Report on the project

“Probing the Deuteron short-range Spin Structure in (d,p) reactions using polarized deuteron beams at Nuclotron-M (DSS)”

JINR (Dubna) has a long and successful history in studying spin physics, both experimentally and theoretically. The present Project continues these traditions.

In general, spin effects are weaker and smaller compared to the observables in reactions with unpolarized particles, that makes relevant experiments more difficult but at the same time more rewarding. Measuring the deuteron spin structure is a routine but very important part along these lines. Unrevealing new effects, in particular the short range spin structure requires high-accuracy experiments and skilled personal to analyze the data. The DSS team provides both, as demonstrated in the present Proposal. Despite the limitations in data taking during 2019-2021, when the Nuclotron could not provide beams because of the construction works at NICA, the DSS team continued working focusing on the analysis of the data collected earlier, namely: analysis of cross sections and analyzing powers in *dp* elastic scattering at the Nuclotron, *dp* non-mesonic breakup below 500 MeV, deuteron and proton beam polarization measurements etc. Even though the 2019-2021 break in data taking happened for objective reasons, still it disfavored DSS' highest classification.

The temporary stoppage in data taking caused by construction works at NICA was not in vain: during that time the DSS team made significant progress in the development of tensor-vector deuteron polarimetry, made first measurements of the proton polarization with internal targets, promising for future experiments at NICA

Among future measurements of first priority should be measurements of the nucleon analyzing power in proton-deutron elastic scattering, provided intense proton beams will be available. Such measurements by DSS are promising also for future SPD at NICA.

The DSS experiment may have also interesting astrophysical applications, namely in studies of the cold and dense nuclear matter. Since the Deuteron short-range Spin Structure (SCR) deals with densities comparable with those in the center of the nucleon (about ρ ≈1 fm-3), it can be related to drops of cold and dense nuclear matter, typical of neutron stars. These studies deserve more attention from the DSS team as well as close collaboration e.g. with theorists working at the Bogolubov Laboratory for Theoretical Physics at JINR. Theses studies will definitely raise the classification of the Project towards category A. Hereby I recommend closer collaboration with theorists on “hot” problems, including: a) new insight in hadron structure and dynamics (origin of polarization, collective properties of nuclear matter, quark confinement), b) cold and dense nuclear matter in laboratory and in the universe (e.g., in neutron stars).

Finally, let me mention recent findings in spin physics, revealed to ultra-relativistic heavy-ion collisions: the STAR collaboration4 discovered a significantly nonzero global polarization of Lambda hyperons produced in non-central Au–Au collisions in the RHIC Beam Energy Scan (BES) Program4 . Different hydrodynamic models generally reproduce the magnitude of the measured polarization. In the hydrodynamic models, the Lambda hyperons produced at “particlization” (fluid to particle transition) hypersurface acquire polarization via a thermodynamic spin-vorticity coupling mechanism. This effect is interesting as a possible manifestation of the most vortic fluid ever made. Future involvement of the DSS team in this and/ore related studies will definitely increase its classification, from **B** to **A**.

The estimated cost of the Project and the requested beam time are reasonable. Impressive is the presence of a considerable group from Japan as well as from the Slovak Republic. The number and level of DSS’s publications, including those by young scientists is reasonable.

Hereby I propose to approve the project for 2022-2024 with first priority.

***Classification****: in my opinion, the present project corresponds to category B with good prospect to advance towards A, provided my recommendations will be satisfied.*



Laszlo Jenkovszky (BITP, Kiev)

jenk@bitp