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AN ANALYTICAL REVIEW OF DSPIN-11

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A short analytical review of the main results of the DSPIN-11 Workshop (JINR, Dubna, September 20–24, 2011) is given.

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The XIV Workshop on High Energy Spin Physics (DSPIN-11) continued a series of similar conferences, the first of which took place 30 years ago in 1981 on the initiative of the outstanding theoretical physicist L. I. Lapidus. Since then each odd year similar conferences have been organized in Protvino or in Dubna. They give a possibility of presenting and discussing the news accumulated during the year. Another important specific feature was always an opportunity for a large number of physicists, from the former USSR and other East European countries for whom distant trips were difficult for the financial (earlier also for bureaucratic) reasons, to participate in the conference.

The special feature of this Conference was a wider geography and a larger number of participants (113 persons) from the countries they represented: Algeria — 1, Belarus — 4, Belgium — 1, Bulgaria — 2, China — 2, Czech Republic — 5, Estonia — 1, France — 5, Germany — 4, Holland — 1, India — 2, Iran — 1, Italy — 2, Poland — 5, Portugal — 1, Russia — 25, Slovakia — 1, Sweden — 1, Switzerland — 1, the UK — 1, Ukraine — 2, the USA — 11, Uzbekistan — 1, Vietnam — 1. As always, many physicists from JINR (about 35) participated in the conference. The reason for the increasing popularity of the conference became, apparently, the fact that this year brought many new experimental results. Some of them were for the first time presented in Dubna.

X. Artru in his work, together with Z. Belghobsi, proposed a simple explanation of the Collins effect and the effect of jet handedness in the model of sequential fragmentation of quark and proposed the programme of realization of the model

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in the Monte Carlo method. Also preliminary results of the new measurements of the structure function g_2 by the HERMES Collaboration (A. Ivanilov) were reported for the first time.

Classical experiments on the study of the nucleon spin structure at high energies use both scattering leptons on polarized nucleons (HERMES, JLab, COMPASS) and collisions of the polarized protons (RHIC, IHEP, JINR). The joint description of such different high-energy processes becomes possible due to the application of the fundamental theory of strong interactions, quantum chromodynamics (QCD), and remarkable properties of factorization, local quark–hadron duality and asymptotic freedom, which allow one to calculate the characteristics of a process within the framework of perturbation theory (PT). At the same time, parton distribution functions, correlation and fragmentation functions, which are not calculable and therefore require modeling methods, are universal and do not depend on the process. A number of reports at the conference were dedicated to the development and application of this type of models (P. Zavada — the original covariant model of nucleon, J. Soffer — quantum statistical model, N. Sharma — chiral model of constituent quarks and others).

The theoretical description of processes with the participation of spin and especially an internal transverse parton motion proves to be, as always, more complicated, so that the number of such functions increases and the picture connected with them loses to a considerable degree the simplicity of a parton model with its probabilistic interpretation. One of the difficulties here is the evolution of these new functions with a change in the wavelength of a tester. An approach to its solution was presented in the talk of I. Cherednikov.

The quark helicity distributions in a nucleon are the most well studied so far. The results of their more accurate measurements by the COMPASS (Y. Bedfer) and CLAS (Y. Prok) Collaborations were presented. Contemporary experimental data are sufficiently precise to include in their QCD analysis not only the correction of perturbation theory but also contributions of higher twists (A. Sidorov, O. Shevchenko, V. Khandramay, E. Christova, G. Ramsey, H. Dahiya, D. Strózik-Kotlorz, F. Arbabifar). In this case, the positive polarization of strange quarks is excluded with high probability. However, the polarization of gluons agrees with the results of their direct measurement (although, with large uncertainty thus far) by the COMPASS (K. Kurek, C. Franco) and PHENIX+STAR (A. Bazilevsky, D. Svirida, I. Alekseev) Collaborations, and its low value seems insufficient for resolving the so-called nucleon spin crisis.

Hope for its overcoming is now on the contributions of the orbital angular momenta of quarks and gluons which can be determined by measuring the so-called Generalized Parton Distributions (GPD). The 15-year history of their appearance and current situation was dwelled upon in the talk by A. Radyushkin — one of the founders of this direction in QCD. Different theoretical aspects of GPDs were considered in the talks by S. Goloskokov, S. Manaenkov, L. Szimanovski,

and K. Semenov-Tyan-Shanskiy. Different experimental aspects of their measurements and preparation for new ones were presented in the talks of A. Sandacz, A. Morreale and P. Sznajder (COMPASS), V. Korotkov (HERMES), and V. Kubarovsky (JLab).

Other important spin distribution functions manifest themselves in scattering of transversely polarized particles. The processes in which the polarization of only one particle (initial or final) is known, are especially interesting and complicated from the theoretical point of view (and relatively simple from the point of view of experiment — such complementarities frequently occur). Such single spin asymmetries are related to the T-odd effects, i.e., they seemingly break invariance under time reversal. Here, however, we deal with an effective breaking connected not with the true noninvariance of fundamental (in our case, strong, described by QCD) interaction under time reversal, but with its simulations by thin effects of rescattering in the final or initial state.

The effects of single asymmetry have been studied by theorists (including Dubna theorists who have priority in a number of directions) for more than 20 years, but their study received a new impetus in recent years in connection with new experimental data on the single-spin asymmetry in the semi-inclusive electroproduction of hadrons off a longitudinally and transversely polarized targets (HERMES — V. Korotkov, CLAS — Y. Prok, and COMPASS — C. Elia). In particular, HERMES data on the so-called «Sivers distribution function» for secondary pions, related to the left–right asymmetry of parton distribution in transversely polarized hadron, are described by the existing theory. However, the data for positive kaons in the region of small x are approximately 2.5 times larger than their predictions, which could testify to an essential role of an antiquark Sivers function. However, the new measurements of this asymmetry by the COMPASS Collaboration do not confirm such a big deviation, which could favor of another possibility — the influence of higher twist contributions.

New data on the single-spin asymmetries of secondary pions and η mesons in polarized proton–proton collisions with the energies RHIC (200×200 GeV) were presented by the PHENIX (O. Eyser) Collaboration. They confirm amazingly large asymmetries in the region of the fragmentation of the polarized proton and their drop to zero in the central region of rapidities and the region of the nonpolarized proton beam obtained earlier at lower energies. This confirms their energy independence. At the same time, particular mechanisms of the origin of these asymmetries remain a riddle so far.

Thus, although single-spin asymmetries on the whole are described by the existing theory, their development continues (I. Anikin). The T-odd distribution functions appearing here lose key properties of universality and become «effective», dependent on the process in which they are observed. In particular, the most fundamental QCD prediction is the change of the sign of the Sivers function in passing from the pion electroproduction process to the Drell–Yan pair produc-

tion on a transversely polarized target. This conclusion is planned to be checked in the COMPASS experiment (A. Guskov) and at colliders RHIC (L. Nogach), NICA and PANDA-PAX (M. Destefanis).

Significant interest and discussions were caused by new JLab data presented at the conference on measurements of the ratio of proton electric and magnetic form factors performed by the «technique of the recoil polarization» (Ch. Perdrisat). The previous JLab measurements showed that this relation was not constant, as it was considered for a long time, but linearly decreases with the increase of momentum transfer Q^2 (the so-called «form factor crisis»). New data obtained in the past year (experiment GEp(III) with JINR participation) indicate flattening of this ratio in the $Q^2 = 6{-}8$ GeV^2 region. A question whether this behavior is due to incomplete calculation of radiative corrections, in particular, two-photon exchange, remains open yet.

As always, the sources of polarized particles (M. Chetvertkov, Yu. Plis, D. Karlovets), physics of the acceleration of polarized beams (Yu. Kondratenko), physics of polarimeters (V. Ladygin, A. Zelenskiy, M. Runtso, D. Smirnov), and the polarized target technique (Yu. Kiselev) were discussed at the Conference.

Great interest was generated by the first results of experiments at the Large Hadron Collider (LHC) at CERN relating to spin physics (C. Buszello); in particular, the determination of spin and quantum numbers of Higgs- and Z-bosons, polarization of W, and also the spin phenomena in heavy quark physics. A number of talks were devoted to theoretical possibilities of Z' search and other exotics at LHC and future International Linear Collider (ILC) of electrons (V. Andreev, A. Tsitrinov, J. Körner).

Finally, considerable attention was given to the projects of further development of polarization studies. A large and detailed report about the project of eRHIC (collider of polarized protons of 250 GeV and nuclei with polarized electrons of 20 GeV) at BNL was made by E. Aschenauer. Having a large luminosity (10^{34}), it will make it possible to increase the accuracy in measurement of gluon and quark spin distribution functions in a proton, as well as GPDs by an order of magnitude. The plans of further studies at the modified accelerator at JLab (Y. Prok, V. Kubarovsky) were also discussed. The programme of polarized proton beam formation from decay of Λ particles at the IHEP accelerator U-70 in Protvino for spin studies at the installation SPASCHARM under construction was presented by S. Nurushev. He emphasized the importance of the comparative study of the spin effects induced by particles and antiparticles. However special interest was caused by the plans of creation at IKP (Jülich) of a unique European complex for determining the electric dipole moment (EDM) of a proton and nuclei (very detailed talk of N. Nikolaev). The matter is that the dipole moment of fundamental particles violates both space and time parity and its detection would indicate violation of the Standard Model and, in particular, a possibility of approach to the problem of understanding of baryon asymmetry of the Universe.

The projected complex will make it possible to lower the limit of deuteron EDM measurement up to $10^{-29}\, e \cdot \mathrm{cm}$.

The reports relate on the development at LHEP accelerating complex of JINR were also presented (R. Kurilkin, N. Ladygina). The newest methods and the results of calculations of specific features of spin dynamics under acceleration at the Nuclotron of polarized protons and the lightest nuclei were also reflected (Yu. Kondratenko). Some new proposals for conducting polarization studies on the basis of the modernized complex Nuclotron-M and at the complex NICA projected at JINR were presented (O. Teryaev, O. Selyugin). Within the framework of DSPIN-11, two working discussions (leader A. Kovalenko) of vital problems of the infrastructure development for further studies in spin physics at the complex Nuclotron/NICA took place in which specialists of JINR, BNL, MEPI, ITEP, and INR participated. Participants heard information about the project «SPRINT» (Spin Physics Research of Infrastructure at Nuclotron) being developed at LHEP, about polarimetry at the complex AGS/RHIC at BNL, in particular, problems of development and use of CNI-polarimeters and possibility of their use at the NICA collider, and other questions.

The spin community represented at the Conference supported these plans to create new unique possibilities for conducting polarization studies at the accelerating complex of LHEP at JINR. The accelerating complex with such potentialities will not have competitions from other centres carrying out polarization studies, and the obtained data will help to solve the riddles of the spin effects which have not been solved since the 70s of the past century.

The summary of the meeting was made in the final report by J. Soffer.

The success of the Conference was due to the support by the Russian Foundation for Basic Research, International Committee for Spin Physics, «Dynasty» Foundation, European Physical Society and the JINR programmes for international collaboration: Heisenberg–Landau, Bogoliubov–Infeld and Blokhintsev–Votruba ones. This made it possible to provide noticeable financial support to participants from Russia and other JINR Member States. The materials of the Conference, including slides of all presented talks, and the Workshop Proceedings (412 pages) are available on the site http://theor.jinr.ru/∼spin/2011/.