Spin Filtering of Stored (anti)Protons from FILTEX to COSY to AD to FAIR

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The enormous physics potential of experiments with highly polarized antiprotons calls for the theoretical scrutiny of methods to effectively polarize the stored antiprotons. The PAX (Polarized Antiproton eXperiment) proposal for the High Energy Storage Ring (HESR) at GSI (Darmstadt/Germany) forsees the spin filtering based on a multiple passage of a stored beam through a polarized internal gas target [1]. Apart from the polarization by the spin-dependent transmission, a unique geometrical feature of interaction with the target in such a filtering process, pointed out by H.O. Meyer [2], is a scattering of stored particles within the ring - stored particles which scatter elastically within the acceptance of the storage ring stay within the stored beam. A contribution from such partcles – they would have been lost in the conventional transmission experiments – which acquire the polarization by spin transfer from the target and whose spin rotates and flips in the scattering process, affects the polarization buildup and must be accounted for. We derive here a quantum-mechanical evolution equation for the spin-density matrix of a stored beam which incorporates the scattering within the ring. We show how the interplay of the transmission and scattering within the ring changes from polarized electrons to polarized protons in the atomic target. Specifically, scattering of heavy (anti)protons off light electrons is entirely within the ring. We argue that there is an almost exact cancellation of effects of the transmission and scattering with the ring, so that interaction with polarized electrons would not contribute at all to the spin filtering of stored (anti)protons [3]. After discussion of the FILTEX results on the filtering of stored protons [4], we comment on the strategy of spin filtering of antiprotons for the PAX experiment at GSI FAIR [1].

There exists an alternative scenario by H.O. Meyer [2] in which polarized electrons contribute to spin filtering via the polarization transfer from electrons to protons – it even gives a somewhat better description of the FILTEX result. We argue that the two scenarios can be distinguished by an accurate measurement of the filtering rate for transverse and longitudinaly polarized protons at COSY, which studies would define a further optimization of spin fitering of anriprotons.

[1] Paolo Lenisa, Frank Rathmann, for the PAX collaboration, hep-ex/0505054

[2] H.O. Meyer, Phys. Rev. E 50, 1485 (1994); C.J. Horowitz and H.O. Meyer, Phys. Rev. Lett. **72**, 3981 (1994)

[3] N. N. Nikolaev and F. F. Pavlov, arXiv:hep-ph/0601184; similar conclusions were reached by A.I. Milstein and V.M. Strakhovenko, Phys. Rev. E **72**, 066503 (2005).

[4] F. Rathmann et al., Phys. Rev. Lett. **71**, 1379 (1993).