A new path to measure antimatter free fall

N. Kuroda[1], L. Liszkay [3,*], B. Mansoulié [3], A. Mohri [2], P. Pérez [3], J.M.Rey [3], H.A. Torii[1], and Y. Yamazaki[1,2]

[1] *Institute of Physics, University of Tokyo, Komaba, Meguro-ku, Tokyo, 153-8902, Japan*
[2] *Atomic Physics Laboratory, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*
[3] *IRFU, CEA-Saclay, Gif-sur-Yvette, 91191, France*

We propose an experiment to measure the free fall acceleration of neutral antihydrogen atoms. The originality of this path is to first produce the $\overline{H}^+$ ion. This ion can be cooled down to μK temperatures (i.e. m/s velocities) according to Walz and Hänsch [1]. The excess positron can then be laser detached in order to recover the neutral $\overline{H}$ atom. This process can be set up to minimize momentum transfer in the vertical direction. The temperature achieved in cooling of the $\overline{H}^+$ ion gives the main systematic error. This ion is produced through the charge exchange process $\bar{p} + Ps \rightarrow \overline{H} + e^-$, followed by $\overline{H} + Ps \rightarrow \overline{H}^+ + e^-$. The matter counterpart of the first process has been measured [2] in agreement with calculations with cross sections of order 10^{-15} cm^{-2} [3]. The calculated cross section for the second process is 10^{-16} cm^{-2} [4]. Thus if 10^7 antiprotons interact with a density of 10^{12} cm^{-3} Ps atoms, 1 $\overline{H}^+$ ion is produced, together with 10^4 $\overline{H}$ atoms. Collecting 1000 events should provide a 2% measurement error on g.

References

[1] J. Walz and T. Hänsch, General Relativity and Gravitation **36,** 561 (2004).

[2] J.W. Humberston, M. Charlton, F.M. Jacobsen and B.I. Deutch, J. Phys. B 20 (1987) L25-29; J. P. Merrison et al., Phys. Rev. Lett. 78, 2728 (1997); J.P. Merrison et al., Hyperfine Interact. 109 (1997) 313321.

[3] M. Yamanaka, Y. Kino, Phys. Rev. A **65** (2002) 062709 and references therein.

[4] H.R.J. Walters and C. Starett, Phys. Stat. Sol. **C**, 1-8 (2007).

---

* on leave from: KFKI Research Institute for Nuclear and Particle Physics, H-1525 Budapest, P. O. Box 49, Hungary