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Majorana Spin-Flip transition in the ALPHA magnetic trap

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ABSTRACT

The main purpose of the ALPHA collaboration is to trap antihydrogen atoms so that the Charge Conjugation-Parity Transformation-Time Reversal (CPT) symmetry can be tested. The trapping mechanism consists on an octupole magnet that traps the atoms near the magnetic field minima. Once trapped, due to the Majorana spin-flip effect, atoms can escape by changing the orientation of its spin. The magnetic field generated by the octupole magnet present in the trap has multiple zeroes of different orders. These zeroes could affect the probability of a spin flip, and therefore alter the number of escaped atoms. The main problem tackled by the research is how the different zeroes affect the dynamics of the spins, testing if different mathematical descriptions alter significantly the probability of a flip. The utilized method to do this was by computer simulations. First, we developed a program that solved Schrödinger's equation numerically, with error of quadratic order, for the Hamiltonian of a spin that follows a magnetic field adiabatically. We used this program to simulate the dynamics of the spin in the neighborhood of the magnetic field zeroes using different order approximations for the field. To generate statistical data, we performed a Monte Carlo simulation that generated random directions of approach and impact parameters so that we can construct a cross sections for the spin flip probability. We found that there was no significant difference between the cross section generated by the linear approximation of the field and the third order approximation. Additionally, the decay rates were obtained and the associated lifetimes were big enough so that measurements can be performed in them.

KEYWORDS

CPT symmetry, antihydrogen, atomic trapping, ALPHA collaboration, antimatter, computer simulation.