuclear double beta decay.

Heavy-ion collisions / 22

Cold Nuclear Matter effects on Quarkonium production with extrinsic transverse momentum

Auteurs: Andry Rakotozafindrabe¹; Elena Ferreiro²; Frédéric Fleuret³; Jean-Philippe Lansberg⁴; Nicolas Matagne⁵

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We study at RHIC and LHC energies the Cold Nuclear Matter (CNM) effects on J/ψ and Υ production, whose understanding is fundamental to evaluate the Quark Gluon Plasma or Hot Nuclear Matter effects.

Photon physics / 23

High-energy physics with particles carrying non-zero orbital angular momentum

Auteur: Igor Ivanov¹

¹ *University of Liege*

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Photons carrying non-zero orbital angular momentum (twisted photons) are well-known in optics. Recently, it was suggested to use Compton backscattering to boost optical twisted photons to high energies. Twisted electrons in the intermediate energy range have also been produced recently. Thus, collisions involving energetic twisted particles seem to be feasible and represent a new tool in high-energy physics. Here we discuss some features of a generic scattering process involving twisted particles and discuss what insights into the structure of hadrons they can offer.

QCD / 24

Can one study timelike Compton scattering at LHC and at JLab ?

Auteur: Lech Szymanowski¹

Co-auteurs: Bernard Pire²; Jakub Wagner³

¹ *Soltan Institute for Nuclear Studies, Department of Theoretical Physics*

² *Ecole Polytechnique, CPhT, Palaiseau*

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Exclusive photoproduction of dileptons, $\gamma N \rightarrow e^+e^-N$, is and will be measured in ultraperipheral collisions at hadron colliders, such as the Tevatron, RHIC and the LHC but also at lower energies at JLab. We demonstrate that the timelike deeply virtual Compton scattering (TCS), $\gamma q \rightarrow e^+e^- q$, where the lepton pair comes from the subprocess $\gamma q \rightarrow \gamma^* q$ dominates in some accessible kinematical regions, thus opening a new way to study generalized parton distributions (GPD) in the nucleon. This subprocess interferes at the amplitude level with the pure QED subprocess $\gamma \gamma \rightarrow e^+e^-$ where the virtual photon is radiated from the nucleon.

QCD / 25

Meson-proton and proton-proton forward elastic scattering in dispersion relations

Auteur: Evgenij Martynov¹

¹ *Bogolyubov Institute for Theoretical Physics*

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Analysis of the data on forward pp , $\bar{p}p$, $\pi^+\pi^-p$ and K^+K^-p scattering is performed making use of the integral and dispersion relations. Predictions of the considered models for the TOTEM experiment at LHC energies are given.

QCD / 26

Chiral condensate and chemical freeze-out

Auteur: David Blaschke¹

¹ *University of Wrocław*

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We consider a chemical freeze-out mechanism which is based on a strong medium dependence of the rates for inelastic flavor-equilibrating collisions based on the delocalization of hadronic wave functions and growing hadronic radii when approaching the chiral restoration. We investigate the role of mesonic (pion) and baryonic (nucleon) fluctuations for melting the chiral condensate in the phase diagram in the (T, μ) -plane. We apply the PNJL model beyond mean-field and present an effective generalization of the chiral perturbation theory result which accounts for the medium dependence of the pion decay constant while preserving the GMOR relation. We demonstrate within a schematic resonance gas model consisting of a variable number of pionic and nucleonic degrees of freedom that within the above model a quantitative explanation of the hadronic freeze-out curve and its phenomenological conditions can be given.

Heavy-ion collisions / 27

First results from Pb+Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV

Auteur: Johanna Stachel¹

¹ *Heidelberg U.*

Discussion of the first ALICE results from the first lead-lead runs.

Astroparticles / 28

Relativistic shock acceleration simulations and ultra high energy cosmic rays

Auteur: Athina Meli¹

¹ *Universite Liege*

Auteur correspondant ameli@ulg.ac.be

The shock acceleration mechanism is invoked to explain non-thermal cosmic rays in Supernova Remnants, Active Galactic Nuclei and Gamma Ray Bursts jets. Especially, the importance of relativistic shock acceleration and ultra high energy cosmic ray production in extragalactic sources such as Active Galactic Nuclei and Gamma Ray Bursts is a recurring theme, raising a significant interest in the research community.

I will briefly discuss the shock acceleration mechanism, I will address properties of non-relativistic and relativistic shocks and the production of ultra high energy cosmic rays, particularly focusing on extensive relativistic simulation studies.

QCD / 29

A short review of the theory of hard exclusive processes

Auteur: Samuel Wallon¹

¹ *LPT Orsay and UPMC university*

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We review the recent progresses in the theory of hard exclusive processes. The collinear factorization approach is presented and illustrated, including deep virtual Compton scattering, non-exotic and exotic meson electroproduction. We then provide a short survey of kt-factorization in the limit of asymptotical center-of-mass energies. We end-up with recent results obtained on the power corrections to the scattering amplitude.

Neutrino physics / 30

Phenomenological aspects of loop-induced neutrino masses

Auteur: Diego Aristizabal¹

¹ *Université de Liège*

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Models for massive Majorana neutrinos in which lepton number is broken at (or near) the electroweak scale lead to direct testable experimental predictions. This talk concentrates on two classes of generic models: models in which neutrino masses arise via radiative corrections and supersymmetric models with broken R-parity. Special emphasis is put on their phenomenological implications, in particular on those involving collider observables.

In honour of Hans-Jürgen Pirner / 31

The edges of knowledge, an attempt to understand uncertainty and how to handle it

Auteur: Hans-Jürgen Pirner¹

¹ *Institut für Theoretische Physik*

In honour of Joseph Cugnon / 33

A Short Introduction to spallation reactions. Nuclear transport

Auteur: Joseph Cugnon¹

¹ *Université de Liège*

After a short introduction to spallation reaction, arguments will be given to view the latter as a transport process and to advocate the treatment of the latter by simulations tools, in particular the Intranuclear Cascade Model. Conditions of validity and unification of reaction models will be shortly discussed.

Photon physics / 34

The Casimir effect

Auteur: Joseph Cugnon¹

¹ *Université de Liège*

The Casimir effect is usually interpreted as due to the modification of the zero point energy of QED when two perfectly conducting plates are put very close to each other, and as a proof of the “reality” of this zero point energy. The Dark Energy, necessary to explain the acceleration of the expansion of the Universe, is sometimes considered as a manifestation of the same reality despite a huge quantitative mismatch. The usual interpretation of the Casimir effect is however challenged by some authors who rather interpret it as a “giant” van der Waals effect. All these aspects are shortly reviewed.

In honour of Joseph Cugnon / 35

Extension of the Liège intranuclear cascade model at incident energies between 2 and 12 GeV. Aspects of pion production

Auteur: Sophie Pedoux¹

Co-auteur: Joseph Cugnon¹

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The validity of the standard version of the Liège Intra-Nuclear cascade (INCL) model, which has been shown to be quite successful for the description of spallation reactions, is limited to an upper incident energy of more or less 2 GeV, because inelastic elementary processes are restricted to the excitation and de-excitation of the Delta resonance. In this talk, I will present how the INCL model is extended to higher incident energy by including other inelastic elementary collisions.

I will also present predictions of the modified model for production of charged pions by proton and pion beams off nuclei, compared with experimental data of the HARP collaboration for beam energies between 2 and 12 GeV.

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Welcome address

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