Joint Institute for Nuclear Research

IX Workshop on High Energy Spin Physics

SPIN•01

Dubna, August 2–7, 2001

Proceedings

Edited by
A. V. Efremov
O. B. Teryaev

Dubna 2002

УДК [539.12.01 + 539.12 ... 14 + 539.12 ... 162.8] (063)
ББК [22.382.1 + 22.382.2 + 22.382.3] я 431
W83

Sponsored by Russian Foundation for Basic Research (grant 01-02-26083), UNESCO (UVO-ROSTE 875.616.1(P-5)), International organizing committee for spin symposia and JINR, through the programmes Heisenberg–Landau, Bogoliubov–Infeld and Blokhintsev–Votruba.

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Workshop on High Energy Spin Physics (SPIN 01) (9; 2001; Dubna).

W83 The Collection of Reports of IX Workshop on High Energy Spin Physics (SPIN 01) (Dubna, August 2–7, 2001). — Dubna: JINR, 2002. — 388 p.: ill.

ISBN 5-85165-703-0

The book is a collection of reports presented at the IX Workshop on High Energy Spin Physics (Dubna, August 2–7, 2001) on different theoretical and experimental aspects of this branch of science. The workshop was dedicated to the 75th anniversary of the birth of L. I. Lapidus (1927–1986), initiator of this series of workshops.

Совещание по физике спина при высоких энергиях (SPIN 01) (9; 2001; Дубна).

Сборник докладов совещания по физике спина при высоких энергиях (SPIN 01) (Дубна, 2–7 августа 2001 г.). — Дубна: ОИЯИ, 2002. — 388 с.: ил.

ISBN 5-85165-703-0

В сборник вошли доклады, представленные на IX совещание по физике спина при высоких энергиях (теория и эксперимент), которое было посвящено 75-летию со дня рождения Л. И. Лапидуса (1927–1986) — инициатора этой серии совещаний.

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RECENT RESULTS ON MEASUREMENT OF TENSOR ANALYZING POWER COMPONENTS IN ELASTIC ELECTRON-DEUTERON SCATTERING IN THE RANGE OF MOMENTUM TRANSFER OF 0.2-0.8 $(GeV/c)^2$

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Abstract

An experiment on measurement of the components of tensor analyzing power in elastic and inelastic *ed* scattering successfully has been performed during the period 1999-2000 at the VEPP-3 electron storage ring, Novosibirsk. Substantial increase of the figure of merit of the experiment has been achieved with application of a novel, high intensity Atomic Beam Source of polarized atoms. The preliminary results on the measurement of the analyzing power component T_{20} in elastic scattering are presented. The measurement has been performed in the range of momentum transfer poorly investigated but important from theoretical point of view because of the node of the monopole charge form factor of the deuteron. The comparison of the other experimental data and some theories are discussed.

Key-words: Tensor analyzing power, deuteron form factors, electron scattering, polarized internal target, cryogenic atomic beam source.

Recent progress of polarization experiments in nuclear and particle physics greatly added to our understanding of the reactions under study. The polarization observables in both elastic and inelastic electron-deuteron scattering provide an important information for the investigation of the nucleon-nucleon interaction as well as for the study of non-nucleon degrees of freedom. Thus the measurement of the polarization observables in the

elastic electron-deuteron scattering together with the differential cross section measurement gives a possibility for complete experimental determination of the electromagnetic form factors of the deuteron (charge monopole, quadrupole and magnetic). Starting from 80th several laboratories (BATES, BINP, Bonn University, NIKHEF, TJNAF) have performed such an experiments in a different modifications.
Here we present recent results on the T_{20} analyzing power measurement which were obtained in the experiment with the use of internal polarized deuterium target in the storage ring VEPP-3, Novosibirsk, at 2 GeV electron energy.

A new Atomic Beam Source has been designed and constructed to fill the storage cell target by polarized atoms [1]. It has a conventional design of the dissociator and high-frequency transitions units. The main difference of this ABS from the other modern sources is the usage of the superconductive sextupole magnets instead of permanent ones usually used. That allows to provide a magnetic pole-tip field three times as larger as that for the best permanent magnets and consequently a higher flux of polarized atoms is available from the source. Magnet system consisting five superconductive magnets delivers 8.2×10^{16} polarized deuterium atoms per second injected into the storage cell.

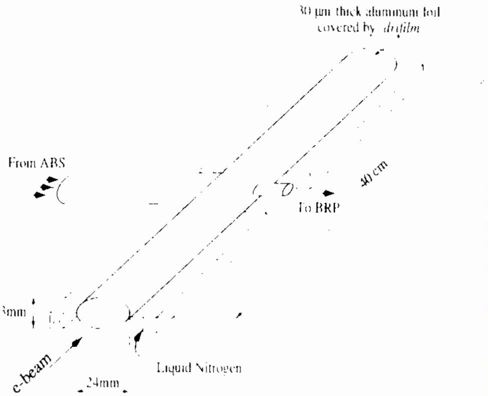


Figure 1: Storage cell for polarized atoms.

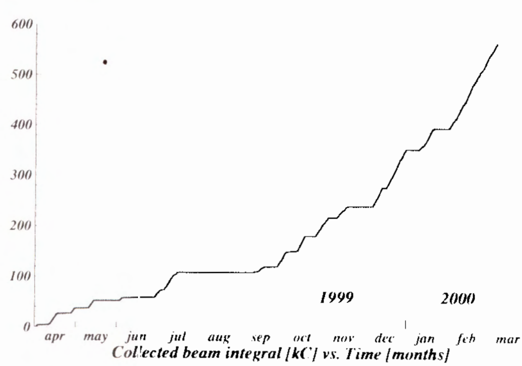


Figure 2: Collected beam integral.

The electron beam optics in the experimental section of VEPP-3 ring was modified to get the possibility to use a small-aperture storage cell. An aluminum (0.03 mm thick) storage cell has an elliptic cross section 13 × 24 mm, the length of 400 mm and coated by 'dri-film' to prevent atoms from depolarization during the wall collisions, see Fig. 1. The cell is cooled by liquid nitrogen to low temperature to get a more densed target.

The particle detector (partly described in [2]) has two identical systems. For the registration of the particle tracks different sets of drift chambers are employed. Each of the systems has a segmented CsI + NaI electron calorimeter (total thickness is 16 radiation lengths) on one side of the electron beam and a hadron scintillation hodoscope (3 layers of plastic scintillators with a total thickness of 26 cm) on the other side. Angular acceptance of each electron arm is $\theta = 20° \ldots 30°$ and $\Delta\phi = 60°$ and that for each hadron arm is $\theta = 60° \ldots 70°$ $\Delta\phi = 60°$. The detection system permits to identify the $D(e, e'd)$, $D(e, e'p)n$ and $D(e, pp)e'\pi^-$ events.

In March 1999 all the equipment was assembled at the VEPP-3. The electron beam current integral of 566 kC was collected during almost one year run, as shown in Fig. 2. A large amount of data for both elastic and inelastic scattering channels was collected.

The tensor polarization of the atomic beam injected into the storage cell is monitored by the Breit-Rabi polarimeter and polarization is very high, about 98%. However, the degree of the polarization in the storage cell is lower due to the depolarization effects, which couldn't be numerically accounted for. Moreover, the polarization is getting worse during the run because of degradation of the cell surface. To control the average polarization of the target during the run so-called Low-Q polarimeter based on the measurements of the asymmetry in elastic *ed* scattering was installed at a small angle ($\theta_e \approx 9°$) where the absolute measurement of the analyzing power T_{20} is available [3]. The polarization of the target versus the time extracted with the use of Low-Q polarimeter is shown in Fig. 3.

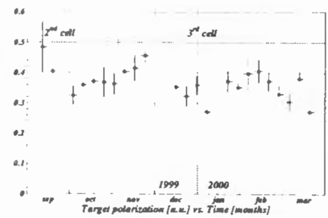


Figure 3: Polarization of the target vs time measured with Low-Q polarimeter.

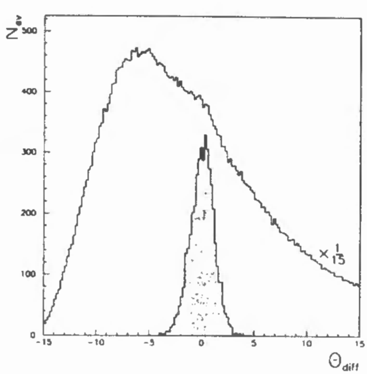


Figure 4: The correlation of the electron-deuteron polar angle in elastic scattering. See text for details.

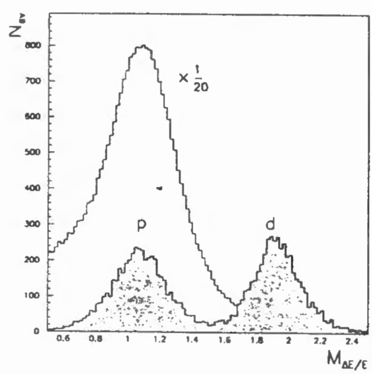


Figure 5: The distribution for mass identification parameter in E-ΔE method.

The cross section of elastic *ed* scattering falls dramatically as compared with the quasi-elastic one when the momentum transfer is increased. To extract the events of the elastic scattering among a lot of background events three kinematical correlations and two particle identification methods were applied:

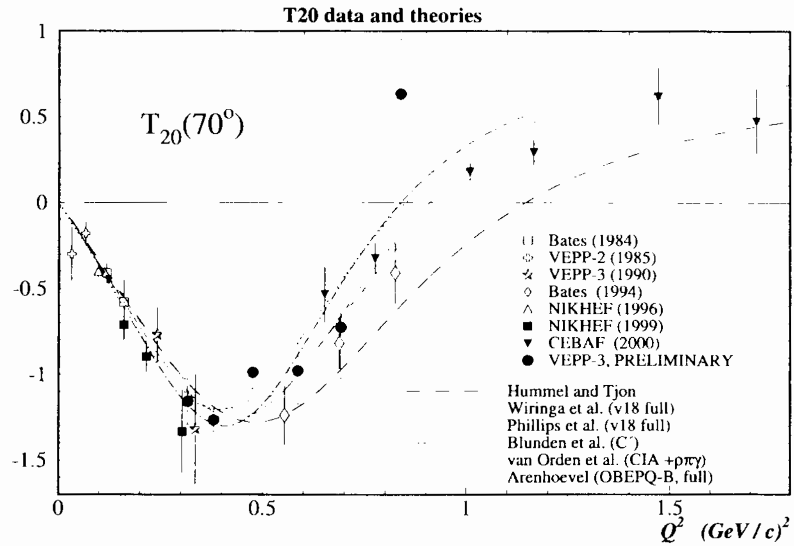
e-d polar angles correlation ,

e-d azimuthal angles correlation,

scattering angle - deuteron energy
correlation,
E-ΔE method,
time of flight method.

In Fig. 4 two histograms of Θ_{diff} are shown. The Θ_{diff} is difference between the measured electron polar angle (Θ_e) and the one deduced from the measured hadron polar angle in assumption that events belong to elastic scattering process. One can see the wide distribution for events connected mainly with proton knock out process (solid histogram). The shaded histogram corresponds to elastic e-d scattering events that are selected by the application of the last four cuts mentioned above.

Preliminary results of the run-99/00 at VEPP-3



Theories:

- E.Hummel and J.A.Tjon, Phys. Rev. C42(1990)423
- P.G.Blunden, W.R.Greenberg and E.L.Lomon. Phys. Rev. C40(1989)1541,
  E.L.Lomon, nucl-th/0002026
- J.W.Van Orden, N.Devine and F.Gross, Phys. Rev. Lett. 75(1995)4369
- R.B.Wiringa, V.G.J.Stoks and R.Schiavilla, Phys. Rev. C51(1995)38
- H.Arenhövel, F.Ritz and T.Wilbois, Phys. Rev. C61(2000)034002

Figure 6: World data on T_{20} measurement in elestic ed scattering versus the square of momentum transfer and some theoretical predictions.

In Fig. 5 the distributions for identification parameter of E-ΔE method are shown. The solid histogram is obtained for the all events. The shaded histogram is for the case when four other cuts are applied. One can see two quite separable peaks (protons and deuterons).

The preliminary results obtained for the tensor analyzing power component T_{20} are shown in Fig. 6 together with the existing world data and with predictions of several theoretical models.

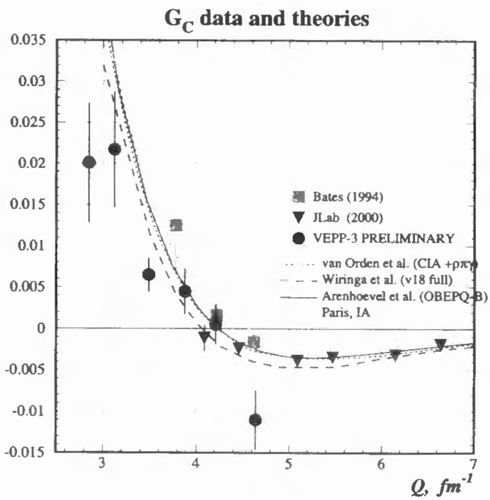
These data are provided by one of the detection system that is sensitive mostly to T_{20} (the other one is sensitive mostly to T_{21} component). Small corrections were applied to calculate T_{20} at the conventionally accepted angle $\Theta_e = 70°$. The shown error bars include statistical errors only. The measurement of T_{20} was performed in the range of momentum transfer where it reaches the minimum and where the experimental data are poor. Analysis of the available theories has shown that the theoretical description of T_{20} given by Wiringa *et al.* (v18full) and Blunden *et al.* (C') ensure almost the same good fit to our experimental data. It seems that prediction for T_{20} given by van Orden *et al.* (CIA + $\rho\pi\gamma$) provides the best description of the experimental data in the whole range of momentum transfer available so far.

The data on the tensor analyzing power component T_{20} in elastic *ed* scattering together with the data on the unpolarized elastic differentional cross section provide a possibility to extract each form factor separately. The results for the monopole G_c charge form factor are shown in Fig. 7. The results show a node located at a lower value than inferred from the Bates measurements and agree well with the recent measurements at JLab [9].

The large amount of data are collected in inelastic channels (reactions $D(e,e'p)n$ and $D(e,pp)e'\pi^-$). The analysis of these data are in progress.

This work was supported in part by the Russian Fund for Fundamental Research under Grants 01-02-16929, 01-02-17276 and State Scientific and Technical Programm (Fundamental Nuclear Physics) 01-31/SC-FNP.

Preliminary results of the run–99/00 at VEPP–3



Node of the G_C : at $Q = 4.05 \pm 0.08$ fm^{-1}
Bates: 4.39 ± 0.16 fm^{-1} JLab+Bates: 4.21 ± 0.08 fm^{-1}

Figure 7: The data on G_c measurement in elastic ed scattering and some theoretical predictions.

References

[1] L.G. Isaeva *et al.*, Proc. of 13th Int. Symp. on High Energy Spin Phys., Protvino, Russia, Word Scientific, p.631 (1998).

[2] Theunissen J.A.P. *et al.*, Nucl. Instrum. and Methods, **A 348**, 61 (1994).

[3] M. Ferro-Luzzi *et al.*, Phys. Rev. Lett. **77**, 2630 (1996).

[4] E. Hummel and J. Tjon, Phys. Rev. **C42**, 423 (1990).

[5] R.B. Wiringa, V.G.J. Stoks and R. Schiavilla, Phys. Rev. **C51**, 38 (1995).

[6] P.G. Blunden, W.R. Greenberg and E.L. Lomon, Phys. Rev. **C40**, 1541 (1989).

[7] J.W. Van Orden, N. Devine and F. Gross, Phys. Rev. Lett. **75**, 4369 (1995).

[8] H. Arenhövel, F. Ritz and T. Wilbois, arXiv:nucl-th/9910009 v2 1 Dec 1999.

[9] D. Abbot *et al.* Phys. Rev. Lett. **84**, 5053 (2000).

Discussion

Q (Piskunov): What are you planning to measure in the nearest two years?

A: In the next year, we plan to study photodisintegration of a tensor polarized deuteron with a detector specially modified for this purpose.

C(Belostotsky): My remark is to try to clarify the question by A.Efremov about T_{20} in the $e\,\vec{d}$-elastic and $\vec{d}\,p$ fragmentation. In the $e\,\vec{d}$ elastic, T_{20} is sensitive to the F_Q/F_C form factors ratio. In the deuteron fragmentation, T_{20} is sensitive to the $\frac{U_d}{U_s}$ ratio of the d/s state deuteron wave functions in momentum space. So, both the values are different but tightly related.

Q (Uzikov): What is the upper limit for Q^2 in T_{20}-measurements expected in the nearest future? According to potential models, T_{20} has to change sign again at $Q^2 > 1$ GeV^2.

A: Unfortunately, I don't know any group who is going to continue the T_{20} measurements for higher momentum transfers.

Q (Efremov): Could you explain why T_{20} obtained by the Strunov group is negative for large momenta, but your T_{20} became positive?

A: In my talk, I considered T_{20} that appears in elastic $e\,\vec{d}$ scattering. If a probe particle is strongly interacting, T_{20} can probably change.

Q (Mikirtytchiants): Was the degree of dissociation along the storage-cell measured?

A: In Novosibirsk, this kind of measurements was never performed. May be, some useful information is contained in measurements from the HERMES storage cell.