Vector and tensor polarization lifetimes for a stored deuteron beam

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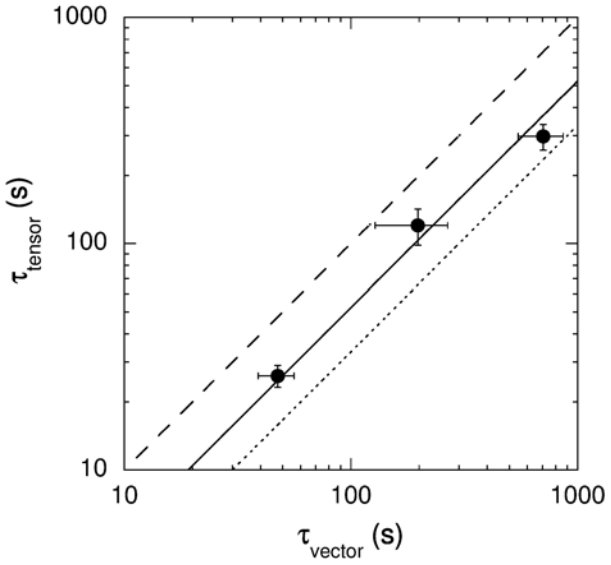
A. Motivation

Usually, the lifetime of the beam polarization is large compared to the lifetime of the stored beam itself, but near a depolarizing resonance the polarization lifetime decreases. This has been studied for protons near an intrinsic depolarizing resonance as a function of the distance to the resonance, given by the machine tune [1]. A similar measurement was also carried out near a resonance that was induced by a longitudinal RF magnetic field [2]. In this case, the distance to the resonance was varied by changing the resonance frequency.

Spin-1 particles can have the projections +1, 0 and –1 with respect to the spin alignment axis, with the respective relative populations of the three states of n_+, n_0 and n_-. Vector polarization is then defined as $P_{vector} = n_+ - n_-$, and tensor polarization as $P_{tensor} = 1–3n_0$. The present experiment was prompted by a speculation that the lifetimes of the two kinds of polarization may differ [3].

B. Experiment

We have measured the time dependence of the vector and tensor polarization of a 270 MeV stored deuteron beam near an RF-induced, depolarizing resonance. The distance to the resonance was varied by changing the oscillation frequency, in such a way that the polarization lifetimes were in the range from 10 s to 1000 s, and could thus be observed easily. The measurement was performed with the Indiana Cooler with the PINTEX detector [4], using a hydrogen gas target. The beam polarization was deduced from the azimuthal dependence of the d+p elastic scattering yield, together with the known analyzing powers [5] of this reaction. The polarization lifetime was then calculated from the time dependence of the measured polarization during a cycle of typically 300 s in length. A given cycle was repeated until the desired statistical uncertainty was obtained. The resulting tensor and vector polarization lifetimes are shown in the Fig.1 for three different distances from the resonance. The dashed line corresponds to equal lifetimes. The solid line shows a fit that yields the ratio $\tau_{vector}/\ \tau_{tensor} = 1.9 \pm 0.2$. The short-dashed line marks the theoretical maximum lifetime ratio of 3.0.



C. Conclusion

One may say that the depolarization mechanism induces transitions between magnetic substates of the stored ensemble. If q_1 is the transition rate between neighboring substates (n_+-n_0, or n_0-n_-), and q_2 the transition rate between n_+ and n_-, then the observed ratio, $\tau_{vector}/\ \tau_{tensor} \sim 2$, implies that q_1 is four times larger that q_2. For more detail, see the full account of this work, which has been accepted for publication [6].

References

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