Measurement of the Ground-State Hyperfine Splitting of Antihydrogen

Bertalan Juhász[1] and Eberhard Widmann[1]

[1] *Stefan Meyer Institute for Subatomic Physics, Boltzmanngasse 3, 1090 Vienna, Austria*

The hydrogen atom is one of the most extensively studied atomic systems, and its ground state hyperfine splitting (GS-HFS) of $\nu_{\mathrm{HFS}} \simeq 1.42$ GHz has been measured with an extremely high precision of $\delta\nu_{\mathrm{HFS}}/\nu_{\mathrm{HFS}} \sim 10^{-12}$. Therefore the antimatter counterpart of hydrogen, the antihydrogen atom, consisting of an antiproton and a positron, is an ideal laboratory for studying the CPT symmetry.

A consistent extension of the standard model by Kostelecký *et al.* [1] introduces parameters into the Lagrangian of the standard model which violate either the CPT symmetry or the Lorentz invariance. These parameters have a dimension of energy (or frequency). Therefore by measuring a relatively small quantity on the energy scale (like the 1.42 GHz GS-HFS), a smaller relative accuracy is needed to reach the same absolute precision for a CPT test. This makes a determination of ν_{HFS} with a relative accuracy of 10^{-4} competitive to the measured relative mass difference of 10^{-18} between K^0 and $\overline{K^0}$, which is often quoted as the most precise CPT test so far.

The ASACUSA collaboration at CERN's Antiproton Decelerator (AD) has recently submitted a proposal [2] to measure ν_{HFS} of antihydrogen in an atomic beam apparatus similar to the ones which were used in the early days of hydrogen HFS spectroscopy. The apparatus will use antihydrogen atoms produced either in a superconducting radiofrequency Paul trap or in a superconducting cusp trap (i.e. anti-Helmholtz coils). In the former case, the apparatus would consist of two sextupole magnets for the selection and analysis of the spin of the antihydrogen atoms, and a microwave resonator to flip the spin. In the latter case, the first sextupole could be omitted because the cusp trap should be able to provide a partially polarized antihydrogen beam. This atomic beam method has the advantage that antihydrogen atoms of temperatures up to 150 K can be used.

Status of the preparations for the experiment will be presented in the talk. Numerical simulations will also be presented which show that such an experiment is feasible if $\sim$100 antihydrogen atoms per second can be produced in the ground state, and that an accuracy of better than 10^{-6} can be reached within reasonable measuring times.

References

[1] R. Bluhm, V. A. Kostelecký, and N. Russell, Phys. Rev. Lett. **82**, 2254 (1999).

[2] ASACUSA collaboration, *Proposal CERN-SPSC 2005-002, SPSC P-307 Add. 1*, 2005.