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Abstract

Full Text

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A NEW MEASUREMENT OF THE MAGNETIC MOMENT OF THE PROTON

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PHYSICS

On a magnetic-resonance mass spectrometer (1), the cyclotron frequencies of the ions He^+, Ne^{2+}, and Ne^+ were measured. At the same time, in the field of the same magnet, the frequency of spin precession of hydrogen nuclei in an aqueous sample was measured. These measurements make it possible to determine the value of the magnetic moment of the proton μ_p in nuclear magnetons μ_n (2–4). In contrast to the previously used methods of the omegatron (2,4) and the retarding cyclotron (3), in which the ions make a large number of revolutions in the magnetic field, the method used by us makes it possible to measure the cyclotron period of the ions during a single revolution of the ions in the magnetic field. This made it possible to develop an exact theory of the motion of ions in the instrument and to calculate the cyclotron frequency of the ions on the basis of experimental data, without introducing any additional assumptions.

Table 1

Source	Method of measurement	Result
(2)	Omegatron	2.79268 ± 0.00006
(3)	Retarding cyclotron	2.79268 ± 0.00005
(4)	Omegatron	2.79283 ± 0.00006
Our data	Magnetic-resonance mass spectrometer	2.79279 ± 0.00002

As a result of several series of measurements carried out at different times, we obtained $\mu_p/\mu_n = 2.79279$, without a correction for the diamagnetic shielding of the hydrogen nuclei in water. This result includes corrections for inhomogeneity of the magnetic field, for electric fields in the chamber caused by contact potential differences, and certain other corrections. The statistical scatter of the results of all measurements amounted to $\pm 4 \cdot 10^{-6}$ (root-mean-square deviation). To this is added the uncertainty in the introduction of some corrections, so that the final root-mean-square error is $6 \cdot 10^{-6}$ of the measured quantity.

Table 1 gives the results of the measurements of the magnetic moment of the proton available at the present time; it is evident from it that the results split into two groups. Our result is in good agreement with the result of Boyne and

Franken (4), but both of them differ from the results of Thomas, Sommer, and Hippel (2) and of Sanders and Turberfield (3) by more than twice the value of the stated error. We carefully searched for possible sources of systematic errors in our method that could explain these discrepancies. A number of control experiments were carried out, as a result of which, however, no substantial systematic errors were found.

From the value of the magnetic moment of the proton and the gyromagnetic ratio γ, the Faraday number can be calculated [2]. If our value of μ_p/μ_n and the gyromagnetic ratio of the proton obtained in recent works, $\gamma = 2.67512 \pm 2$ [5,6], are used, then the Faraday number is found to be 9648.30 ± 0.09 coul/mol on the mass scale with the standard C^{12} (9651.42 ± 0.09 on the old physical mass scale).

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