Letter of intent

SPCHP SPin Control for Hadron Physics-experiments

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1. Research objective

The goal of the project is to offer complete knowledge and control of the electron-spin-vector in scattering experiments for hadron physics, i.e. knowing its length (known as "spin-polarization") and the values of its individual spatial components. This is intended to act as service provision for the TNA-activities at the MAMI/MESA facilities in Mainz. It will allow the international groups working at the P2-experiment at MESA to increase the accuracy of their results.

A chain of polarimeters is available for MESA so that a statement of polarisation accuracy of an experiment will be based on at least two independently calibrated devices. An improvement of a single polarimeter should therefore ideally happen together with a corresponding improvement of another one in the chain.

The project will therefore aim at improvement of accuracy for two of the polarimeters, namely the 5 MeV Mott-polarimeter and the Möller polarimeter which uses a beam energy of 55-155 MeV in front of the P2-experiment where mainly parity violating observables will be measured by the international groups (from France, USA and Canada and, of course, Mainz) that contribute to the P2-project.

To achieve this, experienced personnel at the Post-Doc level is indispensable to carry out the measurement campaigns. We identify three main work packages which will serve to fulfill the needs mentioned above. These will be covered by the following approaches:

1.) **Online capability for Mott-polarimeter at MESA**

Mott scattering is inherently an invasive measurement. Moreover, to avoid radiation damage, the beam has also to be directed by an extraction magnet to a dedicated beam dump. For the polarimeter at MESA an air-coil based extraction magnet is available which offers to use "kicker"-like extraction schemes, for instance to distribute a 1ms fraction every second to the polarimeter which will create a quasi-online measurement, while the experiment itself uses the beam for 99.9% of the available time. Whereas the technical basis for this (e.g. fast kicker magnet with no remanence effects) is already available, it must be investigated which time structure is suitable in order not to interfere with the experiment, for instance how to compensate for the missing power-load on the target. Moreover, during the switching process of the magnet, the beam must be switched off for a period of about 100 Microseconds, which will cause similar concerns. This will have to be pursued in tight cooperation within the international P2-collaboration, to guarantee the most efficient use of data taking time. A continuous polarization measurement will eliminate the interpolation of polarization drifts happening during extended intervals between polarization measurements, leading to reduced inaccuracies.

2.) **Experimental test of radiative corrections to the polarimeter analyzing power.**
One of the main error sources in Mott-polarization measurements is the theoretical prediction of the analyzing power (S) of the scattering process. The polarization (P) is extracted from the experimentally observed scattering rate asymmetry A=S*P. Recent theoretical studies in non-perturbative QED quote a considerably reduced uncertainty of S because radiative corrections have been treated with improved models. We propose to experimentally test the validity of these model-based statements by examining the observed asymmetry for different nuclear charges, on which these corrections have a sensitivity. Our polarimeter is equipped with a target station that can hold a wide variety of targets. Therefore, the technical conditions are available, but the measurements must be done with great care by experienced personnel. If a coherent picture of radiative corrections can be obtained, the accuracy of the polarimeter may be improved considerably.

3.) **Accurate target polarization determination in Möller polarimeter.**
The Möller-polarimeter at MESA will use a superconducting solenoid to polarize electrons in a ferromagnetic (iron-) target. In this case, accurate determination of target polarization is the main accuracy-limiting factor. In the case of MESA, the very low beam energy will require thinner iron targets as commonly used. In this work package, the effect of target deformation due to imperfections (e.g. wrinkles) and mechanical deformations which result from a non-perfect alignment with respect to the magnetic field will be investigated. A further part of the work package is to provide knowledge on transverse spin components which are in some cases unwanted and must be eliminated with the greatest possible precision. This project requires not only expert knowledge in target polarimetry but also in effects of ferromagnetic substances with regard to very accurate statements on their magnetization (spin-density) during the experiment.

2. Connection to Transnational Access infrastructures (TAs) and / or Virtual Access projects (VAs)

The project acts as service provision for the TNA -activities at the MAMI/MESA facilities in Mainz. It will serve the international groups working at the P2-experiment at MESA to increase the accuracy of their results. The most striking example is parity violating scattering on Carbon-12 where the systematic error - and therefore the impact of the achieved result - will be dominated by the uncertainty of spin-polarization.

3. Estimated budget request

2*3 years Post-Doc salary – based on 65k€ salary /year 375k€

Travel (conferences, workshops) 25k€

4. Participating and partner institutions

Johannes Gutenberg University Mainz – Institute of Nuclear Physics

Partners - P2-project: University Paris/Saclay (France); University of Manitoba (Canada); University of Massachussets (USA)