Study of the analysing powers in deuteron-proton elastic scattering at Nuclotron

The purpose of the DSS experimental program is to obtain the information about two- and three nucleon short-range correlations (including their spin-dependent parts) from deuteron induced reactions at the Nuclotron (LHEP JINR). The program includes the beam energy scan of the polarization observables of dp-elastic scattering in the wide energy range, systematic studies of dp-nonmesonic breakup in different kinematic configurations at the intermediate energies using internal target and polarized and unpolarised deuteron beam at the Nuclotron. In perspective, the experiments on the measurements of the tensor analysing power and spin correlation parameter in the (d,p) reactions on different targets can be performed using extracted deuteron beam at the Nuclotron.

Short range correlations (SRC) of nucleons in nuclei is the subject of intensive theoretical and experimental works during last years. Since SRC have densities comparable to the density in the centre of a nucleon which is several times higher than the normal nuclear matter density, they can be considered as the drops of the cold dense nuclear matter. These studies explore a new part of the phase diagram and very essential to understand the evolution of neutron stars. The studies of the SRC were performed recently at BNL, SLAC and JLAB. The use of the polarized deuteron beam at the Nuclotron (and in future at NICA) allows to investigate the spin effects for multi-nucleon correlations in a wide energy range, and, therefore, to obtain the information on the spin parts of the SRCs which are very scarce at the moment.

The goal of the investigation is to obtain new experimental data on the vector Ay, tensor Ayy, Axx analysing powers in deuteron- proton elastic scattering at large angles in the cms in the energy range of 800-1000 MeV. The student will study the details of new polarized ion source working, the methods of the deuteron- proton elastic scattering detection using internal target at the Nuclotron, the scheme of the deuteron beam polarimetry. The analysis of the data will be performed within ROOT package with the use of C++.

The scheme of the DSS setup at internal target at the Nuclotron is shown in Fig.1. The beam interacts with polyethylene (or carbon) target. The scattered deuterons and recoil protons from the elastic scattering are detected by the scintillation counters in the coincidence.

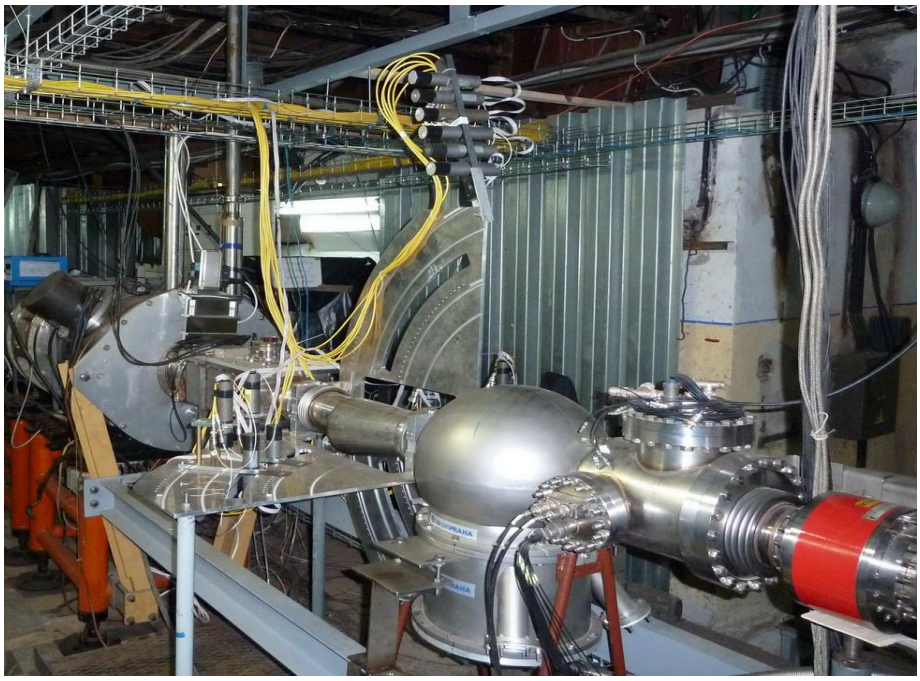

Fig.1. The experimental setup for the SRCs studies at internal target station at the Nuclotron.

Two polarized and one unpolarised spin modes of new polarized ion source are used to measure vector and tensor analysing powers using the scattering on the left, right, up and down. Up to 50 detectors are used simultaneously to detect the deuteron-proton elastic scattering events. Effect on hydrogen is obtained using CH2-C subtraction techniques. The beam polarization is measured using dp-elastic scattering at 270 MeV, where the values of the analysing power are well known.

Deuteron-proton elastic scattering events are selected using amplitude and timing information for each spin mode of the ion source. The values of the analysing powers are obtained using standard formulas taking into account the normalized number of events and measured values of the beam polarization. The obtained results should be presented as the tables and as graphs within ROOT.

The requirements to the student are the following: knowledge of ROOT package and C++ language, knowledge of the definitions of the analysing powers and their relations with the cross section.

I would like to recommend to the student the following papers to be read:

P.K.Kurilkin et al., Nucl.Instrum.Meth.in Phys.Res. A642 (2011) 45-51.
P.K.Kurilkin et al., Phys. Lett.B715 (2012) 61-65.
N.B.Ladygina, Eur.Phys.J. A42 (2009) 91-96.
N.B.Ladygina, Phys.Atom.Nucl. 71 (2008) 2039-2051.
N.B. Ladygina, Eur.Phys.J. A52 (2016) 199.
G.Ohlsen, Rept.Prog.Phys. 35 (1972) 717-801.

Number of students – 1.

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Scientific interests: spin effects and polarization phenomena in hadronic reactions, short-range correlations, polarimetry, heavy ion collisions.

Main publications of the DSS project

A.A.Terekhin et al., arXiv: 1503.07968[nucl-ex],
to be published in Phys.Part.Nucl.Lett. (2015).
P.G.Akishin et al., Phys.Part.Nucl.Lett. 12 (2015) 305-309.
V.P.Ladygin et al., Few Body Syst. 55 (2014) 709-712.
M.Janek et al., Phys.Part.Nucl.Lett. 11 (2014) 552-559.
V.P.Ladygin et al., Phys.Part.Nucl. 45 (2014) 327-329.
P.K.Kurilkin and V.P.Ladygin, Phys.Part.Nucl. 45 (2014) 265-267.
N.B.Ladygina, Phys.Part.Nucl. 45 (2014) 187-189.
A.K.Kurilkin et al., Phys.Rev.C87 (2013) 051001(R).
A.Yu.Isupov et al., Nucl.Instrum.Meth.in Phys.Res. A698 (2013) 127-134.
Yu,V.Gurchin et al., Phys.Part.Nucl.Lett. 10 (2013) 243-247.
S.M.Piyadin et al., Phys.Part.Nucl.Lett. 9 (2012) 589-592.
P.K.Kurilkin et al., Phys. Lett.B715 (2012) 61-65.
N.B.Ladygina, Few Body Syst. 53 (2012) 253-265.
V.V.Glagolev et al., Eur.Phys.J. A48 (2012) 182.
S.M.Piyadin et al., Int.J.Mod.Phys. A26 (2011) 683-685.
N.B.Ladygina, Int.J.Mod.Phys. A26 (2011) 728-730.
P.K.Kurilkin et al., Phys.Part.Nucl.Lett. 8 (2011) 1081-1083.
A.K.Kurilkin et al., Phys.Part.Nucl.Lett. 8 (2011) 1078-1080.
Yu.V.Gurchin et al., Phys.Part.Nucl.Lett. 8 (2011) 571-575.
S.M.Piyadin et al., Phys.Part.Nucl.Lett. 8 (2011) 1084-1086.
Yu.V.Gurchin et al., Phys.Part.Nucl.Lett. 8 (2011) 566-570.
P.K.Kurilkin et al., Nucl.Instrum.Meth.in Phys.Res. A642 (2011) 45-51.
P.K.Kurilkin et al.,Int.J.Mod.Phys. A24 (2009) 530-533.
A.K.Kurilkin et al.,Int.J.Mod.Phys. A24 (2009) 526-529.
N.B.Ladygina, Eur.Phys.J. A42 (2009) 91-96.
V.P.Ladygin et al., Few Body Syst. 44 (2008) 45-48.
N.B.Ladygina, Phys.Atom.Nucl. 71 (2008) 2039-2051.
M.Janek et al., Phys.Atom.Nucl. 71 (2008) 1495-1501.
A.S.Kiselev et al., Eur.Phys.J. ST162 (2008) 143-146.
A.K.Kurilkin et al., Eur.Phys.J. ST162 (2008) 133-136.
P.K.Kurilkin et al., Eur.Phys.J. ST162 (2008) 137-141.

M.Janek et al., Eur.Phys.J. A33 (2007) 39-46.
Yu.V.Gurchin et al., Phys.Part.Nucl.Lett. 4 (2007) 263-267.
T.Uesaka et al., Phys.Part.Nucl.Lett. 3 (2006) 305-311.
V.P.Ladygin et al., Phys.Atom.Nucl. 69 (2006) 1271-1278.
M.Janek et al., Int.J.Mod.Phys. A20 (2005) 646-648.
V.P.Ladygin et al., Phys.Lett. B598 (2004) 47-54.
V.P.Ladygin and N.B.Ladygina, Phys.Atom.Nucl. 65 (2002) 1609-1615.

V.P.Ladygin, I.Dobrin, V.V.Fimushkin, D.A.Finogenov, S.G.Genchev, Yu.V.Gurchin, A.P.Ierusalimov, A.Yu.Isupov, K.Itoh, M.Janek, E.V.Karpechev, J.-T.Karachuk, S.V.Khabarov, T.Kawabata, A.N.Khrenov, A.B.Kurepin, A.K.Kurilkin, P.K.Kurilkin, N.B.Ladygina, D.Lipchinski, A.N.Livanov, Y.Maeda, A.I.Malakhov, G.Martinska, S.M.Piyadin, J.Popovichi, A.N.Prokofichev, A.I.Reshetin, S.G.Reznikov, P.A.Rukoyatkin, S.Sakaguchi, H.Sakai, Y.Sasamoto, K.Sekiguchi, Ya.G.Skhomenko, K.Suda, V.V.Syschenko, G.Tarjanyiova, A.A.Terekhin, T.Uesaka, J.Urban, I.E.Vnukov, N.I.Zamiatin, E.V.Zubarev

Collaboration: Bulgaria-Japan-JINR-Romania-Russia-Slovakia

Probing the Deuteron short-range Spin Structure in the (d,p) reactions using polarized deuteron beam at Nuclotron