Towards Polarized Antiprotons at FAIR

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In order to clarify the role of polarized electrons in the spin filtering process, we have recently submitted a Letter-of-Intent to COSY [1] to carry out spin filtering studies with proton beams. Understanding the interplay of the nuclear interaction with polarized protons and the electromagnetic interaction with polarized electrons in the polarized target atoms is crucial to progress towards the PAX goal to eventually produce stored polarized antiproton beams at FAIR. At the AD–ring of CERN, using stored antiprotons, we will determine for the first time the two total spin–dependent cross sections σ_1 and σ_2 at antiproton beam energies in the range from 50 to 200 MeV [2]. The data will allow the definition of the optimum working parameters of a dedicated Antiproton Polarizer Ring (APR), which has recently been proposed by the PAX collaboration for the new Facility for Antiproton and Ion Research (FAIR) at GSI in Darmstadt, Germany. The experimental equipment for the AD spin filtering studies comprises a polarized internal Hydrogen storage cell target, surrounded by a detector system residing in a dedicated low-β section, and a Siberian snake for the opposite straight section of the AD ring to provide a stable longitudinal beam spin direction at the target. This equipment will be commissioned during the COSY spin filtering studies.

The availability of an intense beam of polarized antiprotons will provide access to a wealth of single– and double–spin observables, thereby opening a new window to QCD transverse spin physics. The physics program proposed by the PAX collaboration [3] includes a first measurement of the transversity distribution of the valence quarks in the proton, a test of the predicted opposite sign of the Sivers–function, related to the quark distribution inside a transversely polarized nucleon, in Drell–Yan (DY) as compared to semi–inclusive Deep Inelastic Scattering, and a first measurement of the moduli and the relative phase of the time–like electric and magnetic form factors $G_{E,M}$ of the proton.

A low–energy Antiproton Polarizer Ring (APR) yields — depending on the spin filtering mechanism — an antiproton beam polarization of $P_{\bar{p}} = 0.2$ to 0.3 after about two beam life times, which is of the order of 5–10 h. By using an internal $H^{\uparrow}$ target and a detector installed in a 3.5 GeV/c Cooler Synchrotron Ring (CSR), the Phase–I experimental $\bar{p}^{\uparrow}p^{\uparrow}$ program could start in 2014, completely independent of the operation of the HESR. In Phase–II, the CSR serves as an injector for the polarized antiprotons into the HESR. A

chicane system inside the HESR is proposed to guide the high–energy $\bar{p}^{\uparrow}$ beam to the PAX detector, located inside the CSR straight section. In Phase–II, fixed–target or collider $\bar{p}^{\uparrow}p^{\uparrow}$ experiments over a broad energy range become possible. In the collider mode, polarized protons stored in the CSR up to momenta of 3.5 GeV/c are bombarded head–on with 15 GeV/c polarized antiprotons stored in the HESR. This asymmetric double–polarized antiproton–proton collider is ideally suited to map e.g. the transversity distribution in the proton. This collider scenario also facilitates transversity studies in pp collisions.

In this talk we briefly outline the PAX physics program and give an overview about the current status of the planning for the required spin filtering studies at COSY and at the AD of CERN.

[1] Letter of intent for *Spin–Filtering Studies at COSY*, PAX Collaboration, Spokespersons: P. Lenisa (Ferrara University, Italy) and F. Rathmann (Forschungszentrum Jülich, Germany), available from `http://www.fz-juelich.de/ikp/pax`.

[2] Letter–of–Intent for *Measurement of the Spin–Dependence of the $\bar{p}p$ Interaction at the AD–Ring*, PAX Collaboration, Spokespersons: P. Lenisa (Ferrara University, Italy) and F. Rathmann (Forschungszentrum Jülich, Germany), available from `arXiv:hep-ex/0512021 (2005)`.

[3] Technical Proposal for *Antiproton–Proton Scattering Experiments with Polarization*, PAX Collaboration, Spokespersons: P. Lenisa (Ferrara University, Italy) and F. Rathmann (Forschungszentrum Jülich, Germany), available from `arXiv:hep-ex/0505054 (2005)`. An update of this proposal can be found at the PAX website `http://www.fz-juelich.de/ikp/pax`.