1 INTRODUCTION

Between 1.1.93 and 6.30.95 we have published 24 papers in the refereed journals (including those in print), and prepared for publication several more papers. Publications include a first comprehensive review of the color coherent phenomena which appeared in Annual Review of Nuclear and Particle Physics 1994. We gave 56 talks at conferences, workshops and schools (the written versions of 22 talks have been published in the proceedings). We also gave 36 Colloquia and seminars. The number of talks reflects growing interaction between particle and nuclear physicists, wider realization that methods of high-energy physics provide new probes of nuclear structure as well as usefulness of nuclear targets for the investigation of dynamics of hadrons.

Highlights of our research during 1993-1995 were

(i) first legitimate QCD calculations of hard coherent diffractive processes off nucleon(nuclear) targets which established novel features of color transparency phenomenon not anticipated in the previous intuitive or QCD inspired model calculations and predicted the fast increase of the of the cross section for electroproduction of $\rho$-mesons with increase of the energy, which was confirmed very recently by the first HERA data on this reaction (see section 2.1).

(ii) first theoretical demonstration that color transparency phenomenon for the hard diffractive processes follow from QCD in the kinematics when both $x \rightarrow 0$ and $Q^2 \rightarrow \infty$. Thus we found that pattern of color transparency in nonabelian theory - QCD is different from Chudakov effect - the charge transparency phenomenon in QED. So the analogy between QCD and QED as gauge theories used previously to suggest color transparency phenomenon in QCD is incomplete.

(iii) Establishing the pattern of color (cross section) fluctuations in hadrons. Confirmed by the FNAL inelastic diffraction data.

(iv) Finding that in realistic quark, skyrmion models of a hadron large momentum transfer elastic lepton- hadron scattering occurs through formation of small spatial size configurations.

(v) Discovering a novel class of color transparency sensitive double interaction processes which is complementary to quasielastic reactions originally suggested by S.Brodsky and A.Mueller.

(vi) Adopting ideas suggested by E.J.Moniz, D.R.Yennie, J.D.Walecka and G.D.Nixon for hadron initiated reactions we developed a method for taking into account nuclear correlations in $(e,e'p)$ reactions. Such an approach gives practical possibility to overcome ambiguities of optical model approximation used before and to reliably interpret color transparency effects at intermediate $Q^2$.

Working on the interface of QCD and nuclear physics requires collaborative efforts with theorists working on QCD and nuclear physics. Such collaborations are especially crucial for small groups as ours. They allow to build network of connected, extended and flexible groups capable of doing new projects without building large local groups. Our major collaboration efforts during the last 3 years were with G.Baym group (UIUC), S.Brodsky (SLAC), J.Collins (Penn State), J.Gunion (Univ.of California), G.A.Miller (Univ. of Washington), E.Moniz (MIT), A.Mueller (Columbia Univ.), M.Zhalov (St.Petersburg Nuclear Physics Institute)

An important component of our research was also at the interface of theory and experiment.
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We identified new promising avenues of experimental studies of color coherent phenomena in intermediate energy hadron and electron scattering (BNL, CEBAF, HERMES) as well as at high energies (FNAL, CERN). This work was done in close contact and sometimes in collaboration with members of the EVA group (one of the spokesmen of the group, S.Heppelmann, works in PSU; J.Alster and E.Piasetsky work at Tel Aviv University), with members of the CLAS collaboration at CEBAF, members of HERMES collaboration (T.O'Neill (ANL), K.Rith (Univ. of Erlangen)), members of the ZEUS collaboration at HERA (DESY) (H.Abramovicz, A.Levy - Tel Aviv Univ.; J.Whitmore (Penn State), A.Caldwell (Columbia Univ.), members of E-665 and E-781 groups at FNAL.

Dr.A.Berera has recently joined the group. A substantial part of his activities were dealing with the projects he started before coming to Penn State. However a number of new projects are a result of interaction with the Penn State group. So I have decided to present his activities separately and in his own words.

Report of activities of L.Frankfurt and M.Strikman

2 MAIN RESULTS OF INVESTIGATIONS DURING 1993-1995

2.1 Color Coherent Diffractive Phenomena.

Coherence specific for high energy phenomena in QCD, QED and important role of color most clearly reveal themselves in diffractive processes. This is because in QCD hadrons are bound states of constituents and the role of Lorentz slowing down of interaction between constituents of a fast projectile is increasing with increase of energy. It is important that some of diffractive processes can be calculated reliably in QCD as this gives a solid basis for building models appropriate for the wider range of phenomena. This is why we pay special attention to diffractive processes.

2.1.1 Interaction of high-energy small $q\bar{q}$ with hadron targets

We calculated in QCD the cross section of interaction of a sufficiently energetic small transverse size wave packet of $q\bar{q}$ pair [P2,P7] off any hadron target. The obtained cross section decreases with decrease of $b^2$ - the transverse size of the wave packet. Thus in QCD Color Transparency (CT) of hadron matter for a sufficiently energetic small transverse size wave packet follows in certain kinematical region from the factorization theorem and QCD evolution equation [P2,P7]. This result qualitatively agrees with the suggestion of F.Low(1975) made on the basis of the two gluon exchange model. At the same time in many respects QCD predictions are qualitatively different from the expectations based on the two gluon exchange model suggested by F.Low(1975) and J.Gunion and D.Soper (1977). In difference from the two gluon exchange model QCD predicts: i) Fast increase of the cross section for a sufficiently energetic small transverse size wave packet with increase of the incident energy. ii) Considerably slower decrease of this cross section with decrease of $b^2$ due to 1/2 evolution of the gluon field in the wave packet [P13,C17]. This prediction is in line with the first HERA data on $\rho$ meson electroproduction (see discussion in 2.1.3). iii) Nuclear shadowing in QCD is a leading twist effect. It should not disappear at large but fixed $Q^2$ when $x$ tends to 0. iv) Color transparency phenomenon should be valid in QCD when $x$ is sufficiently small but $Q^2$ increases [P10,P13]. This is another important distinction between QCD
and the two gluon exchange model where final state interactions are higher twist effects at small x. Thus QCD predicts a different pattern of CT as compared to the models based on 2 gluon exchange and on the popular in the literature analogy with Perkins/Chudakov effect in QED. In summary, the nontrivial dependence of color transparency phenomenon on incident energy, \( Q^2 \) and on atomic number are distinctive consequences of nonabelian gauge symmetry in QCD. In particular, small objects have small interaction cross section but only in a restricted range of energies.

To summarize, QCD confirms the basic assumption leading to color transparency phenomenon on smallness of interaction of small white objects, but puts a limit on the range of energies where this interaction remains small. Besides QCD predicts nontrivial dependence of diffractive processes on nuclear number which was not anticipated before.

### 2.1.2 Diffractive production of 2 jet by pion projectiles

We found a new group of high-energy hard processes which are higher twist but calculable in QCD. In ref.[P7] together with G.A.Miller we calculated the cross section of the process \( \pi + N(A) \rightarrow 2 \text{ high } p_t \text{ jets} + N(A) \). The cross section was expressed through the minimal Fock space component of the pion and the gluon density in the target. We explained that color transparency at rather large energies should decrease with energy. Search for this effect is performed now by E-781 experiment at FNAL.

### 2.1.3 Diffractive leptoproduction of vector mesons off nucleons and nuclei

Together with S.J.Brodsky, J.F.Gunion, A.H.Mueller we have calculated in QCD the cross section of hard diffractive vector meson electroproduction [P13]. The cross section of this hard process initiated by a longitudinally polarized photon should increase with energy as the power of energy. This behavior is qualitatively different from cross sections typical for the two body soft diffractive processes initiated by the exchange by soft pomeron which are almost independent of energy. For the reactions initiated by transversely polarized photon whose cross section should decrease with \( Q^2 \), we expect nontrivial interplay of hard and soft QCD. In [C17] we found an important role of \( Q^2 \) evolution in hard diffractive processes. First experimental data of ZEUS,H1 (HERA,DESY,Germany) on diffractive electroproduction of \( \rho \) mesons at \( Q^2 \geq 8 \text{(GeV/c)}^2 \) [1] reasonably agree with the predicted fast increase with energy of this cross section and don't contradict to the predicted \( Q^2 \) dependence of this cross section. If QCD predictions for diffractive electroproduction of vector mesons with different hidden flavor mesons[P13] are confirmed by more detailed data, these observations would provide a unique direct experimental probe of the small size \( q\bar{q} \) components in both the lightest vector mesons and excited mesons. It would allow one to measure the probability of these configurations, which appears to be rather large. It would demonstrate also that it is possible to obtain information about hadron structure from higher twist diffractive processes which is complementary to that obtained in leading twist processes. Besides, both this calculation and data confirm basic assumptions leading to Color Transparency Phenomenon.

### 2.1.4 Coherent Pomeron phenomenon

Together with J.Collins and L.Frankfurt we continued investigation of the structure of hard diffraction which we started in ref.[2]. In [P6] we have demonstrated that the factorization theorem for jet production is not applicable for diffractive processes. This leads to a possibility of hard processes where the Pomeron interacts as a whole. Recent experiment \( UA-8 \) at CERN [3] has confirmed presence of the hard tail of the parton structure function of the Pomeron. Further experimental studies are been planned at the FNAL collider to check this result.
2.2 Study of Color Fluctuations in Hadrons.

Experimental investigation of hard processes has established that at small space–time intervals hadron interactions can be described in terms of quantum chromodynamics – QCD. However soft hadron interactions are not well understood in spite of many brilliant ideas. One of the promising ideas for the expansion of QCD into the nonperturbative domain is to combine well understood methods of the physics of hard processes with the physics of color coherent phenomena to investigate softer ones. The idea is that Lorentz slowing down of the interactions at high energies results in enhancement of the coherent effects due to color distributions in colliding hadrons (color transparent and color opaque fluctuations). Together with G.Miller we have published a review for Annual Review of Nuclear and Particle Physics 94 which summarizes current status of research of color coherent effects in lepton-, hadron-, and nucleus- nucleus processes [P14].

The constructive way to incorporate this physics into the dynamics of relativistic collisions is provided by the concept of hadronic cross-section fluctuations (color fluctuations) which was first introduced by E. L. Feinberg and I. Y. Pomeranchuk [4], and by M. L. Good and W. D. Walker [5]. The key quantity one has to know is the probability, \( P(\sigma) \) to find a nucleon in the configuration with cross section \( \sigma \). \( P(\sigma) \) was first introduced by H.Miettinen and J.Pumplin [6].

Therefore we have undertaken a comprehensive analysis of information about \( P(\sigma) \). We developed a procedure to extract \( P(\sigma) \) from the current data on cross section of the hadron interaction with deuteron suggesting in addition the QCD quark-counting rule constraint on the behavior of \( P(\sigma) \) at small \( \sigma \) [7]. In the case of \( \pi N \) scattering we produced an independent check of this procedure. We calculated \( P_\pi(\sigma \ll \sigma >) \) directly from pQCD using the QCD wave functions of the pion in the \( q\bar{q} \) configuration [P2]. The results of two determinations are reasonably close.

Nontrivial check of this picture has been provided in [P10] where we have calculated inelastic diffraction off nuclei through \( P(\sigma) \). For the interaction with a black disc this cross section should be proportional to the radius of a nucleus. Experiments performed at FNAL (which measured semi-inclusive channels) found considerably faster increase of cross section with atomic number. The data agrees with our theoretical calculations of the \( A \)-dependence of the cross section confirming significant probability of color fluctuations in the wave function of a hadron near its average configuration.

Very recently [P22] M.Strieman and V.Guzev (graduate student at Penn State) have extended the analysis of [P10] to the case of the lightest nuclei and applied it to calculate the total cross section of inelastic coherent diffractive dissociation off \(^4\text{He} \) in the process \( p + ^4\text{He} \rightarrow X + ^4\text{He} \) in terms of the relative cumulants of the cross-section distribution \( P_N(\sigma) \). The theoretical result for the ratio \( r = \left( \frac{d\sigma_{\text{diff}}}{dt} \right)_{p^4\text{He}} \bigg/ \left( \frac{d\sigma_{\text{diff}}}{dt} \right)_{pp} \bigg|_{t=0} = 6.8 \div 7.6 \) is close to the value \( r = 7.1 \pm 0.7 \) which we extracted from the FNAL jet target 1981 data. These are the only \( A > 2 \) data of this kind.

The comparison provides the first confirmation of the cross-section fluctuation approach to the description of the absolute value of the inelastic diffraction cross-section off nuclei. It provides also a new constraint on the first 4 cumulants of the cross-section distribution.

2.3 Color transparency phenomena in quasielastic processes and models of hadrons.

For wide angle two body collisions, QCD predicts dominance of small spatial size configurations in the interacting hadrons. If this process takes place within nuclear medium, the produced small configuration propagates within nucleus with small cross section. This CT phenomenon was predicted a long ago by S.Brodsky [8] and A.Mueller [9]. The argument was based on the application
of perturbative QCD which is likely to be applicable for such processes for very large $Q^2$ only.

2.3.1. In [P1] we performed extensive analysis of current models of nucleon and pion form factors and found that in practically all the models small size configurations determine form factors already for momentum transfers as low as 2-3 GeV$^2$ which is well below the region where perturbative QCD may be applicable for the calculation of the form factors. However at energies feasible for experiments it is necessary to take into account space-time evolution of produced small size wave packet, and this tends to suppress CT. (G.Farrar, H.Liu, L.Frankfurt and M.Strikman 1988 [10]). Besides at feasible energies it is necessary to take properly nuclear effects. So we have developed mathematical methods to account for these effects.

2.3.2. In ref.[P12] together with M.Zhalov we demonstrated that the conventional (optical) model (DWIA) predicts a substantial decrease of transparency, T, with Q in the kinematics of the NE-18 $(e,e'p)$ experiment, while the color transparency phenomenon may lead to a nearly Q independent T. In the kinematical region when the momentum of final proton is around 1 GeV/c the dip in Nuclear Transparency has been predicted in [P12]. The NE18 data [11] indicates a presence of this dip. Further studies in this momentum range (which will be done at CEBAF in the end of the year) would provide a sensitive check of applicability of the semiclassical approximation. In the case of $A(p,2p)$ reaction we demonstrated that conventional optical model well describes the 1 GeV $A(p,2p)$ data but not the transparency observed at higher energies. We find also that DWIA (with or without color transparency) predicts strong dependence of T on the momentum of the struck nucleon which is consistent with the pattern of the BNL $A(p,2p)$ data at $p = 6$ GeV/c and 10 GeV/c.

Smallness of CT effects expected in the NE-18 type experiments combined with expectation of dominance of rather small configurations in the form factors already at $Q^2 \geq 4(\text{GeV/c})^2$ leads to a challenging situation - it is necessary to find processes which are less affected by the quantum diffusion in order to check whether at the momentum transfer accessible for CEBAF, and CEBAF II ($Q^2 \leq 6 - 8(\text{GeV/c})^2$) small size configurations are produced.

2.3.3. One idea was to study transitions to the well defined nuclear levels [12]. This strategy is persuaded now in the CEBAF experiment E-91-007. Together with E.Moniz and M.Sargsyan we deduced eikonal formulae for the final state interaction in $(e,e'p)$ processes taking into account in a consistent way short-range correlations in nuclei [P18]. We found that uncertainties in the theoretical calculations of the excitation of the low nuclear levels in $A(e,e'p)$ reactions are sufficiently small and the final result is close to the results of the optical model calculation [12]. This result indicates that in spite of a small value of CT effects expected in the forthcoming CEBAF experiments the high energy resolution of these experiments would allow one to obtain data for which eikonal predictions can be calculated with accuracy of few percent. Thus there is a chance to observe and to interpret reliably $\sim 10\%$ effects of CT expected in these experiments.

2.3.4. Together with G.Miller, W.Greenberg, K.Egiyan and M.Sargsyan we suggested a novel class of reactions with the lightest nuclei which is more sensitive to CT effects than conventional $(e,e'p)$ processes [P8]:

$$l(h) + A \rightarrow l(h) + p + p + (A - 2).$$
where the second nucleon is selected in the kinematics corresponding to rescattering of knocked out nucleon. The idea is that at intermediate energies CT is suppressed by evolution of small configurations with time. However if instead of determining probability for ejected nucleon \textit{not to interact} one would measure probability \textit{to interact} one can use the lightest nuclei. As a result one can explore in the discussed reactions, interaction of ejected system at small distances from the production point \(\sim 1\text{fm}\) there expansion of the wave packet is suppressed. Our first results of theoretical calculations seem to indicate that one can look for CT effects at much smaller \(Q^2\) than in the more traditional processes like \(A(e,e'p)\). So there is a chance to observe this physics at CEBAF energies. We are now in the process of building more detailed models for double scattering processes, including effects of short-range correlations. With experimentalists of CEBAF we wrote a proposal to search for such effects at CEBAF (Virginia): "Measurement of nuclear transparency in double rescattering processes"; Spokespersons: K. Egiyan, Y. Sharabian, M. Strikman. [P16]

2.3.5. Together with W. Greenberg, G. Miller and M. Sargsyan we studied high momentum transfer electro-disintegration of polarized and unpolarized deuterium targets, \(d(e,e'p)n\) [P19, P20]. We have shown that the importance of final state interactions FSI, occurring when a knocked out nucleon interacts with the other nucleon, depends strongly on the momentum \(\vec{p}_n\) of the spectator nucleon. In particular, these FSI occur when the essential contributions to the scattering amplitude arise from internucleon distances \(\leq 1.5\text{ fm}\). If the point like configuration is still small after propagating about 1.5 fm, the FSI are suppressed. The result is that significant color transparency effects, which can either enhance or suppress computed cross sections, are predicted to occur for \(10(GeV/c)^2 > Q^2 > 4 (GeV/c)^2\). Evident advantage of such reactions is that nuclear effects are under very good control since the wave function of the deuteron is well known for these momenta from other experiments. Measurements seem feasible both at CEBAF and with HERMES.

2.4 Microscopic nuclear structure and the origin of nuclear forces

2.4.1 Light-cone dynamics and nuclear structure.

1. Together with D. Day (University of Virginia) and M. Sargsyan we have finished the analysis of the ratios of cross sections of quasielastic electron scattering off heavy and light nuclei at \(x > 1\) and \(Q^2 > 1(\text{GeV}/c)^2\) [P5]. We argued that the ratios should exhibit simple scaling relations which are ultimately expressed through the ratio of the light-cone nucleon distributions in nuclei. We extracted these ratios from existing data in a model independent way. The results are found to be in a reasonable agreement with our scaling relations, with light-cone quantum mechanics of nuclei, and provide further evidence for the dominance of short range correlations in nuclei at \(k > 0.3 \text{ GeV}/c\).

2. Together with T. Frederico (University of Washington/Brazil) we reexamined the problem of calculation of form factors of the deuteron within light-cone dynamics [P4]. We have formulated the criteria for choosing "good" matrix elements of the "good" components of the operator of electromagnetic current in the infinite-momentum frame, and in the Breit-frame which allows one to resolve ambiguity in the calculations discussed in the literature.
2.4.2 Probing short range nucleon correlations in high energy hard quasielastic pd reactions

We performed together with E. Piasetsky (Tel Aviv University) and M. Sargsyan a detailed analysis of hard $p + d \rightarrow ppn$ reaction [P17]. We found that the strong dependence of the amplitude for $NN$ hard scattering on the collision energy and the exclusive nature of the reaction can be used to magnify the effects of short range nucleon correlations. The initial and final state interactions are calculated for the discussed exclusive processes. We find that for spectator momenta $\leq 350 MeV/c$ and $p_t \sim 0$ the effect of initial and final state interactions can be accounted for by rescaling the cross section calculated within the plane wave impulse approximation. The feasibility to investigate in this kinematics the role of relativistic effects in the deuteron wave function is demonstrated by comparing the predictions of different relativistic formalisms. It is demonstrated also that in this kinematics the final and initial state interactions reduce sensitivity of the cross section to uncertainties in the high momentum component of the deuteron wave function. We also find that for $p_t \sim 0$, $150 MeV/c \geq p_t \geq 50 MeV/c$ initial and final state interaction strongly reduce the cross section while relativistic effects are very small. This kinematic is optimal for color transparency studies. We also analysed binding effects due to short range correlations in deuteron. EVA (E-850) experiment (Brookhaven) has included such a measurement in their plans. First results are expected next year.

2.4.3 Changes in the radius of a nucleon in the interaction with another nucleon

In Ref.[13] we argued that QCD effects lead to a substantial deformation of the bound nucleon wave functions. This effect is relevant both for deep inelastic scattering off nuclei at large $x$ and for quasielastic nucleon knock out at $Q^2 \geq 3(GeV/c)^2$. For the review and references see [14]. We started a new systematic study of these effects using realistic models of low-energy nucleon-nucleon interaction. In Ref.[P5] L. Frankfurt together with G. Kalbermann, and J.M. Eisenberg considered a two-nucleon system described by two different skyrmion models that provide attraction for the central $NN$ potential. Within these models the the question was addressed, To what degree does the nucleon swell or shrink when the internucleon separation distance is appropriate to attraction or repulsion? Typical swelling of 3 to 4 percent for central attraction of some 40 to 50 MeV was found which is quite close to the estimate of Ref.[13].

2.5 Parton distributions in nuclei at small $x$

Knowledge of the nuclear gluon shadowing at small $x$ is very important for describing in a realistic way early stages of the heavy ion collisions at RHIC [15, 16]. Thus we continued our analysis of this effect based on the space-time picture of deep inelastic scattering at small $x$ and the QCD concept of color fluctuations. We were able to obtain realistic estimates of gluon shadowing at small $x$ as well as to estimate probability of coherent diffractive dissociation off nuclei and rapidity gap events at HERA. Our analysis is in a good agreement with the recent experimental data of E665, [C14] and work in preparation.

2.6 Nucleus-nucleus collisions

To search for new phenomena in heavy ion collisions it is necessary to take into account correctly semiclassical geometry of collisions and to calculate reliably fluctuations of average quantities. We continued analysis of the role of color fluctuations in high-energy nucleus-nucleus collisions which was started in [17]:

7
1. Bulgac and Frankfurt have demonstrated [P11] that high $E_t$ trigger leads to selection of "fat" configurations in colliding nucleons of nuclei. As a result high $E_t$ triggers may allow to search for percolation phase transitions in central heavy ion collisions. Also this effect leads to dependence of the effective parton distribution on the trigger used to select central collisions. We also formulated a procedure for implementing color fluctuation effect in Monte-Carlo models of $AA$ collisions [B4, P21]

2. With H.Heiselberg, G.Baym, B.Blattel we found that fluctuations of color in nucleons leads to significant fluctuations in the number of collisions. [P11]. We demonstrate also how to account for in $AA$ collisions nucleon-nucleon correlations in nuclei and show that account of nucleon correlations is important to describe $AA$ collisions. [P21]

2.7 Other Developments

1. The first results of disentangling polarization of valence and sea quarks were reported by Spin Muon Collaboration (SMC) (CERN) using the method of studying the difference of $\pi^+$ and $\pi^-$ yields which we suggested in Ref.[18]. Further plans of studies using the refinements of this method [C16] are been planed by SMC. Extensive studies of the valence quark polarization using this method will be performed by HERMES.

2. A new experiment is approved at CEBAF, E-94-102, which will explore non nucleonic degrees of freedom in the deuteron using the tagged structure function approach we suggested in ref. [13].

3. The problems with pion field in nuclei which we pointed out in Ref.[P9] were addressed in a number of papers including papers of the G.Brown group [19].

4. We also tried to enhance interaction between various nuclear and particle physics groups involved in the studies of high-energy interactions with nuclei by organizing a series of workshop on QCD and nuclear physics during 93-95:

   (a) Workshop "Perspectives of QCD and Nuclear Physics studies at Multi GeV hadron facilities" (Los Alamos,1993) supported by LAMPF (organizers G.Garvey, L.Frankfurt, M.Strikman)

   (b) "Perspectives of High Energy Strong Interaction Physics at Hadron Facilities", FNAL (1993), supported by grant of DOE/Institute of Nuclear Theory (Seattle) and FNAL (organizers G.Garvey, L.Frankfurt, M.Strikman)

   (c) "Mini-school on high and low $Q^2$ diffraction at HERA" May 1994, at DESY supported by Deutsches Electronen-Synchrotron DESY (Hamburg) (organizes J.Bartels, L.Frankfurt G.Knies and M.Strikman)

   (d) Workshop “QCD and Nuclear Physics” Trento, Italy July- August 1994; supported by European Center for Theoretical Studies Nuclear Physics and Related Areas. (organizers L.Frankfurt, P.Kroll, P.Muelders M.Strikman, V. Vento, M.Traini )

   (e) Workshop on Options for Color Coherence/Transparency Studies at CEBAF, CEBAF 1995, supported by DOE and CEBAF, organizer M.Strikman
LIST OF PUBLICATIONS

L.Frankfurt and M.Strikman
Publications in the refereed Journals (1993-present)


Parts of the books.


C8. L.Frankfurt and M.Strikman "Hard diffraction processes" p. 196-200

Proceedings of "2nd Workshop on Small-x and Diffractive Physics at the Tevatron FNAL, USA (1994):

C9. L.Frankfurt "Hard Diffractive Exclusive Processes in DIS"

C10. M.Strikman "Interplay of Soft and Hard Diffraction at DIS"


C11. L.Frankfurt, M.Sargsyan and M.Strikman "COLOR COHERENT EFFECTS IN (e,e'N) AND (e,e'N,N(h)) PROCESSES AT CEBAF" pp. 499-508,

C12. D.B.Day, L.Frankfurt, M.Sargsyan and M.Strikman "EVIDENCE FOR SHORT RANGE CORRELATIONS FROM HIGH Q^2 (e,e') REACTIONS". p. 529-533,


C15. Intersections between particle and nuclear physics, St. Petersburg, FL (1994) L.Frankfurt, M.Strikman and M.Zhalov, "COLOR FLUCTUATIONS, DIFFRACTION AND COLOR TRANSPARENCY", in press


C17. H.Abramovicz(Tel Aviv U), L.Frankfurt and M.Strikman INTERPLAY OF SOFT AND HARD PHYSICS IN SMALL x PHYSICS, DESY preprint 95-046, to be published in proceeding of SLAC 95 summer school.


References


4 Report of activities of A. Berera

This report summarizes the present research activities of Arjun Berera beginning 9/94. There are two primary research directions, diffractive hard scattering and nuclear structure functions. Both will be discussed in that order below. In addition I have been pursuing a cosmological inflation model over the past three years [1, 2, 3]. There are some gained advantages in our theory over the conventional theory. The direction of this work will be discussed at the end of this report.

High energy hadron physics has moved into the realm of interfacing hard and soft strong physics. This presents a new channel for studying the longstanding problem of confinement. It also opens up the opportunity of having cleaner final state environments. This advantage may be significant for new physics searches.

4.0.1 Pomeron structure

Theoretically, as a first step, the recent experimental developments in diffractive hard scattering have prompted development of new calculational methods beyond standard QCD-parton model techniques. In the past year D. E. Soper at the University of Oregon and I have analyzed the quark and gluon diffractive distribution functions. We have found that the diffractive constraint qualitatively alters diffractive parton distribution functions at x=z from their inclusive counterparts. Here x is the momentum fraction of the probed parton and z is the lost momentum fraction of the diffractive proton. We are presently in course of completing this analysis. In the near future, data on \( F_2^D(x/z, Q^2) \) from HERA will allow us to test our theory. Present data from HERA out to \( x/z \sim 0.65 \) is consistent with our expectations. However this data is insufficient for conclusive analysis of our theory.

The experimental confirmation of single hard diffraction naturally suggests double hard diffraction at hadron colliders. In double hard diffraction one tags on both impinging hadrons as well as some hard process. In both single and double hard diffraction, factorization, as in the sense found for inclusive processes, fails. This was predicted in [4] and later clarified in the formal sense in [5]. At present there is limited knowledge of the non factorizing component.

J. C. Collins here at Penn State and I have been computing two-jet cross sections for double diffractive events [6]. We have formulated a field theory model for the non factorizing process. Our cross section results have been presented to members in CDF and D0. Presently we are preparing our results for publication. In the coming year we expect more experimental data from what is typically called double pomeron hard processes. We anticipate undertaking a phenomenological analysis at that point. In addition, we will further develop our zeroth order model to account for Sudakov and shadowing corrections.

4.0.2 Deuteron Form-Factors

The second topic of research is nuclear structure functions. At present L. Frankfurt, M. Strikman and I are computing structure functions for polarized deuteron targets. Experimental precision has reached a tolerable level to undertake such measurements. Theoretically this involves combining quantum mechanical and relativistic methods. The simple impulse model, which is often used, is insufficient. Shadowing and s-d wave mixing must also be treated. Here a relativistic implementation of the Glauber model is being developed. Much of this has been done for unpolarized studies and even more without treating d-wave mixing. However in the polarized case d-wave mixing is necessary. In addition there our other complications that must be resolved. We believe to have resolved these problems for the present calculations.
4.0.3 Cosmological Inflation Theory

The final topic of research is in cosmological inflation theory. I have been developing a theory of inflation which incorporates a thermal component. This work began with Professor L. Z. Fang at the University of Arizona. Our work initially began by investigating thermal effects during inflation. In the standard description it is assumed that all thermal radiation is red shifted away. This need not be so if a sufficiently large dissipative mechanism exists. In [1, 2] we made essentially thermodynamic studies of such possibilities. Recently in [3] I have formulated an explicit model scenario, termed warm inflation.

The conventional description is known to suffer several problems. In particular, consistency with observation requires fine tuning the coupling constant to an exceptionally small value. The warm inflation scenario in [3] is shown to require no fine tuning and is consistent with observation. Presently I am formulating a firmer quantum field theoretic justification for our model.

References


Publications List

A Publications 94-95


B Publications 94-95 completed during present position

B-2. "Second-order Scaling in the Two Flavor QCD Chiral Transition"


B-4. "Thermally Induced Density Perturbations in the Inflation Era",