

# Transverse Spin Physics

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## Some Comments on Hard Scattering

## Transverse Spin Puzzle and Solutions

QCD @ high energies  $\rightarrow$  small transverse spin asymmetries  
Experiment  $\rightarrow$  observe large transverse spin asymmetries

- Solutions:
- (I) **correlation** between **proton spin** and intrinsic quark transverse momentum  $k_T^{\text{quark}}$ : **Sivers effect**
  - (II) **correlation** between the struck **quark spin** and transverse momentum  $k_T^{\text{hadron}}$  of final state hadron: **Collins effect**
  - (III) **quark-gluon correlations** in the initial or final state  
**Koike, Qiu & Sterman**



# Transverse Spin Physics

**Dr. Vincenzo Barone, Philip G. Ratcliffe**



## **Transverse Spin Physics:**

**Transverse Spin Physics** Dr. Vincenzo Barone, Philip G. Ratcliffe, 2003 This study deals with the theory and phenomenology of transverse spin effects in high energy hadronic physics Contrary to common past belief it is now rather clear that these effects are far from irrelevant A decade or so of intense theoretical work has shed much light on the subject and brought to the surface an entire class of new phenomena which now await thorough experimental investigation Over the next few years a number of experiments worldwide at DESY CERN and Brookhaven will run with transversely polarised particles providing data that will enrich our knowledge of the transverse spin structure of hadrons The principle aim of this work is to assess the state of the art as it stands in 2002 After a few introductory remarks Chapter 1 in the first part Chapters 2 4 attention is directed to polarised deep inelastic scattering DIS particularly DIS on transversely polarised targets which probes the transverse spin structure function  $g_2$  This structure function is examined within the framework of the quark parton model and its improvement via perturbative QCD The existing data are reviewed and commented on for completeness and comparison a brief presentation of longitudinally polarised DIS and of the helicity structure of the proton is provided The second part of the book Chapters 5 8 focuses on the transverse polarisation of quarks the so called transversity The partonic content and the QCD evolution of the transversity distributions are presented in detail The phenomenology of transversity is then studied in the context of Drell Yan processes and of semi inclusive lepto and hadroproduction The interpretation of data on single spin asymmetries is discussed and finally the prospects for future measurements are reviewed

**Transverse Spin Physics**, 2008 [Theoretical Overview on Recent Developments in Transverse Spin Physics](#), 2009 Transverse spin physics has been very active and rapidly developing in the last few years In this talk I will briefly summarize recent theoretical developments focusing on the associated QCD dynamics in transverse spin physics [Transverse Spin Physics, DESY Zeuthen, July 9-11, 2001](#), 2001 **Overview of Transverse Spin Physics in the PHENIX Experiment**, 2017

*Transversity 2005* Dr. Vincenzo Barone, Philip G. Ratcliffe, 2006 The notion of transversity in hadronic physics has been with us for over 25 years Intriguing though it might have been for much of that time transversity remained an intangible and remote object of interest principally to a few theoreticians In recent years transversity and transverse spin effects in general have grown as both theoretical and experimental areas of active research This increasing attention has now matured into a thriving field with a driving force of its own The ever growing bulk of data on asymmetries in collisions involving transversely polarised hadrons demands a more solid and coherent theoretical basis for its description Indeed it now appears rather clear that transversity and other closely related properties play a significant role in such phenomena As part of a Ministry funded inter university Research Project this workshop was organised to gather together experimentalists and theoreticians engaged in investigating the nature of transverse spin in hadronic physics with the intent of favouring the exchange of up to date theoretical and experimental ideas and news on the subject Over 70 physicists took part and very nearly all the major

experiments involved in transverse spin studies were officially represented as too were the main theory groups working in the field New results and new analyses sparked many interesting and lively discussions Deep Inelastic Scattering: Dis 2006 - Proceedings Of The 14th International Workshop Masahiro Kuze, Kunihiro Nagano, Katsuo Tokushuku, 2007-01-23 These proceedings present the most up to date status of deep inelastic scattering DIS physics Topics such as structure function measurements and phenomenology quantum chromodynamics QCD studies in DIS and photoproduction spin physics and diffractive interactions are reviewed in detail with emphasis on those studies that push the test of QCD and the Standard Model to the limits of their present range of validity towards both the very high and the very low four momentum transfers in lepton proton scattering **Transverse Spin Effect** Mustapha Mekhfi, 1990 Quantum Phase Transitions in Transverse Field Models Amit Dutta, 2015-01-28 This book establishes the fundamental connections between the physics of quantum phase transitions and the technological promise of quantum information *DIS '99* Johannes Blümlein, Tord Riemann, 1999 *Particles And The Universe - Proceedings Of The Eighteenth Lake Louise Winter Institute* Alan Astbury, Bruce A Campbell, Faqir C Khanna, Manuella G Vincter, 2004-03-09 The Lake Louise Winter Institute is held annually to explore recent trends in physics Pedagogical and review lectures are presented by invited experts A topical workshop is held in conjunction with the Institute with contributed presentations by participants **Particles and the Universe** A. Astbury, 2004 The Lake Louise Winter Institute is held annually to explore recent trends in physics Pedagogical and review lectures are presented by invited experts A topical workshop is held in conjunction with the Institute with contributed presentations by participants **Proceedings of the 17th International Spin Physics Symposium** Kenichi Imai, 2007-07-02 Getting down to the bottom line is what this proceedings digest is all about as any physicist will tell you spin is the fundamental concept in physics The applications are pretty universal due to the fact that using spin related phenomena physicists are trying to reveal the fundamental principles of nature and things don't come much more bottom line than that This volume is the proceedings of the 17th International Spin Physics Symposium which is a forum to discuss spin physics and related topics *Energy Research Abstracts*, 1991-10 **Spin 96 - Proceedings Of The 12th International Symposium On High-energy Spin Physics** J E J Oberski, C W De Jager, Tjeerd Ketel, Petrus J Mulders, M Oskam-tamboezer, 1997-04-15 Experiments using highly polarized intense beams and targets and theoretical studies of spin and polarization phenomena are now providing us with numerous additional details of the electroweak and strong interactions and the structure of matter The spin structure of the nucleon has been measured over wide ranges of kinematic variables and the cross sections have been calculated to several orders in perturbative field theory At present the influence of the higher twist contributions the gluon spin and the quark orbital angular momentum are under scrutiny Quantum chromodynamics QCD captures a lot of our experimental knowledge of hard polarized scattering processes Can our understanding of such processes within QCD be further improved Hyperons produced in high energy reactions show how puzzling strong interactions between hadrons still are Spin observables in

experiments at intermediate energy are used to test parity and charge symmetries Will they also reveal at low energy a violation of time reversal symmetry We are on the verge of using parity violation measurements at intermediate electron scattering energies to determine the amount of strange quark contributions to the neutral weak form factor of the nucleon The polarization of the sea quarks is expected to be measured soon in W decays produced in high energy polarized proton interactions Will the jets in polarized Z decays show a definite handedness These and many other topics are discussed in these proceedings

**Soviet Physics, Solid State** ,1985      PKU-RBRC Workshop on Transverse Spin ,2008 Understanding the structure of the nucleon is a fundamental question in subatomic physics and it has been under intensive investigation for the last several years Modern research focuses in particular on the spin structure of the nucleon Experimental and theoretical investigations worldwide over the last few decades have established that contrary to naive quark model expectations quarks carry only about 30% of the total spin of the proton The origin of the remaining spin is the key question in current hadronic physics and also the major driving forces for the current and future experiments such as RHIC and CEBAF in US JPARC in Japan COMPASS at CERN in Europe FAIR at GSI in Germany Among these studies the transverse spin physics develops actively and rapidly in the last few years Recent studies reveal that transverse spin physics is closely related to many fundamental properties of the QCD dynamics such as the factorization the non trivial universality of the parton distribution and fragmentation functions It was very timely to bring together the theorists and experimentalists in this field at this workshop to review and discuss the latest developments and future perspective in hadronic spin physics This workshop was very successful in many aspects First of all it attracted almost every expert working in this field We had more than eighty participants in total among them 27 came from the US institutes 13 from Europe 3 from Korea and 2 from Japan The rest participants came from local institutes in China Second we arranged plenty physics presentations and the program covers all recent progresses made in the last few years In total we had 47 physics presentations and two round table discussions The discussion sessions were especially very useful and very much appreciated by all participants In addition we also scheduled plenty time for discussion in each presentation and the living discussions impressed and benefited all participants

Spin Physics Don G. Crabb,2009-08-25 The topics covered in the conference ranged from the physics that can be done with polarized beams of particles protons electrons gamma rays etc to the techniques and instrumentation necessary to achieve this Topics included nucleon structure measurements from where does the spin of the proton and neutron come the acceleration storage and polarization of particle beams and the polarized targets and sources necessary for mounting the experiments

Physics Briefs ,1991      **Soviet Physics, JETP.** ,1967

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