ORGANIZATION FOR NUCLEAR RESEARCH

Measurement of Antiproton Lifetime Using the ICE Storage Ring

M. Bregman*), M. Calvetti**), G. Carron, S. Cittolin,
M. Hauer, H. Herr***), H. Koziol, F, Krienen, P. Kristensen,
G. Lebée, D. Möhl, G. Petrucci, C. Rubbia, D. Simon,
G. Stefanini, L. Thorndahl, S. van der Meer, T. Wikberg

CERN, Geneva

Abstract

Antiprotons have been stored in the ICE Storage Ring and held for 85 hours with the help of stochastic cooling. We set a limit of at least 32 hours for the antiproton lifetime (in its rest frame).

(Submitted to Physics Letters)

August 1978

---

*) Visitor from Harvard University, USA

**) Visitor from the University of Pisa, Italy

***) Visitor from the University of Bonn, Germany

We have performed an antiproton lifetime measurement storing $\bar{p}$ in the 2.1 GeV/c ICE ring[1)] and following the time evolution of the circulating beam[2)]. The motivations for these measurements, in spite of the $\bar{p}$ stability postulated by the CPT invariance theorem, were:

1) the present experimental lower limit of $\bar{p}$ lifetime equal to 1.2×10^{-4} seconds [3)]
2) cosmological models implying $\tau_{\bar{p}} \simeq$ "few hours" [4)]
3) the CERN p-$\bar{p}$ project[5)] requiring accumulation times of about 24 hours at 3.5 GeV/c.

Antiprotons for ICE were produced by 18 GeV protons from the CERN proton synchrotron (CPS) impinging on a tungsten target. We tested the set-up with 2.1 GeV/c secondary protons from the target and then inverted the polarities of the transfer line (downstream of the target) and of the ICE ring for injection of negatively charged particles. Injection was optimized by observing with counters located along the ring, the flash produced on the first turn, mainly by particles of momentum outside the ring acceptance.

Since other negative particles (π^-, μ^-, K^- ...) decay and electrons are lost due to synchrotron radiation, only antiprotons will remain a few milliseconds after injection.

The number of circulating antiprotons was determined in a destructive way[6)] by ejecting the beam onto scintillation counters and in a non-destructive way by observing the signal induced on a "pick-up cavity" resonating at the 35th harmonic of the revolution frequency. Stochastic cooling of beam size and momentum spread[1)] was used to practically eliminate beam decay due to multiple Coulomb scattering on the residual gas and to reduce the momentum spread to $\sim 2 \times 10^{-5}$ FWHM. With such a small dispersion the circulating particles could be clearly detected by the cavity. Figure 1 shows the initial signal. The narrow peak corresponds to about 240 circulating particles. After a run of 85 hours the intensity had decreased to about 80 particles. This is consistent with the calculated loss rate due to single Coulomb scattering on the residual gas (10^{-9} Torr N_2 scattering equivalent). A similar run with protons, done immediately after the $\bar{p}$ run, showed the same decay rate to within the experimental error ($\sim$ 20%). However, even neglecting the losses due to interactions with the residual gas, our result gives a lower limit of the rest frame life time equal to about 32 h.

An arrangement of lead glass shower counters for observing $\bar{p}$ decay products[2)] was installed and tested during this run. Although with the lifetime limit now obtained and the present stored intensity, no significant number of events could have been expected, we believe that this approach will eventually yield a sensitivity better than the time evolution method, provided a substantially larger number of particles can be stored in the ring. We plan to pursue these studies in the near future.

References

1) G. Carron et al., Stochastic cooling tests in ICE, Phys. Lett. 77B (1978) 353.

2) D. Cline, P. McIntyre, C. Rubbia, Antiproton decay and the baryon number of the universe, Phys. Lett. 66B (1977) 429.

3) S.N. Ganguli et al., An experimental lower limit on the antiproton lifetime, Phys. Lett. 74B (1978) 130.

4) G. Cocconi, unpublished. We would like to express our appreciation for very stimulating discussions.

5) CERN $\bar{p}$-p project design study group: Design study of a proton-antiproton colliding beam facility, CERN/PS/AA report 78-3.

6) H. Herr and D. Möhl, A simple scheme for antiproton lifetime tests in ICE - CERN/PS/DL 78-13.

Figure Caption

Fig. 1 Signal induced in the resonant cavity by the circulating $\bar{p}$ beam (about 240 particles) about half-an-hour after injection into the ICE ring. The horizontal coordinate shows the frequency, i.e. the particle momentum; the vertical coordinate is $\approx \sqrt{n^2+N}$ where n is the electronics noise and N is proportional to the particle density versus frequency.