Search for Electric Dipole Moments with Polarized Beams in Storage Rings.

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An electric dipole aligned along the spin axis of a fundamental particle, nucleus, or atomic system violates both parity conservation and time reversal invariance. The observation of such a phenomenon would, at present or proposed levels of experimental sensitivity, signal new physics beyond the Standard Model.

The usual method for identifying an electric dipole moment (EDM) in such searches is to observe the rotation of the spin axis or polarization under the influence of a strong electric field. The use of a storage ring opens the search to charged, polarized particles such as the proton, deuteron, ^{3}He, etc. that would otherwise not be manageable in such a field. The best procedure begins with the alignment of the beam polarization along the velocity of the beam followed by the observation of any slow rotation of that polarization into the vertical direction perpendicular to the ring. Electric ring fields of the right strength or the correct combination of electric and magnetic ring fields are needed to ensure that the polarization does not rotate relative to the velocity ("frozen" spin).

This imposes several feasibility requirements. First, the ring must utilize a special combination of higher order fields to ensure that the usually unstable polarization along the direction of the velocity remains for times up to 1000 s to allow any EDM effect to accumulate to a measurable level. Second, the beam must be slowly sampled during the storage time by a polarimeter capable of detecting a change in the vertical polarization of several μrad over the 1000 s storage time. The required large polarimeter efficiency and polarization sensitivity may be achieved by continuously extracting the beam onto a carbon target several cm thick. In combination with an array of calorimeter detectors that emphasize elastic scattering events at forward angles, it has been shown to be possible to meet these requirements for an EDM search [1]. In addition, when the sensitivity of the polarimeter to systematic rate and geometric errors is calibrated, it becomes possible to correct the measurements in real time using only the online data itself to levels approaching or exceeding 1 ppm. This demonstration was made using the EDDA detector [2,3] located on the Cooler Synchrotron (COSY) at the Forschungszentrum-Jülich [4]. First results covering the contribution of synchrotron oscillations to RF-solenoid induced spin resonances may be found in Ref. 5.

At present, dedicated studies are being performed at COSY to examine the use of higher-order (sextupole) fields in the storage ring to lengthen the coherence time of the stored, horizontal beam polarization. To support these studies, a novel polarimeter system has been developed that is capable of monitoring the horizontal polarization of the beam circulating in the ring as it precesses at ~120 kHz. So far, the sextupole fields have been tuned to produce horizontal polarization lifetimes in excess of 200 s.

This presentation is meant to provide a general introduction to the EDM search by means of polarized beams in storage rings and to highlight the developments in the polarimeter system accomplished at the COSY ring at FZ-Jülich

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