COMMENTS

New Value for the Magnetic Moment of the Antiproton*

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(Received 19 August 1974)

From a study of the fine-structure splittings in antiprotonic atoms formed in Pb and U, we have obtained a precise value of the $\bar{p}$ magnetic moment: $\mu_{\bar{p}} = (-2.819 \pm 0.056)\mu_N$.

We wish to report a more precise value for the antiproton magnetic moment than that published by us in an earlier Letter.[1] This more precise value was obtained from data collected on the same experiment as described in our earlier publication, but is based on a more comprehensive analysis of the data.

In this more complete analysis of the $\bar{p}$-U and $\bar{p}$-Pb x-ray transitions for fine-structure information, we incorporated the following:

(1) Corrections for the contributions from the dominant noncircular ($l = n - 2$) transitions. The amplitudes of these noncircular transitions (averaging between 10 and 15%) were obtained in a number of ways, including (a) a free-parameter fit to several of the lower-lying x-ray transitions, (b) various cascade calculations, and (c) direct information from experimental limits on the am-

TABLE I. Magnetic moment derived from antiprotonic x rays in Pb and U. The contributions of the first noncircular transitions were included in the data analysis for each of the doublet transitions indicated. The errors quoted not only represent statistical uncertainty but reflect also the uncertainties associated with the contribution from noncircular transitions.

Element	Transition ($n_i \rightarrow n_f$)	μ ($e\hbar/2m_p c$)
Pb	$13 \rightarrow 12$	-2.70 ± 0.85
	$12 \rightarrow 11$	-2.76 ± 0.55
	$11 \rightarrow 10$	-2.58 ± 0.21
U	$13 \rightarrow 12$	-2.78 ± 0.65
	$12 \rightarrow 11$	-2.81 ± 0.13
	$11 \rightarrow 10$	-2.847 ± 0.066
Weighted average		-2.819 ± 0.056

plitudes of $\Delta n = 2$ transitions.[2]

(2) Calculation of the effect of dynamic electric-quadrupole mixing of nuclear and atomic states[3] in U. In particular, for the $\bar{p}$ atomic states formed with the deformed U nucleus, we calculate that the two fine-structure components of the $n = 10$, $l = 9$ doublet are shifted equally to within 20 eV, a difference which is far less than the experimental precision. Our results agree with those of Ara and Chen.[3]

(3) Inclusion of the $n = 13 \rightarrow n = 12$ and $n = 12 \rightarrow n = 11$ $\bar{p}$-Pb and $\bar{p}$-U x-ray transitions in this fine-structure analysis, as well as the (statistically more important) $11 \rightarrow 10$ transition.

The results of this analysis are given in Table I, and the final value for the $\bar{p}$ magnetic dipole moment,

$$\mu_{\bar{p}} = (-2.819 \pm 0.056)\mu_N$$

(where μ_N is the nuclear Bohr magneton, $e\hbar/2m_p c$), is in very good agreement with the value predicted by the TCP theorem.

We thank Dr. D. Berley, Dr. D. Lazarus, Dr. Y. Y. Lee, and the staff of the Brookhaven National Laboratory alternating-gradient synchrotron for their continued support.

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*Work supported in part by the National Science Foundation and the U. S. Atomic Energy Commission.

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[1]J. D. Fox *et al.*, Phys. Rev. Lett. 29, 193 (1972).

[2]For a more complete description of the effects of contributions from the noncircular transitions see B. L. Roberts, thesis, College of William and Mary, Report No. WM-74-52, 1974 (unpublished).

[3]G. Ara and M. Y. Chen, Bull. Amer. Phys. Soc. 19, 599 (1974); M. Y. Chen, Phys. Rev. C 1, 1176 (1970).