



XII Advanced Research Workshop on High Energy Spin Physics

(DSPIN-07)

Abstracts

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**XII Advanced Research Workshop
on High Energy Spin Physics**

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Abstracts

Dubna 2007

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XII Advanced Research Workshop on High Energy Spin Physics

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The collection of abstracts presented to the XII Advanced Research Workshop on High Energy Spin Physics (ARW DSPIN-07), (Dubna, September 3–7, 2007) on different theoretical, experimental and technical aspects of this branch of physics.

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XII Рабочее совещание по физике спина при высоких энергиях

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Сборник аннотаций представленных на Рабочее совещание по физике спина при высоких энергиях (Дубна, 3–7 сентября 2007 г.) посвященное теоретическим, экспериментальным и техническим аспектам этой области физики.

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1 . The origin of single spin effects in collisions of hadrons

Abramov, Victor V.

Institute for High Energy Physics, Protvino, 142281 Russia

Experimental data on transverse single-spin asymmetry, hyperon polarization and vector meson alignment in h+h, h+A and A+A-collisions have been analyzed. The data reveal a scaling behavior, which originates from interactions at constituent level. A new mechanism for the origin of single spin effects is proposed, which takes into account the interaction of massive constituent quarks via their chromomagnetic moment with an effective inhomogeneous chromomagnetic field of gluon strings, produced after initial color exchange. Quark spin precession in the color field is taken into account, which can be the reason of the non-linear single spin effect dependence on Feynman x_F and its energy dependence. The polarization oscillation for anti-hyperons and single spin asymmetry for protons produced in nucleon-nucleon collisions as a function of its momentum is predicted. The quark counting rules for single spin effects in inclusive hadronic reactions are formulated. The model predictions are compared with the experimental data, in particular with the heavy ion collision data. The data are consistent with large anomalous chromomagnetic moment of the constituent quarks which is predicted in the instanton model.

2 . Hyperon and anti-hyperon polarization in heavy ion collisions

Abramov, Victor V.

Institute for High Energy Physics, Protvino, 142281 Russia

Experimental data on hyperon polarization in heavy ion collisions have been analyzed in the framework of the effective color field model. Constituent quarks with large negative anomalous chromomagnetic moment get significant transverse polarization due to Stern-Gerlach type force. Quark spin precession in the effective color field is the reason of polarization oscillation as a function of kinematical variables. The existing data on hyperon and anti-hyperon polarization are in agreement with the effective color field model predictions.

3 . Polarimetry of the proton beams at RHIC

Alekseev, Igor

Institute for Theoretical and Experimental Physics, Moscow, Russia

Spin physics program of RHIC (BNL) requires good knowledge of the beam polarization for the experiments as well as the machine tuning. These data are

provided by a set of two proton-carbon and one proton-hydrogen jet polarimeters. These polarimeters utilize a huge cross section of the small angle elastic scattering which despite of a small analyzing power provides an excellent figure of merit. Small energy dependence of the analyzing power together with energy independent geometry allows the same setup to cover the whole energy range 25-250 GeV.

This talk will cover the polarimeters progress and performance in the last proton run.

4 . Polarization of Lambda and anti-Lambda hyperons in deep-inelastic scattering at COMPASS

*Alexakhin, Vadim (on behalf of the COMPASS Collaboration)
JINR, Dubna, Russia*

The study of the longitudinal polarization of Λ and $\bar{\Lambda}$ hyperons in deep-inelastic scattering (DIS) is important for understanding fundamental properties of the nucleon. Comparing the results for Λ and $\bar{\Lambda}$ in DIS one could test if strange and antistrange quark distributions are equal and, in principle, it would be possible to obtain information about the polarization of the strange quarks in the nucleon.

The longitudinal polarization of Λ and $\bar{\Lambda}$ hyperons produced in deep-inelastic scattering of 160 GeV/c polarized muons on a polarized ${}^6\text{LiD}$ target is studied in the COMPASS (CERN NA58) experiment. Large and comparable statistics on both Λ and $\bar{\Lambda}$ hyperons is a distinct feature of the COMPASS experiment.

Results of the x_{Bj} -, y -, x_F - and z - dependence of the longitudinal polarization of Λ and $\bar{\Lambda}$ hyperons are presented. There is an indication that the $\bar{\Lambda}$ polarization is high at large z and x_F .

5 . Transverse Λ^0 polarization in quasi real photoproduction at high energies: Quark Recombination Model.

*Alikhanov, Ibragim
Saint Petersburg State University, Russia*

Transverse Λ^0 polarization in γp -reaction is approached within the Quark Recombination Model which has reasonably reproduced the polarization in a variety of hadron-hadron reactions. Results are compared with preliminary HERMES data on Λ^0 quasi-real photoproduction.

6 . Positivity domains for pairs or triple of spin observables

Xavier Artru (1), Jean-Marc Richard (2), Jacques Soffer (3)

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(2) Laboratoire de Physique Subatomique et Cosmologie, CNRS-IN2P3 and Grenoble Universités F-38026 Grenoble, France

(3) Department of Physics, Temple University, Philadelphia, PA 19122-6082, USA

Positivity constraints between different single- or multi-spin observables in polarized collisions are found by empirical and/or algebraic methods. A variety of shapes is found for the allowed domains of pairs or triples of spin observables: disks, triangles, balls, tetrahedrons, cones, cylinders, pyramids and more complex shapes.

7 . Classical and non-classical constraints for spin observables

Xavier Artru

Institut de Physique Nucléaire de Lyon, CNRS-IN2P3 and Université Lyon -1, F-69622 Villeurbanne, France

Positivity constraints for spin observables in polarized collisions may be divided in two types : 1) classical ones, which insure the positivity of the cross sections for individually polarized particles; 2) non-classical ones, which insure the positivity of the cross sections for entangled polarizations of the particles. Constraints coming from parity, charge conjugation and time reversal are also divided into classical and non-classical ones.

8 . Polarized electron and positron light-cone distributions in the high-Z hydrogen-like atom

Xavier Artru (1), Karima Benhizia (2)

(1) Institut de Physique Nucléaire de Lyon, CNRS-IN2P3 and Université Lyon-1, F-69622 Villeurbanne, France

(2) Laboratoire de Physique Mathématiques et Physique Subatomique, Université Mentouri, Constantine, Algeria

The electron of a relativistic hydrogen-like atom observed in the infinite momentum frame exhibits the same spin properties as quark-partons in nucleons, in particular: axial and tensor charges sum rules; Soffer inequality; correlation

between spin and transverse momentum (Sivers and Boer-Mulders effects); connection between Sivers effect and the magnetic moment. A positron sea is also found, with substantial polarization.

9 . Observation of tensor polarization of deuteron beam travelling through matter

L.S. Azhgirey, V.P. Ladygin, A.V. Tarasov, L.S. Zolin
JINR, Dubna, Russia

The tensor polarization of deuteron beam arising as deuterons pass through carbon target was measured for the first time in the experiment performed at an extracted unpolarized 5.5 GeV/c deuteron beam of the Nuclotron. The effect observed is compared with calculations made in the framework of the Glauber multiple scattering theory.

10 . $\Delta G/G$ at COMPASS

Y. Bedfer, on behalf of the COMPASS collaboration
DAPNIA/SPhN, Saclay, France

The COMPASS experiment at CERN SPS is studying the spin structure of the nucleon via the scattering of high energy polarized muons off polarized nucleons. Its main goal in this context is the direct measurement of the gluon polarization, $\Delta G/G$, which it performs by the measurement of the double spin asymmetry of the photon-gluon fusion process (*PGF*) $\gamma g \rightarrow q\bar{q}$. Two different channels are investigated for the selection of *PGF*, open charm production and high p_T hadron production.

The results from the 2002-2004 data taking period and the expectations for the 2006 and, on-going, 2007 runs are presented.

11 . HERMES experiment : new and finalized results

Belostotski, Stanislav (for the HERMES Collaboration)
PNPI, Gatchina, Russia

The HERMES experiment at DESY studies the spin structure of hadrons using the 27.6 GeV longitudinally polarized positron beam of the HERA e-p collider and polarized (longitudinally or transversely) or unpolarized gaseous target. Due to reliable particle identification and relatively large acceptance the HERMES spectrometer detects not only inclusive reactions in deep-inelastic scattering but also semi-inclusive events, where hadrons are measured in coincidence with the scattered lepton. Exclusive processes in deep-inelastic lepton scattering are also under study. Most of the data were collected from

the hydrogen and deuterium targets but in order to study nuclear effects the ${}^4\text{He}$, ${}^{14}\text{N}$, ${}^{20}\text{Ne}$ and ${}^{84}\text{Kr}$ targets were also used. In the talk, an overview is given of recently obtained and finalized HERMES results.

12 .The first results on the spin asymmetries in elastic pp scattering at $\sqrt{s} = 200$ GeV and small t at RHIC

*A.A. Bogdanov (on behalf of pp2pp Collaboration)
Moscow Engineering Physics Institute, Russia*

We present the measurements of the single spin analyzing power A_N and the double spin asymmetries A_{NN} and A_{SS} at $\sqrt{s} = 200$ GeV, obtained by the pp2pp Collaboration using polarized proton beams at the Relativistic Heavy Ion Collider (RHIC). Data points were measured in the four momentum transfer t range $0.01 < |t| < 0.03$ (GeV/c)². Our result on A_N , averaged over the whole $|t|$ -interval is about one standard deviation above the calculation, which uses interference between electromagnetic spin-flip amplitude and hadronic non-flip amplitude. The measured double spin asymmetries, which are consistent with zero, allow us to estimate upper limits on the double helicity-flip amplitudes at small $|t|$ as well as on the difference between the total cross sections for collisions of transversely polarized protons and antiprotons.

13 . New results of exclusive ρ^0 and ϕ meson production at HERMES

*Borissov, Alexander (on behave of HERMES Collaboration)
DESY, D-22603 Hamburg , Germany*

The exclusive diffractive production of light vector mesons (ρ^0 and ϕ) on Hydrogen and Deuterium targets is described at HERMES kinematic region of $0.5 < Q^2 < 7 \text{ GeV}^2$ and $3.0 < W < 6.3 \text{ GeV}$. Data for Q^2 and W dependences of total cross sections are presented.

Spin density matrix elements have been determined for exclusive ρ^0 and ϕ production and compared with GPD based calculations. New kinematic dependences of beam polarization dependent and independent SDMEs and on Q^2 and t' are presented. Violation of s -Channel Helicity Conservation (SCHC) is observed on several non-zero values of SDMEs for ρ^0 , but not for ϕ . An indication on contribution of unnatural parity exchange amplitudes of exclusive ρ^0 production is observed on proton data and presented via the relations of several SDMEs as function of Q^2 , t' and x_{Bj} . The longitudinal to transverse electroproduction cross section ratio $R = \sigma_L/\sigma_T$ is compared for ρ^0 and ϕ mesons with world data.

14 . Transverse spin effects in COMPASS

Bressan, Andrea
(University of Trieste, Italy)

In the years 2002-2004 COMPASS has collected data with the ${}^6\text{LiD}$ target polarization oriented transversely with respect to the muon beam direction for about 20% of the running time, to measure transverse spin effects in semi inclusive deep inelastic scattering, one of the main objectives of the COMPASS spin program.

The results for the Collins and the Sivers asymmetries, both for unidentified and identified hadrons, together with the other TMD asymmetries, are presented here. Also two hadron asymmetries for both unidentified and identified hadrons, which allows to access transversity through the interference fragmentation function, are presented.

15 . Recent Results from the RHIC Spin Program

Bunce, Gerry
BNL, Brookhaven, USA

I will discuss new results from the RHIC program, colliding polarized protons to study the spin structure of the proton. In 2006 a long spin run reached high polarization (60% and above), and high luminosity. The run included collisions at $\sqrt{s} = 200$ and 62 GeV, and experiments used longitudinal and transverse spin. I will discuss results from this program, including Phenix, Star, and Brahm, for both longitudinal and transverse spin.

16 . Kerr's Geometry Indicates the Compton Size of Extended Electron

Burinskii, Alexander
Nuclear Safety Institute, RAS

The Kerr geometry is the most adequate metric to take into account gravity in the Dirac theory of electron and QED. The results of estimations are shocking - electron has to be a thin rotating disk of the Compton radius with a closed string on its rim.

We discuss the origin of this discrepancy and put a conjecture leading to compatibility of the Kerr geometry with the Dirac theory and QED.

It is supposed that the Compton size of electron may be observed in the experiments with a low energy scattering of the coherent light on the polarized electrons.

17 . Spin structure of nucleon and anti-hyperon polarization in high energy pp collision with polarized beams

Chen, Ye

Shandong Univesity, China

We study the longitudinal polarization of anti-hyperons in polarized high energy pp collisions at large transverse momenta. Using the Monte-Carlo event generator PYTHIA, we make a detailed analysis of the different contributions to the anti-hyperons in the final states. We calculate the anti-hyperon polarization using the different parameterizations of polarized parton densities and models for polarized fragmentation functions. We found out that the polarization of anti-Lambda and anti-Xi are quite sensitive to the polarization of the anti-strange sea of the nucleon while the polarization of anti-sigma- and anti-sigma+ show sensitivities to the light sea quarks' polarized distribution. Our results show that, by measuring the polarization of those anti-hyperons, we should be able to obtain useful information on the anti-sea polarization of nucleon.

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18 . Gauge-invariance and RG effects in TMD PDF's

Cherednikov, Igor

JINR, Dubna, Russia and and Ruhr-U. Bochum, Germany

A range of issues pertaining to the use of Wilson lines in integrated and transverse-momentum dependent parton distribution functions is discussed. The relation between gauge invariance and the renormalization properties of the Wilson-line integrals is given particular attention. Using anomalous-dimensions sum rules, we show how the gauge link can be self-consistently split to go through light-cone infinity. Anomalous dimension of the TMD PDF is studied in the light-cone gauge, for different pole prescriptions for the gluon propagator.

19 . Electromagnetic wave-particle with spin and magnetic moment

Chernitskii, Alexander A.

University of Engineering and Economic, St. Petersburg, Russia

An axi-symmetric static solution of nonlinear electrodynamics is considered as massive charged particle with spin and magnetic moment [1-3]. A linearization of the nonlinear electrodynamics around the static solution is obtained [4]. The appropriate problem for linear waves around the static solution is investigated. This wave part of a particle solution is considered to provide the appropriate wave properties for the particle.

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20 . Relativistic transformation of proton and muon polarization vectors from decays $\Lambda \rightarrow p + \pi^-$, $\pi \rightarrow \mu + \nu$ and their practical applications

V.A. Chetvertkova¹, S.B. Nurushev²

¹*Physics Department, Moscow State University, Moscow, Russia*

²*Institute for High Energy Physics, Protvino, Russia*

We study the relativistic transformation of the proton and muon polarization vectors from their rest frames to Laboratory system. The Lorenz transformation was applied to proton polarization vector from decays $\Lambda \rightarrow p + \pi^-$, $\pi \rightarrow \mu + \nu$. The first process was used as the source of the polarized proton beam in Fermilab E581/E704 The second process furnished the polarized high energy muon beam for the famous EMC experiment at CERN. Several specific features of relativistic polarization vector are outlined in the domain of high energy polarized beams. The comparisons are made to the known results.

21 . Non-singlets in kaon production in e^+e^- and SIDIS reactions

Christova, Ekaterina

Institute of Nuclear Research and Nuclear Energy, Sofia Bulgaria

In semi-inclusive unpolarized DIS with final charged K^\pm we consider different possibilities to test the conventionally used assumptions $s - \bar{s} = 0$ and $D_d^{K^+-K^-} = 0$. The tests do not require any knowledge of the fragmentation functions. The feasibility to the existing HERMES SIDIS data is considered. We also show that measurements of both charged and neutral kaons would allow the determination of the kaon fragmentation functions without the uncertainties of the strange and gluon parton densities. All analysis are performed in LO and NLO in QCD.

22 . Solid Polarized Targets

Crabb, Donald Graham

University of Virginia, Charlottesville, VA22903, USA

As the technology associated with solid polarized targets matures, the emphasis over the past few years has been on the materials used with various refrigerators in different types of particle beams. The progress in materials used with high power ^4He evaporation refrigerators and those used with low temperature (frozen spin) dilution refrigerators are discussed. Data for different doping techniques with a variety of materials are presented.

23 . GPD studies at COMPASS

d'Hose, Nicole

CEA, Saclay, France

24 . Spin Physics with CLAS

Dodge, Gale

Old Dominion University, Norfolk, USA

The CLAS collaboration at Jefferson Lab is pursuing a broad program of measurements with polarized electrons incident on polarized proton and deuteron targets. Our data include DVCS measurements of the beam and target single spin asymmetries, semi-inclusive deep inelastic scattering and the spin structure function g_1 over a wide kinematical range in momentum transfer Q^2 . These data will be reviewed, with an emphasis on new results. Experiments planned for the proposed 12 GeV upgrade to the CEBAF accelerator will also be discussed.

25 . Production of Polarized Vector Mesons

Dorokhov, Alexander

JINR, Dubna, Russia

Based on the model of instanton vacuum the photon and rho meson light- cone distributions are constructed. We investigate effects of nonperturbative input in electroproduction of longitudinally (L) and transversally (T) polarized vector mesons. Motivated by forthcoming data from the HERMES experiment we predict Q^2 dependence of the L/T- ratios, for ρ^0 mesons produced coherently and incoherently off nuclei.

26 . Recent results from STAR on the source of the spin of the proton

Dunlop, James

BNL, Upton, USA

RHIC is the world's first collider of beams of polarized protons. Such beams open up a window for the investigation of the source of spin in the proton in unprecedented detail. The STAR experiment at RHIC is one of the two main experiments devoted to using these beams. I will review recent progress, from STAR measurements, towards understanding the contributions of the polarization of gluons, and other mechanisms, to the spin of the proton.

27 . Model-independent QCD description of the spin structure function g_1 at arbitrary x and arbitrary Q^2

Ermolaev, Boris

Ioffe Physical-Technical Institute, St.Petersburg, Russia

The standard description of g_1 exploits the DGLAP evolution equations and therefore describes g_1 at large x and large Q^2 only. Extrapolating DGLAP into the small- x region is done through introducing singular fits for the initial parton densities. which has absolutely no theoretical grounds. Extrapolating DGLAP into the small Q^2 region in a model-independent way is impossible. A much more natural way is the total resummation of the leading logarithms of x . This approach simplifies the fits and extrapolating it into the small Q^2 can be done in the model-independent way.

28 . The possibility to accelerate polarized $p, d, t, {}^3\text{He}$ beams at the JINR Nuclotron

Filatov, Yury
JINR, Dubna, Russia

The calculations of power of spin resonances in the linear approximation for p, d, t and ${}^3\text{He}$ beams in the JINR Nuclotron are presented. The methods to preserve the degree of polarization during the crossing spin resonances are examined. The method of matching the direction of polarization vector during the beam injection in to the ring of Nuclotron is given. These methods of spin resonance crossing can be used to accelerate polarized beams in the other cyclic accelerators.

29 . Forward Dispersion Relations for Compton Scattering and FESR for Nucleons and Light Nuclei: New Results

Gerasimov, Sergo
Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna, Russia

The new testable finite energy sum rules for relevant combinations of the forward Compton scattering amplitudes on nucleons and light nuclei are presented and used to discuss the quantitative role of possible constant terms in the real part of the high-energy photon-nucleon and photon-nucleus amplitudes, representing the contribution of the non-Regge (the fixed $j = 0$ -pole) singularities. The importance of more detailed and precise data on the pion photo production off the neutron and the necessity of the extension of measurements of the total photonuclear absorption cross sections up to photon energy range about 2 GeV is stressed as the prerequisite for an analysis of newly derived integral sum rules for the nucleon and lightest nuclei total photoabsorption cross sections which could be sensitive to presently poorly known in-medium effects on the pionic part of the " σ -terms" inside nuclei and the values of the $j = 0$ fixed-pole residues in the real part of respective Compton scattering amplitudes.

30 . Charge asymmetry of leptons in $\gamma\gamma \rightarrow \ell^+\ell^- + \nu's$ in collision of polarized photons

Ginzburg, Ilya
Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia

Parity non-conservation in weak interaction transform initial photon polarization in Photon colliders into charge asymmetry of leptons in $\gamma\gamma \rightarrow \ell^+\ell^- + \nu's$

in collision of polarized photons. This asymmetry can be used for discovery of New Physics effects.

31 . Electroproduction of light vector mesons.

Goloskokov, Sergey
JINR, Dubna, Russia

We analyze ρ and ϕ mesons electroproduction at large photon virtualities within the handbag approach. A model for the generalized parton distributions (GPDs) for gluon and quarks is used. Our results are in fair agreement with HERA and HERMES data.

32 . Measurement of Collins Asymmetries in e^+e^- Annihilation at the KEK B-Factory

Grosse Perdekamp, Matthias
University of Illinois, Urbana, USA

We present the first measurement of azimuthal Collins asymmetries for back-to-back hadron pairs in electron-positron annihilation at the KEK-B-factory using the Belle detector. The analysis is based on a data sample of $1.5 \cdot 10^9$ hadronic events. We will briefly discuss our plans to use this large data sample to study further spin effects in quark fragmentation; examples include di-hadron interference fragmentation and lambda fragmentation.

33 . PANDA at FAIR – Using anti-protons to study QCD

Hoek, Matthias
University of Glasgow, UK

The upcoming PANDA experiment located at the future FAIR facility at GSI will utilise an anti-proton beam to study QCD with unprecedented precision. The physics program ranges from high-precision Charmonium spectroscopy and the search for exotic hybrids and glueballs, to the study of nucleon structure via Drell-Yan processes and hard exclusive reactions with electromagnetic final states. Drell-Yan processes in proton-antiproton annihilation allow to study parton distributions complementary to DIS. No unknown quantities like fragmentation functions, as needed in SIDIS measurements, are necessary to extract these functions. Hard exclusive reactions are a tool to access Generalized Parton Distributions. The theoretical framework of GPDs has been developed in recent years and yields a more complete picture of the nucleon structure in terms of QCD. It also gives a possibility to access the orbital angular momentum of partons inside a nucleon.

34 . Asymmetry in heating of charged leptons and antileptons by neutrinos in a strongly magnetized thermal plasma

V.A. Huseynov, R. Gasimova and B.T. Hajiyeva
Nakhchivan State University, Azerbaijan

We have investigated asymmetry in heating of charged leptons and antileptons by neutrinos in a strongly magnetized thermal plasma. It is shown that asymmetry in heating is sensitive to neutrino flavor and spin variables of initial charged leptons and antileptons. Asymmetry in heating is determined with the fundamental parameters that contain the Weinberg angle. The obtained result can be generalized for asymmetry in heating of a matter and an antimatter by neutrinos in a strongly magnetized thermal plasma.

35 . Spin polarization phenomena in dense nuclear matter

Isayev, Alexander
Kharkov Institute of Physics and Technology, Ukraine

Spin polarized states in nuclear matter with effective nuclear forces are studied for a wide range of isospin asymmetries and densities. Based on a Fermi liquid theory, it is shown that there are a few possible scenarios of spin ordered phase transitions: (a) nuclear matter undergoes at some critical density a phase transition to a spin polarized state with the oppositely directed spins of neutrons and protons [1,2] (SLy4, SLy5 Skyrme and D1S Gogny interactions); (b) at some critical density, a spin polarized state with the like-directed neutron and proton spins appears [1] (SkI5 Skyrme interaction); (c) nuclear matter under increasing density, at first, undergoes a phase transition to the state with the opposite directions of neutron and proton spins, which goes over at larger density to the state with the same direction of nucleon spins [1] (SkI3 Skyrme interaction). These results clearly indicate the necessity to construct a new generation of the energy functionals with the properly constrained time-odd part.

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36 . Dispersion representations for hard exclusive processes

Ivanov, Dmitry

Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia

Several hard exclusive scattering processes admit a representation in terms of generalized parton distributions and perturbative hard-scattering kernels. Both the physical amplitude and the kernel fulfill dispersion relations. We give a detailed investigation of their consistency at all orders in perturbation theory. The results shed light on the information about generalized parton distributions that can be extracted from the real and imaginary parts of exclusive amplitudes. They also provide a practical consistency check for models of these distributions where Lorentz invariance is not exactly satisfied.

37 . ρ -3 production in diffractive DIS

Ivanov, Igor

Universite de Liege, Belgium

We review the unusual properties of diffractive production of spin-excited states in DIS and discuss how one can study them experimentally.

38 . Research on Drell-Yan and J/Psi physics at J-PARC and COMPASS

Ivanov Oleg, Shevchenko Oleg

JINR, Dubna, Russia

39 . Vector meson electroproduction and DVCS with spin

Jenkovszky, Laszlo

Bogolubov Institute for Theoretical Physics, Academy of Sciences of Ukraine

A dynamical model for vector meson electroproduction and deeply virtual Compton scattering developed earlier for high-energy reactions (at HERA) is further elaborated to include spin and polarization with the HERMES and JLab data in mind.

40 . Polarized structure function and flavor symmetry breaking of polarized nucleon sea

Ali N. Khorramian and S. Atashbar

Semnan University and Institute for Studies in Theoretical, Physics and Mathematics, Tehran, Iran.

Next-to-leading order approximation of the quark helicity distributions are used in the frame work of polarized valon model. The flavor-asymmetry in the light-quark sea of the nucleon can be obtained from the contributions of unbroken sea quark distributions. We employ the polarized valon model and extract the flavor-broken light sea distributions which are modeled with the help of a Pauli-blocking ansatz. Using this ansatz, we can obtain broken polarized valon distributions. From there and by employing convolution integral, broken sea quark distributions are obtainable in this frame work. Our results for δu , δd , $\delta \bar{u}$, $\delta \bar{d}$ and $\delta \bar{s}$ are in good agreement with recent experimental data for polarized parton distribution from HERMES experimental group and also with GRSV model.

41 . Vector and tensor analyzing powers in $^{12}\text{C}(d, p)^{13}\text{C}$ reaction at energy $T_d = 270 \text{ MeV}$

Kiselev, Anton

JINR, LHE, Dubna, Russia

The (d, p) stripping reaction has proved a useful tool for probing single particle aspects of nuclear structure. With the advent of beams of exotic nuclei there has been renewed interest in charged particle spectroscopy and (d, p) stripping in particular as a means of investigating the structure of neutron-rich nuclei via reactions in inverse kinematics. The $^{12}\text{C}(d, p)^{13}\text{C}$ and $d(d, p)X$ reactions has been studied at 140, 200 and 270 MeV deuteron polarized beams. The experiment was performed at RIKEN Accelerator Research Facility (RARF), Japan. In this work we present the experimental results on vector and tensor analyzing powers at energy $T_d = 270 \text{ MeV}$ for $^{12}\text{C}(d, p)^{13}\text{C}$ reaction with excitation of levels of a nucleus ^{12}C . The results on analyzing powers at energy $T_d=140, 200$ and 270 MeV for $^{12}\text{C}(d, p)^{13}\text{C}$ and $d(d, p)^3\text{H}$ reactions at emission angle $\Theta_{cm} = 0$ are presented. The $d(d, p)X$ data near breakup threshold are also obtained. The experimental data for these reactions are sensitive to the spin structure of the deuteron.

42 . New nonlinear magnetic phenomena in highly Polarized Target Materials

*Kiselev, Yury (on behalf of the COMPASS collaboration)
CERN, Geneve, Switzerland*

This report introduces and surveys nonlinear magnetic phenomena which have been observed at record nuclear polarizations in the COMPASS experiment at CERN. Some of them, namely the frequency modulation effect and distortions of the NMR line shape, promote the development of the polarized target technique. Another one, as the superradiation can be used for the development of quantum statistical physics in the negative temperature region. The new experiments detected an electromagnetic noise radiated by negatively polarized nuclei during their relaxation at low magnetic field. As a result the relaxation time depends on the value of the polarization and spectral resolved spin radiation was observed.

43 . Breakdown of chiral expansion for parton distributions

*Kivel, Nikolai
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The generalized parton distributions (GPDs) carry important information about the structure of the proton, in particular, about its spin. At present one usually constructs some reasonable models for these nonperturbative functions and compares the theoretical predictions with the existing experimental data. Moreover, in order to extract the value of the angular momentum J from Ji's sum rule one has to approximate the GPDs to the non-physical values of the momentum transfer $t = 0$.

Can we apply the approach χ PT in order to get some additional information about GPDs, to study the small- t behavior or behavior in quark mass which important for the lattice calculations? Recently these issues has been addressed in many papers.

In our presentation we study the structure of the χ PT expansion in the region of the small momentum fractions x . For simplicity we consider only the pion parton distributions (PDFs). We computed two- and three-loop corrections to the PDFs which posses δ -function singularities at $x_{Bj} \rightarrow 0$. This calculation explicitly demonstrates that in the region of small $x_{Bj} \sim m_\pi^2$ standard χ PT breaks down and one needs re-summation of all orders of χ PT. We demonstrate that the same conclusion is valid also for the chiral expansions of the GPDs.

44 . ΔG from high p_T events at COMPASS

Klimaszewski, Konrad

Soltan Institute for Nuclear Studies, Warsaw, Poland

The one of the main goals of Compass experiment is a precise determination of $\Delta G/G$. Which will lead to better understanding of the nucleon spin structure. Polarization of the gluons in the nucleon is measured by tagging photon-gluon fusion (PGF) process in scattering of polarized muons of polarized deuteron target. One of the methods used to tag PGF events is a selection of the pair of high p_T hadrons in the final state. Two independent analysis were performed in Compass. One in the DIS regime ($Q^2 > 1(\text{GeV}/c)^2$) and the other in quasi-real photoproduction ($Q^2 < 1(\text{GeV}/c)^2$) kinematical range. The high p_T quasi-real photoproduction channel yields the most precise measurement up to date.

45 . Polarization effects in $e^+e^- \rightarrow t\bar{t}$ at $O(\alpha_s)$ up to a given gluon energy cut

Körner, Jürgen

University of Mainz, Germany

We determine the $O(\alpha_s)$ radiative corrections to polarized top quark pair production in e^+e^- annihilations with a specified gluon energy cut. We write down fully analytical results for the unpolarized and polarized $O(\alpha_s)$ cross sections $e^+e^- \rightarrow t\bar{t}(G)$ and $e^+e^- \rightarrow t\bar{t}^\dagger(G)$ including their polar orientation dependence relative to the beam direction. In the soft gluon limit we recover the usual factorizing form known from the soft gluon approximation. In the limit when the gluon energy cut takes its maximum value we recover the totally inclusive unpolarized and polarized cross sections calculated previously. We provide some numerical results on the cut-off dependence of the various polarized and unpolarized cross sections and discuss how the exact results numerically differ from the approximate soft-gluon results.

46 . Transverse Spin Physics at HERMES

Korotkov, Vladislav

Institute for High Energy Physics, Russia

A review of the results obtained by the HERMES Collaboration with a transversely polarized hydrogen target will be given.

47 . Heavy-quark contributions to structure function g_1

Kotikov, Anatoly
JINR, Dubna, Russia

The heavy-quark contributions have been considered for structure function g_1 .

48 . Spin and TMD azimuthal asymmetries in SIDIS

Kotzinian, Aram
JINR, Dubna, Russia and University of Turin, Italy

The following subject will be covered:

- 1) Model estimations for all 8 transverse spin dependent azimuthal asymmetries in SIDIS,
- 2) P_T and azimuthal dependence of A_{LL} ,
- 3) Azimuthal effects in the target fragmentation region.

49 . Deeply Virtual Compton Scattering and Meson Production at Jlab

Kubarovsky, Valery
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Deeply virtual Compton scattering and meson electroproduction offer a unique opportunity to study the structure of the nucleon as one varies both the size of the probe - the photon virtuality, Q^2 - and the momentum transfer to the nucleon, t . Such processes can reveal much more information about the reaction dynamics and the structure of the target than either inclusive electroproduction (Q^2 only) or elastic form factors ($t = -Q^2$). The recent CLAS data will be presented for DVCS and DVMP (π^0 and η), including cross section measurements, their ratios, and beam spin asymmetries.

50 . The angular distributions of the vector and tensor analyzing powers in the $dd \rightarrow {}^3H p$ reaction at 200 MeV

Kurilkin, Aleksey
JINR LHE, Dubna, Russia

The behavior of the vector A_y and tensor A_{yy} , A_{xx} , A_{xz} analyzing powers in the $dd \rightarrow {}^3H p$ reactions at 200 MeV has been investigated. The data on polarization observables in the angular range of 1 - 95 degrees in the c.m.s have been obtained. These polarization observables are sensitive to the momentum distribution of the proton spin in 3H at the small internucleonic distances in the framework of one-nucleon exchange approximation. The experimental data are compared with theoretical calculations in the framework ONE with the use of Urbana, Paris and RSC wave functions of three-nucleon bound state.

51 . Angular distribution of vector and tensor analyzing powers in dp elastic scattering at energy 880 MeV

Kurilkin, Pavel

JINR LHE, Dubna, Russia

The behavior of the vector A_y and tensor A_{yy} , A_{xx} , A_{xz} analyzing powers in the $dd \rightarrow {}^3H p$ reactions at 200 MeV has been investigated. The data on polarization observables in the angular range of 1 - 95 degrees in the c.m.s have been obtained. These polarization observables are sensitive to the momentum distribution of the proton spin in 3H at the small internucleonic distances in the framework of one-nucleon exchange approximation. The experimental data are compared with theoretical calculations in the framework ONE with the use of Urbana, Paris and RSC wave functions of three-nucleon bound state.

52 . Polarization phenomena in elastic backward P-D scattering

A.P.Ierusalimov , G.I.Lykasov,

JINR, Dubna, Russia

M. Viviani

Dipartimento di Fisica "E.Fermi", Università di Pisa, and INFN, Italy

The elastic backward proton-deuteron scattering is analyzed including both the relativistic effects in the deuteron and the reaction mechanism. The role of the mechanism due to rescattering and absorption of the virtual π -meson by a deuteron nucleon is analyzed. It is shown that this effect contributes significantly to differential cross section, as well as the deuteron tensor analyzing power T_{20} and the transfer polarization κ_0 at the initial energies about 1 GeV. Mainly it is due to a possible creation and decay of the Δ -isobar and other nucleon resonances during the reaction. A strong sensitivity of all the considered observables to deuteron structure and reaction mechanism is shown. The inclusion of these effects allows us to describe the existing experimental data on the elastic backward $p - d$ scattering rather satisfactory. The contribution of the P -wave components of the relativistic deuteron wave function to T_{20} and κ_0 is also discussed.

53 . Spin physics at Nuclotron-M

Ladygin, Vladimir

JINR LHE, Dubna, Russia

The review of the current status of the polarization experiments at Nuclotron will be reported. New high intensity polarized deuterons ion source as well as update of Nuclotron will extend significantly the spin program at LHE.

54 . Spin structure of the "forward" charge-exchange reaction $n + p \rightarrow p + n$ and the deuteron charge-exchange breakup $d + p \rightarrow (pp) + n$

Lyuboshitz, Vladimir L. and Lyuboshitz, Valery V.

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The structure of the nucleon charge-exchange process $n + p \rightarrow p + n$ is investigated basing on the isotopic invariance of the nucleon-nucleon scattering. Using the operator of permutation of the spin projections of the neutron and proton, the connection between the spin matrices, describing the amplitude of the nucleon charge-exchange process at zero angle and the amplitude of the elastic scattering of the neutron on the proton in the "backward" direction, has been obtained. Due to the optical theorem, the spin-independent part of the differential cross-section of the process $n + p \rightarrow p + n$ at zero angle for unpolarized particles is expressed through the difference of total cross-sections of unpolarized proton-proton and neutron-proton scattering. Meantime, the spin-dependent part of this cross-section is proportional to the differential cross-section of the deuteron charge-exchange breakup $d + p \rightarrow (pp) + n$ at zero angle at the deuteron momentum $\mathbf{k}_d = 2\mathbf{k}_n$ (\mathbf{k}_n is the initial neutron momentum). Analysis shows that, in the wide range of neutron laboratory momenta $k_n > 700 \text{ MeV}/c$, the main contribution into the differential cross-section of the process $n + p \rightarrow p + n$ at zero angle is provided namely by the spin-dependent term.

55 . Relations between GPDs and TMDs: model results and beyond

Meissner, Stephan

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Comparing the respective structures of the correlators defining generalized and transverse momentum dependent parton distributions, one finds possible relations between these two distinct objects. Although it looks like the relations found do not hold in general, we show that they can be established at least in simple spectator model calculations. In addition, we also present the explicit form of these relations for quarks as well as for gluons and discuss their physical meaning.

56 . Nuclear medium effect on pp scattering at 1 GeV

Miklukho, Oleg

Petersburg Nuclear Physics Institute RAS, Gatchina, Russia

Polarization of secondary protons from the $(p, 2p)$ reaction on S-shell protons of several nuclear targets at 1 GeV is studied. The secondary protons are detected in coincidence with the help of a two-arm magnetic spectrometer at non-symmetric kinematics under condition that the residual nucleus momentum is close to zero. The polarizations are measured with proportional chamber polarimeters installed in the two spectrometer arms.

A reduction of the measured polarizations in scattering off the S-shell protons of nuclei ${}^6\text{Li}$ (1S), ${}^{12}\text{C}$ (1S), ${}^{40}\text{Ca}$ (2S) in comparison with that in the free elastic proton-proton scattering has been observed. This reduction cannot be explained by conventional rescattering and absorption in the nuclear matter. The value of the polarization reduction correlates strongly with the effective mean nuclear density. One may assume that such correlation indicates a modification of the proton-proton scattering matrix in nuclear medium. A similar experiment with a liquid helium (${}^4\text{He}$) target shows another trend. Mentioned above deviation from the free pp -scattering is found to be a monotonous function of the S-shell proton binding energy E_s for all the investigated nuclei.

57 . The Ratio R_{dp} of the Quasi-elastic $nd \rightarrow (nn)p$ to the Elastic $np \rightarrow np$ Charge-exchange Differential Cross Sections Over the 1.0 - 1.2 GeV Neutron Beam Energy

Morozov, Alexey

Joint Institute for Nuclear Research, Dubna, Russia

New experimental results on the ratio R_{dp} of the charge-exchange quasi-elastic scattering yield at 0° for the $nd \rightarrow (nn) + p$ reaction to the elastic $np \rightarrow np$ scattering yield are presented. These two charge -exchange angular dependences measured in a vicinity of the incident neutron direction, corrected for well known instrumental effects and extrapolated towards 0° are proportional to the differential cross sections of the two relevant reactions. The measurements were carried out at the Nuclotron of the Veksler and Baldin Laboratory of High Energies of the Joint Institute for Nuclear Research (JINR) at the neutron beam kinetic energies of 0.8, 1.0, 1.2, 1.4, 1.8 and 2.0 GeV. The intense quasi-monochromatic neutron beam was produced by break-up of accelerated deuterons extracted to the experimental area. The data were accumulated using the "Delta-Sigma" set-up magnetic spectrometer with two sets of multi-wire proportional chambers, located upstream and downstream of the analyzing

magnet. Inelastic processes were considerably reduced by detectors surrounding either of the hydrogen or deuterium targets. The time-of-flight system was used for detected particle identification. The data treatment and analysis of possible systematic errors are discussed. The obtained R_{dp} values remain nearly constant with energy. The new data are compared with existing ones, measured only at energies below 1 GeV.

58 . Towards a fitting procedure for deeply virtual Compton scattering

Müller, Dieter

Ruhr-University Bochum, Germany

Combining dispersion and operator product expansion techniques, we derive the conformal partial wave decomposition of the virtual Compton scattering amplitude in terms of complex conformal spin to twist-two accuracy. The perturbation theory predictions for the deeply virtual Compton scattering (DVCS) amplitude are presented in next-to-leading order for both conformal and modified minimal subtraction scheme. Within a conformal subtraction scheme, where we exploit predictive power of conformal symmetry, the radiative corrections are presented up to next-to-next-to-leading order accuracy. Here, because of the trace anomaly, the mixing of conformal moments of generalized parton distributions (GPD) at the three-loop level remains unknown. Within a new proposed parameterization for GPDs, we then study the convergence of perturbation theory and demonstrate that our formalism is suitable for a fitting procedure of DVCS observables.

59 . Spin effects predicted by the strongly correlated quark model

Musulmanbekov Genis

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In the framework of the Strongly Correlated Quark Model, elaborated by the author, the significant spin effects are predicted for transversely and longitudinally polarized (anti)proton - proton, proton - triton and proton - helium-3 beams. The possible enhancement of the fusion reactions in a Tokomaks with polarized deuteron-deuteron, deuteron - tritium, deuteron - helium is foreseen.

60 . Longitudinal Polarization of Lambda and anti-Lambda Hyperons in Lepton-Nucleon Deep-Inelastic Scattering

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We consider models for the spin transfer to Lambda and anti-Lambda hyperons produced in lepton-nucleon deep-inelastic scattering. We make predictions for longitudinal Lambda and anti-Lambda spin transfer for the COMPASS experiment and for HERA, and for the spin transfer to Lambda hyperons produced at JLAB. We show that a measurement of Lambda polarization in the COMPASS experiment in a region of x that has not previously been explored will sharpen the free parameters of our model, while a measurement of anti-Lambda polarization will provide a new and clean tool to distinguish between SU(6) and Burkardt-Jaffe (BJ) models for the nucleon spin decomposition, as well as to probe the strange parton distributions in the nucleon. These may also be distinguished very cleanly by accurate measurements of Lambda and anti-Lambda spin transfers in experiments at HERA, which have an unprecedented potential to separate hyperons produced in the fragmentation of the struck (anti-)quark and the remnant nucleon. Finally, we show that the spin transfer to Lambda hyperons measured in a JLAB experiment would be dominated by the spin transfer of the intrinsic polarized strangeness in the remnant nucleon, providing an independent way to check our model predictions.

61 . Foldy-Wouthuysen Approach to the Standard Model Construction Without Yukawa Couplings

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An expression for general Foldy-Wouthuysen transformation is obtained using chiral representation of Dirac matrix and in the presence of boson fields, interacting with fermion fields. The possibility to formulate the Standard model with massive fermions is shown using the modified Foldy-Wouthuysen representation without introduction of Yukawa couplings of Higgs bosons with fermions. At that, the theory remains invariant with respect to the transformation $SU(3) \times SU(2) \times U(1)$ and preserves all other theoretical and experimental consequences. With such approach Higgs bosons are responsible for only the gauge invariance of the theory boson sector and interact with gauge bosons, gluons and photons, only.

62 . Spin filtering in storage rings: new developments

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A status report on the theoretical aspects of spin filtering in storage rings will be presented.

63 . Two - photon exchange and elastic scattering of electrons/positrons on the proton

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Rachek^b, R.Sh.Sadykov^b, Yu.V. Shestakov^b, V.N. Stibunov^c, D.K. Toporkov^b,
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The electromagnetic form factors of the proton are under the study long enough time. However recent measurements of form factors ratio G_E^P/G_M^P , performed in TJNAF by polarization transfer method, have delivered unexpected results, which are contradictory with measurements by traditional Rosenbluth method.

A number of authors suggest that the possible origin of this discrepancy is the failure of the one-photon approximation to adequately describe the results of high-precision unpolarized experiments. Other authors suggest to explain this discrepancy by systematic effects due to the large radiative corrections. Therefore a precise measurement of the two-photon exchange contribution is important.

64 . The comparative study of the inclusive π^0 analyzing power in reactions $pp(\uparrow) \rightarrow \pi^0 X$ and $\pi^-p(\uparrow) \rightarrow \pi^0 X$ at 50 GeV and 40 GeV respectively

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The measured analyzing powers in reactions $pp(\uparrow) \rightarrow \pi^0 X$ and $\pi^-p(\uparrow) \rightarrow \pi^0 X$ at 50 GeV and 40 GeV respectively behave in drastically different ways in function of transverse momentum in the central region. At the same time in the polarized proton fragmentation region the analyzing powers of these reactions are practically coinciding. Our data are compared with the known experimental data at various energies.

65 . Polarization buildup by spin filtering in storage rings

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There has been much recent research into polarizing an antiproton beam, instigated by the recent proposal of the PAX project at GSI Darmstadt. They plan to polarize an antiproton beam by repeated interaction with a hydrogen target in a storage ring. This method of polarization by spin filtering requires many of the beam particles to remain within the ring after interaction with the target, so small scattering angles are important. We present and solve sets of differential equations which describe the buildup of polarization by spin filtering in many different scenarios of interest. These scenarios are: 1) spin filtering of a stored beam, 2) spin filtering while the beam is being accumulated i.e. unpolarized particles are continuously being fed into the beam, 3) the input rate is equal to the rate at which particles are being lost due to scattering beyond ring acceptance angle, the beam intensity remaining constant, 4) increasing the initial polarization of a stored beam by spin filtering, 5) the input of particles into the beam is stopped after a certain amount of time, but spin filtering continues. Finally some numerical estimates are made comparing these scenarios, with emphasis on the PAX project.

66 . Elastic proton-proton and proton-antiproton scattering: analysis of complete set of helicity amplitudes

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The differential cross-section and several polarization parameters are calculated for proton-proton and proton-antiproton elastic scattering using the phenomenological model based on the crossing symmetry and derivative relations. The calculations are made at several c.m. energies. We confront our model predictions with available experimental data in wide range of initial energy and momentum transfer. The suggested method of reconstruction of a complete set of helicity amplitudes may be useful for PAX Program (GSI) as well as for high-energy experiments at RHIC and LHC.

67 . Contact Interaction Searches at e^+e^- International Linear Collider: Role of Polarization

Pankov, Alexander

Gomel Technical University, Belarussia

We explore the potential of e^+e^- International Linear Collider (ILC) to study four-fermion contact interactions in fermion pair production. We stress the role played by the initial state polarization to increase the reach of this machine to discover of the new phenomena. Discovery limits are discussed in a model-independent way.

68 . Double diffractive production of mesons and spin effects polarization

Pasechnik, Roman

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We calculate several differential distributions for exclusive double diffractive heavy scalar and vector charmonia χ_c production in proton-antiproton collisions at the Tevatron and in proton-proton collisions at the LHC in terms of unintegrated gluon distributions (UGDFs) within the k_t -factorisation approach. The matrix element is calculated as a function of gluon virtualities applying the standard pNRQCD technique. Different models of UGDFs are used and the results are shown and discussed.

69 . Dependence of longitudinal polarization of Λ and $\bar{\Lambda}$ in DIS on the target polarization

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One of the goals of the COMPASS experiment at CERN is the investigation of the quark contributions to the nucleon spin. The study of the longitudinal polarization of Λ -hyperons may provide important information on the polarized strange quark distribution functions (Δs , $\Delta \bar{s}$). The longitudinal polarization of Λ and $\bar{\Lambda}$ hyperons produced in deep-inelastic scattering of 160 GeV/c polarized positive muons off a polarized ${}^6\text{LiD}$ target is studied in the COMPASS (CERN NA58) experiment. The data analysis was done in the kinematic region of DIS ($Q^2 > 1 (\text{GeV}/c)^2$). Preliminary results on the dependence of longitudinal polarization of Λ and $\bar{\Lambda}$ on the target polarization from data collected during the 2003-2004 runs are presented.

70 . Spin manifestation in channeling of relativistic leptons and heavy ions

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The phenomenon of spin deflection of relativistic particles during channeling through a bent crystal has been well investigated during last decades, although mainly theoretically.

Here, we discuss some new features of spin manifestation in channeling of relativistic particles, i.e. electrons and positrons, bare nuclei and hydrogen-like heavy ions, through straight crystals.

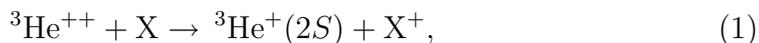
In a case of relativistic electrons and positrons, the spin interaction with continuous crystal potential splits and shifts the transverse energy levels and may result in a fine structure of e.g. channeling radiation.

In a case of coherent excitation of relativistic heavy ions by periodic electric crystal field, spin-orbit coupling of electron spin in an ion, and interaction with continuous potential of crystal planes changes drastically the structure of the resonance, as in a case of recent experiments at HIMAC (Tokyo) and planned experiments at GSI.

71 . Lamb Shift Polarimeter for a Helium-3 Ion Beam

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The principle of the polarimeter is based on the Lamb shift energy difference and the dependence between the nuclear spin polarization of ${}^3\text{He}^{++}$ and the populations of the hyperfine levels of the $2S_{1/2}$ metastable state of the ${}^3\text{He}^+$ ions which are produced in the process



As X it is possible to use different gases. This method is similar to the one developed earlier for protons and deuterons. There is a difference: instead of atoms we have charged ions, so at low ion energies it may be difficult to apply a transverse electric field for quenching the ions in the metastable states. It is proposed for this aim to use a longitudinal electric field (mixing with $\Delta m_J = 0$).

The relative populations of the four $2S_{1/2}$ hyperfine levels $N(F, m_F)$ of ${}^3\text{He}^+$ ions produced in the process (1) are as follows:

$$N(0, 0) = (1 - P_z \frac{x}{\sqrt{1+x^2}})/4, \quad N(1, 1) = (1 + P_z)/4, \quad (2)$$

$$N(1, 0) = (1 + P_z \frac{x}{\sqrt{1+x^2}})/4, \quad N(1, -1) = (1 - P_z)/4, \quad (3)$$

where $x = B/B_c \ll 1$, B is the field in the gas cell, $B_c = 387$ G for $2S_{1/2}$ state of ${}^3\text{He}^+$ ions, P_z is the projection of nuclear polarization on the direction of the magnetic field in the polarimeter.

In the absence of any fields, the lifetime of the metastable state is $\tau_{2S} = 2 \times 10^{-3}$ s. If an electric field is parallel to a magnetic field, the allowed mixing of the sub-levels are those with $\Delta m_J = 0$, that is, $(\alpha - f)$ and $(\beta - e)$ in terms of $\alpha - 2S_{1/2}(m_J = +1/2)$, $\beta - 2S_{1/2}(m_J = -1/2)$, $e - 2P_{1/2}(m_J = +1/2)$, $f - 2P_{1/2}(m_J = -1/2)$. The lifetimes of the perturbed states are:

$$\tau_{2S} = \tau_{2P}[\nu^2 + (4\pi\tau_{2P})^{-2}]h/|V|^2, \quad (4)$$

where $\tau_{2P} = 10^{-10}$ s, $h\nu$ is the energy difference between the levels involved in the transitions, and V is the electric dipole matrix element.

Let a beam of metastable helium ions pass through a magnetic field corresponding the level crossing and in a rather weak electric field, so chosen that only small quantity of the ions in the α state decays, while practically all the ions in the β state are quenched to the ground state. The population of the α state is the function of the nuclear polarization of the primary helium ions:

$$N(\alpha) = N(0, 0) + N(1, 1) = (1/2)[1 + P_z(1 - x/\sqrt{1+x^2})/2]. \quad (5)$$

We can measure the quantity of ions in the α state by quenching them in the region of a strong electric field and detecting 41 eV photons. So, if we measure the count of 41 eV photons (normalized to intensity) for the case of zero polarization (I_0) and for a polarized beam (I_+), then the polarization equals

$$P_z = \frac{2}{1 - x/\sqrt{1+x^2}} \left(\frac{I_+}{I_0} - 1 \right). \quad (6)$$

72 . Transversity and Collins functions from SIDIS and e^+e^- data

Prokudin, Alexei

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A global analysis of the experimental data on azimuthal asymmetries in semi-inclusive deep inelastic scattering (SIDIS), from the HERMES and COMPASS Collaborations, and in $e^+e^- \rightarrow h_1 h_2 X$ processes, from the BELLE Collaboration, is performed. It results in the extraction of the Collins fragmentation function and, for the first time, of the transversity distribution function for u and d quarks. These turn out to have opposite signs and to be sizably smaller than their positivity bounds. Predictions for the azimuthal asymmetry $A_{UT}^{\sin(\phi_h + \phi_S)}$, as will soon be measured at JLab and COMPASS operating on a transversely polarized proton target, are then presented.

73 . Dominant contributions in pion-production single-spin asymmetries

Ramilli, Marco

University of Insubria, Como, Italy

Working with a completely collinear twist-3 factorized cross-section formula, we identify two largely dominant partonic sub-processes contributing to the single-spin asymmetries in pion production, in the large p_T and medium-large x_F region.

74 . Spin-Orbit Dynamics from the Gluon Asymmetry

Ramsey, Gordon P

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Determination of the orbital angular momentum of the proton is a difficult but important part of understanding fundamental structure. Insight can be gained from suitable models of the gluon asymmetry applied to the $J_z = 1/2$ sum rule. We have constrained the models of the asymmetry to gain possible scenarios for the angular momentum of the proton's constituents. Results and phenomenology for determining L_z will be presented.

75 . The Analysis of Elastic $p\bar{p}$ Scattering in the Forward Direction for PAX Experiment Energy Range

S.B. Nurushev and M.F. Runtso

Moscow Engineering Physics Institute (State University), Russia

Comparison is made between theoretical predictions and experimental data for antiproton-proton elastic scattering in the forward direction for future PAX experiment energy range (3 - 10) GeV. Some discrepancy is discussed.

76 . COMPASS results on inclusive and semi-inclusive polarized DIS

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Portugal*

The COMPASS experiment at the CERN SPS has an extensive experimental program focused on the nucleon structure and on hadron spectroscopy. A main topic of investigation is the spin structure of the nucleon via deep-inelastic scattering of 160 GeV polarized muons on polarized nucleon targets. Results obtained in the kinematic ranges $Q^2 < 1$ (GeV/c)² and $0.0005 < x < 0.02$,

as well as $1 < Q^2 < 100 \text{ GeV}^2$ and $0.004 < x < 0.7$ are shown. The results of a global QCD fit at NLO to the world g_1 data are discussed.

Then, the evaluation of the polarized valence quark distributions $\Delta u_v(x) + \Delta d_v(x)$ is presented. The analysis is based on the difference asymmetry, $A^{(h+-h-)}$, for hadrons of opposite charges. This approach gives direct access to the valence quark helicity distributions, as the fragmentation functions do cancel out in LO QCD. The results derived provide information about the contribution of the sea quarks to the nucleon spin. Comparisons with previous measurements performed at SMC and HERMES are also shown.

77 . Modified method of azimuthal asymmetries analysis in SIDIS

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Using advantages of the world largest COMPASS polarized target with two cells simultaneously polarized in opposite direction, the modified method of double ratios of cross section asymmetry measurements is suggested. The method permits to study the cross section asymmetries at the level of few per mill and smaller and to search for tiny effects connected with polarization of quarks in polarized nucleons.

78 . GPDs and Nucleon Form factors

*Selyugin, Oleg
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The new t -dependence of the GPD is determined. The calculations of the corresponding nucleon form factors are made. The comparison with existing experimental data of the charge form factors of the proton and neutron at small and large momentum transfer show the good agreement. The gravitational form factors of the nucleons are calculated.

79 . The ratio R_{dp} of the quasi-elastic and $p(nn)$ to the elastic pn charge-exchange process yields at 0° over 0.5-2.0 Gev neutron beam energy region.

*Sharov, Vasilij
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New experimental results on the ratio R_{dp} of the charge-exchange quasi-elastic scattering yield at 0° for the $nd \rightarrow p + (nn)$ reaction to the elastic $np \rightarrow pn$

scattering yield are presented. Measured in the same data taking runs, two change-exchange angular distributions were corrected for the well known instrumental effects and averaged in a vicinity of the incident neutron beam direction. These two corrected angular distributions are proportional to the differential cross sections of the two relevant reactions. Measurements were carried out at the Nuclotron of the Veksler and Baldin Laboratory of High Energies of the Joint Institute for Nuclear Research (JINR) at the neutron beam kinetic energies 0.55, 0.8, 1.0, 1.2, 1.4, 1.8 and 2.0 *GeV*. The intense quasi-monochromatic neutron beam was produced by break-up of accelerated deuterons extracted to the experimental area.

The data were accumulated using the "Delta-Sigma" set-up magnetic spectrometer with two sets of multiwire proportional chambers located upstream and downstream of the analyzing magnet. Inelastic processes were considerably reduced by detectors surrounding either the hydrogen or deuterium targets. The time-of-flight system was used for detected particle identification. The accumulated data treatment and analysis of possible systematic errors are discussed. The obtained R_{dp} values remain nearly constant with energy. The new data are compared with existing ones, measured only at energies below 1 *GeV*.

80 . Optical potential model for the elastic $\vec{d}p$ scattering at intermediate energies

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A calculation of the wide-angle deuteron polarization observables A_y^d , A_{yy} , A_{xx} and A_{xz} through an optical potential model for the elastic proton-deuteron scattering at the incident deuteron energy $E_d = 880$ MeV in lab is presented. The main aim is to point out the role of the double-scattering mechanism in the optical potential as well as to perform a comparison of calculations with two different deuteron wave-functions derived from Bonn-CD NN -potential model [1] and the dressed bag model of Moscow-Tübingen group [2] which develops a nodal behavior of the deuteron wave function at a small distance. For NN input, a model-independent approach is used in which nucleon-nucleon T -matrix is presumably local and taken on-shell, but energy-dependent. So, this approach is beyond the conventional impulse approximation.

The calculated polarization observables are compared with experimental data obtained recently by LNS group at LHE JINR (Russia) in cooperation with RIKEN group (Japan). A comparison with older data at $E_d = 270$ MeV [3] is also presented. The calculation is carried out in the helicity partial wave

decomposition, and total angular momenta up to $J = 43/2$ in proton-deuteron system seem to be sufficient to obtain a convergent result. As for NN -partial waves, we take all SAID partial waves up to $J_{NN} = 7$. A large effect from double-scattering mechanism at 880 MeV as well as large dependency on the short-range behavior of deuteron wave function are observed whereas at 270 MeV, the sensitivity of the observables to these effects is quite modest, however, not negligible.

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81 . Polarization physics at the high p_T region on the JINR LHE acceleration complex

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The physical program of studies of polarization effects in the high p_T region and energies $s^{1/2} < 10$ GeV is discussed. Opportunities to resolve puzzles of large polarization effects in the elastic pp (at 90° c.m.s.) and the nature of cumulative processes are considered.

82 . Determination of the FLIP and NON-FLIP parts of nucleon-nucleon scattering in the elastic charge exchange reaction at 0 degree over the energy region

$T_n = 0.55 - 2.0$ GeV

*Shindin, Roman
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Determination the $r^{nfl/fl}$ ratio used DELTA-SIGMA experimental setup (VBLHE JINR) and the measurement of the ratio R_{dp} over the energy region $T_n = 0.55 - 2.0$ GeV. Two different approach for description of reactions elastic np-np backward and Charge-Exchange np-pn forward will be discussed. For determination the $r^{nfl/fl}$ in impulse approach frame the Dean formula was used.

83 . Progress in the Determination of Polarized PDFs and Higher Twist

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We have re-analyzed the world data on inclusive polarized DIS including the very precise CLAS proton and deuteron data, as well as the latest COMPASS data on the asymmetry A_1^d , and have studied the impact of these data on polarized parton densities and higher twist effects. We demonstrate that the low Q^2 CLAS data improve essentially our knowledge of higher twist corrections to the spin structure function g_1 , while the large Q^2 COMPASS data influence mainly the strange quark density. In our new analysis we find that a negative polarized gluon density, or one that changes sign as a function of x , cannot be ruled out from the present DIS data.

84 . Tensor magnetic polarizability of the deuteron in storage-ring experiments

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Magnetic polarizability is an important property of deuteron and other nuclei. Tensor magnetic polarizability is defined by spin interactions of nucleons. Measurement of the tensor magnetic polarizability of the deuteron gives an important information about an interaction between spins of nucleons and provides a good possibility to examine the theory of spin-dependent nuclear forces.

Tensor magnetic polarizability, β_T , causes the spin rotation with two frequencies instead of one and therefore conditions beating with the frequency proportional to β_T [1]. This effect makes it possible to measure the tensor magnetic polarizability of the deuteron in storage ring experiments. An influence of the tensor magnetic polarizability of the deuteron on the spin motion in the EDM experiment is calculated.

We propose to use the tensor-polarized beam for measuring the tensor magnetic polarizability of the deuteron. If the initial vector polarization of such a beam is zero, the interaction of the magnetic moment of the deuteron cannot lead to the appearance of any vector polarization. However, the tensor interactions cause nonzero final vector polarization of the beam. According to estimates, the final vector polarization can be of order of 1%. Such a polarization can be measured.

The effect of the tensor magnetic polarizability on the spin dynamics in the deuteron electric-dipole-moment experiment has been calculated.

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85 . Progress in the determination of the polarized gluon distribution

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We discuss the current status of the determination of the gluon distribution from global fits. First, we discuss the effect of the inclusion of recent inclusive deep-inelastic scattering data from the COMPASS, CLAS and HERMES collaborations, and we show that they lead to a smaller gluon polarization than that obtained by using previous NMC and SLAC data. Then, we examine the impact of forthcoming COMPASS charm production data on this determination.

86 . Polarizing Fragmentation Functions and Fracture Functions for Baryons

Sivers, Dennis
Portland Physical Institute, USA

87 . Quark Orbital Structures From the Weyl-Dirac Equation In SU(2) Gauge Theory

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Spin-orbit dynamics in the proton are associated with chiral dynamics and the confinement of color constituents. An important supplement to the study of chiral mechanisms therefore involves the spatial representation of quantum structures in a gauge theory. This can be investigated using an explicit ansatz for the Weyl-Dirac equation in an SU(2) gauge theory. The Wilson operators that enter into the process dependence of single-spin asymmetries can be directly evaluated in this approximation.

88 . Nucleon Spin Structure and QCD Spin Physics

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Our knowledge of the nucleon spin structure has greatly improved over the last twenty years or so, but still many fundamental questions remain unsolved. I will try to review some of the puzzling aspects of the structure of the nucleon spin, in particular, what is known, what remains to be discovered and the prospects for the near future. I will also focus on the current activities in QCD spin physics.

89 . Polarized measurements of energy dependences of the complete set of np observables at 1-6 GeV monochromatic neutron beams from the Nuclotron and direct reconstruction of the isosinglet NN-amplitudes of forward elastic scattering for search signals of phase transition of NN to 6-quarks

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To advance studies of the short range spin structure of NN interactions, there were (np) spin observables measured for the first time at 0° up to the highest nucleon internal momenta k in np -core. Both the bounded polarized (np)-couple (in deuteron) and a polarized free np -couple were probed up to $k \approx 5 \text{ fm}^{-1}$ and 6 fm^{-1} respectively. The highest energy polarized deuteron (up to $9 \text{ GeV}/c$) and polarized monochromatic neutron beams (up to $4.5 \text{ GeV}/c$), provided now only by the JINR accelerators, were used for energy dependence measurements $T_{20}(k)$ up to $k \approx 5 \text{ fm}^{-1}$ in the $d \rightarrow p$ stripping up to kinematic limit of k , and $\Delta\sigma_L(np)$ total np cross section differences in new energy range of 1.2–3.7 GeV.

90 . Spin effects for neutrinos and electrons moving in dense matter

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We give a review on a recently developed powerful method for investigation of different phenomena that can appear when neutrinos and electrons are moving in background matter. This method is based on solutions of the modified

Dirac equations, derived for the case of particles interaction with matter. The developed approach is similar to the Furry representation of quantum electrodynamics, widely used for description of particles interactions in the presence of external electromagnetic fields. For several particular cases, that are of interest for the astrophysical and cosmological applications, we show how to derive exact solutions of the correspondent modified Dirac equations for fermions (neutrino and electron), and classify the obtained wave functions over the spin states. The discussed approach is used for study different processes in external environment. In particular, we investigate in detail the "spin light" of neutrino and electron in matter, the two recently proposed new mechanisms of electromagnetic radiation of polarized particles.

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91 . Asymmetry Measurement in Elastic π^+p Scattering at 0.8 GeV/c

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New experimental data on the asymmetry in the elastic π^+p scattering at 0.8 GeV/c are presented by the ITEP-PNPI collaboration. The kinematic region of the measurement corresponds to the very backward c.m. scattering angles, where no other experimental data are available due to low cross section values and the predictions of the partial wave analysis are most contradictory. The results are obtained in two geometrical configurations of the SPIN setup and cover the angular range of 140–175° in the center of mass frame.

92 . Siverson function: from small to large transverse momenta

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Soft-gluon contributions to single-spin asymmetries (SSA) in hard processes may be presented in the form of *effective* T-odd Siverson distributions, whose signs and scales are modified by process-dependent colour factors. These factors are related to colour charges of incoming partons from other participating hadrons and violate factorization in the usual sense.

We thus prove that the Siverson mechanism may be applied at large transverse momenta. We stress that twist3 SSA in semi-inclusive deeply inelastic scattering and Drell–Yan processes are suppressed by transverse momentum rather than a virtual-photon momentum transfer and thus naively correspond to twist two at the hadronic level. More rigorously, the transverse-momentum weighted averages of the Siverson function correspond to increasing twists 3, 5, 7... while the full TMD Siverson function (just as other transverse-momentum dependent distribution and fragmentation functions) corresponds to a resummed infinite tower of higher twists.

93 . Probing the anomalous triple gauge coupling with polarized electron-positron beams

Tikhonin, Feodor
IHEP, Protvino, Russia

Investigated the possibility to probe the $W\gamma W$ vertex with the transversally polarized e^+e^- beams.

94 . Handedness analysis of the $\pi^- A$ interactions with COMPASS data

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Some years ago the concept of a Handedness was introduced as a measure of the polarization of parent partons. In a strong decay, one needs to consider at least three particles in the final state. Then the axial 4-vector $n_\mu = \epsilon_{\mu\nu\sigma\rho} k_1^\nu k_2^\sigma k^\rho$, where k^ρ is 4-momentum of a particle (or a system) in question ($k = k_1 + k_2 + k_3 + \dots$), can be constructed and contracted with the polarization axial 4-vector to form a parity-conserving term in a resonance decay amplitude. As a consequence, the Handedness is proportional to the polarization of the fragmenting system and can be defined as an asymmetry of a process

probability to have a spatial component n_i of this axial 4-vector with respect to longitudinal n_L or transversal n_{T1} , n_{T2} resonance momentum directions.

The Handedness analysis of COMPASS hadron data taken with a 190 GeV/c pion beam in 2004 is in progress. The transversal Handedness component, n_{T1} , dependencies of the invariant three pion mass and other kinematical parameters of pion triples are investigated for diffractive, intermediate and non-diffractive regions for C, Cu and Pb targets.

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95 . Directed flow as orbital angular momentum effect in hadron and nucleus collisions

Troshin, Sergey
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We discuss rotational properties of the specific strongly interacting transient collective state of matter in hadron and nuclei reactions and emphasize similarity in their dynamics. We consider elliptic flow introduced for description of nucleus collisions and discuss its possible behavior in hadronic reactions due to rotation of the transient matter.

96 . Spin Observables in Reactions $pp \rightarrow \{pp\}_s X^0$ with Final 1S_0 Diproton and meson X^0

Uzikov, Yuri
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Formalism for spin observables in the reactions of pseudoscalar, scalar and vector meson production in pp -collision with formation of the 1S_0 diproton $\{pp\}_s$ in the final state is derived in model independent way assuming parity and angular momentum conservation. Pseudoscalar meson production is described by two spin amplitudes and both of them can be completely determined by measurement of $d\sigma_0$, A_y and spin-correlation coefficient $C_{x,x} = -C_{z,z}$. Similar result is obtained for scalar mesons production. It is shown that measurement of the tensor polarization t_{20} of the vector meson produced by unpolarized initial pp system in collinear kinematics is equivalent to measurement of the spin-correlation coefficients $C_{z,z}$ or $C_{y,y}$. The OPE model is used for some numerical calculations.

97 . Recent HERMES Results on the Helicity Substructure of the Nucleon

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During the period 1996 - 2000 (“Run 1”), the HERMES experiment measured inclusive and semi-inclusive deep inelastic scattering of 27.5 GeV positrons from longitudinally-polarized hydrogen and deuterium gas targets. These data have yielded a variety of results on the spin structure of the nucleon, including the first 5-flavor separation of the quark helicity distributions $\Delta q(x, Q^2)$ in the proton. Three recent measurements from the longitudinal target data will be shown. The first is the final HERMES result on the inclusive spin structure functions $g_1^p(x, Q^2)$ and $g_1^n(x, Q^2)$, based on a refined analysis procedure where an unfolding algorithm is used to account for kinematic migration of events (due to QED radiation and detector smearing effects). The most precise determination to date of the neutron spin structure function g_1^n is obtained by combining the HERMES deuteron and proton data. Integrals of g_1^p , g_1^d and g_1^n are calculated over the measured x range, at $Q^2 = 5 \text{ GeV}^2$. Neglecting any possible contribution to the g_1^d integral from the region $x \leq 0.021$, a value of 0.330 ± 0.011 (theo.) ± 0.025 (exp.) ± 0.028 (evol.) is obtained for the flavor-singlet a_0 in a leading twist NNLO analysis. Second, a precise measurement of the strange quark polarization will be presented. This result was obtained from the double-spin asymmetry for charged kaon production from the deuterium target using an extraction procedure with entirely different systematics to that used for the published 5-flavor extraction.

98 . New polarization program in Protvino

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A new project is being prepared at IHEP on new miscellaneous single spin asymmetry measurements at the 70-GeV Protvino accelerator. Exclusive and inclusive production of many light resonances on a polarized proton target will be studied as well as charmonia production at the second stage of the experiment.

99 . Measurements of A_{yy} , A_{xx} and A_y analyzing powers of triton fragmentation in $d(\vec{d}, p)$ reaction at 270 MeV

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The final results on the polarization observables of A_{yy} , A_{xx} and A_y analyzing powers of the $\vec{d}d \rightarrow pX$ breakup reaction at 270 MeV of deuteron kinetic energy is presented. The obtained angular distributions of these polarization observables compared with data on the binary reaction $\vec{d}d \rightarrow pT$. The analyzed data refer to the triton breakup above threshold up to 8 MeV.

100 . Lambda polarization in photoproduction at HERMES

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Spin transfer K_{LL} from the longitudinally polarized target to the Λ and $\bar{\Lambda}$ hyperons produced inclusively in quasi-photoproduction regime has been measured for the first time. Dependence of the spin-transfer coefficient on kinematical variables has been investigated. K_{LL} shows the trend towards higher positive values at small longitudinal Λ momenta p_z (negative x_F). Spin-transfer coefficient from E704 and STAR data shows similar trend. No dependence on transverse Λ momentum is found in the whole investigated p_t range. The K_{LL} is not sensitive to the beam polarization. Averaged over Λ kinematics, spin transfer K_{LL} is found to be $0.024 \pm 0.008_{stat} \pm 0.003_{syst}$. For the $\bar{\Lambda}$ hyperon, averaged spin transfer coefficient is found to be compatible with zero: $0.002 \pm 0.019_{stat} \pm 0.008_{syst}$. The systematic uncertainty has been investigated using hadron pairs and K_s meson data samples.

101 . First results from the HERMES recoil detector

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The HERMES experiment, installed in the 27.5 GeV HERA electron ring at DESY/Hamburg, is used to study the spin structure of the nucleon. To get information about the orbital angular momentum of quarks, exclusive DIS reactions are investigated. This requires the detection of recoil protons with low momentum. The HERMES recoil detector is specifically built to improve the exclusivity of such reactions at the event level. Deeply Virtual Compton Scattering is the main processes to be studied.

The HERMES recoil detector consists of 3 subcomponents inside a superconducting magnet that provides a longitudinal magnetic field of 1 Tesla. From the beam-line, surrounding the target cell inside the HERA e-beam vacuum, going outside, the silicon detector is positioned, followed by a scintillating fiber tracker (SciFi) and a photon detector with three tungsten/scintillator layers.

The silicon and SciFi detector are designed to detect protons with momenta between 0.135 - 1.4 GeV/c and 0.3 - 1.4 GeV/c respectively, able to distinguish pions and protons for momenta less than 0.8 GeV/c (together with the photon detector). Photons coming from π^0 decay are detected by the photon detector.

The detector was installed in January 2006 and commissioning started in February. First results from the detector will be presented. The performance of the detectors will be reviewed with special attention to the influence coming from the HERA beam.

102 . Comparative analysis of transversities and the longitudinally polarized distribution functions of the nucleon

*Wakamatsu, Masashi
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We have carried out a comparative analysis of the transversities and the longitudinally polarized distribution functions in light of the new global fit of the transversities and the Collins fragmentation functions carried out by Anselmino et al. We point out that their result, although with large uncertainties, already indicates a remarkable qualitative difference between the transversities and the longitudinally polarized distributions such that $|\Delta_T d(x)/\Delta d(x)| \ll |\Delta d(x)/\Delta u(x)|$, the cause of which can be traced back to the relation between the isoscalar axial and tensor charges, $g_A^{(I=0)} \ll g_T^{(I=0)}$. Combining the standard nucleon spin sum rule and the BLT transverse spin sum rule, we can further conjecture that the above relation between the axial and tensor charges would mean $L_{s_T}^Q + L_{s_T}^g \ll L^Q + L^g$, i.e. the transverse component of the quark plus gluon orbital angular momentum would be sizably smaller than the corresponding longitudinal component. Then, if the feature $g_T^{(I=0)} \gg g_A^{(I=0)}$ is in fact confirmed experimentally, it would provide us with valuable information on the transverse as well as the longitudinal motion of quarks and gluons inside the nucleon.

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