LETTERS

Incorrect constant?

In the article "New Values for the Physical Constants" (PHYSICS TODAY, Feb. 1964, page 48) the dimension of the magnetic moment, as given with reference to the Bohr magneton, nuclear magneton and proton moment, appears to be incorrect. The magnetic-moment values are expressed in terms of energy value per unit magnetic flux density (B) instead of energy value per unit magnetic field strength (H).

The expression for a couple acting on a magnet of moment M in a magnetic field of intensity H corresponding to a magnetic flux density $B = \mu H$ is $MH \sin \theta$ in the CGS system, and the expression is the same in the MKSA system.[1] Hence the energy of the magnet is $-MH \cos \theta$ (not $-MB \cos \theta$). Thus the unit of magnetic moment should be expressed in terms of energy per unit of magnetic field intensity (that is, per unit of H, not per unit of B.

In the CGS system a magnetic flux density of one gauss (B) in air is equivalent to a field strength of one oersted (H). Thus there is no change in the numerical values, and discepancy with respect to numerical values is absent. But discrepancies in this respect do appear, causing serious confusion, when one tries to use the MKSA system. Thus in the rationalized MKSA unit the magnetic moment of a current loop of area A carrying a current i is given by μAi. So the magnetic moment of an electron due to its motion in a circular orbit of radius r in a vacuum is given by the equation

$$\mu_0 \pi r^2 (ev/2\pi r) = \mu_0 (e/2m) L$$

Here $L = mvr$ is the orbital angular momentum. Hence in rationalized MKSA units the expression for a Bohr magneton is $\mu_0 eh/4\pi m$ in which μ_0 is the magnetic permittivity of vacuum. With $\mu_0 = 4\pi \times 10^{-7}$ henries per meter we get a Bohr magneton of value 1.17×10^{-29} MKSA units instead of 9.27×10^{-24} units as shown in the article under review.

This discrepancy is of course caused by the discrepancy in the dimension. The actual dimensions of the magnetic moment in the MKSA system are webers $\times$ meters or joules $\times$ webers^{-1} $\times$ meters. Because in a vacuum one tesla is equivalent to $10^7/4\pi$ amperes per meter, the energy of a Bohr magneton placed antiparallel to a magnetic field with flux density of one tesla in a vacuum is $1.17 \times 10^{-29} \times 10^7/4\pi$ or 9.27×10^{-24} joules. So in this sense a value of 9.27×10^{-24} joules per tesla may be said to be correct. But the concept is wrong and is a hindrance to the consistent use of MKSA-system units, and therefore it requires rectification.

In this connection, I might mention that the value of the Bohr magneton is given in terms of the wrong dimension (that is, ergs per gauss) in the AIP Handbook (1957 [and 1963] edition, section 7, page 3).

Reference

1. W. H. Furry, E. M. Purcell and J. C. Strut, *Physics for Science and Engineering Students* (Blakiston Co., New York, 1952), page 669.

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Reply by A. G. McNish

It is not meaningful to say that the dimension of magnetic moment in the article on physical constants is correct or incorrect but only whether or not it is consistent with other dimensions in the article and with usual practice.

The contention that the torque on a magnet should be expressed as $MH \sin \theta$ arises from the concept that in the MKSA system, now called SI, there are two kinds of magnetic moments: dipole moments, M_d, expressed in weber-meters, and area mo-

ments M_a expressed in amperes × square meters. The appropriate expressions for torque in the two cases are $M_d H \sin\theta$ and $M_a B \sin\theta$, respectively. Dimensionally these two expressions are identical, reducing to the dimension of torque ML^2T^{-2} as it is frequently given. (This is identical with the dimension of energy!)

The present trend is to disparage the use of M_d in favor of M_a and regard M_a as subjected to a torque when in a magnetic flux of density B (or μH). It would have been more consistent with this trend to have magnetic moment values expressed in terms of amperes × square meters since the expression for the Bohr magneton in SI is $\mu_B = eh/4\pi m_e = 9.2732 \times 10^{-24}$ Am². However, since it has been customary to express magnetic moment in energy per unit field, this past practice was followed.

A more subtle inconsistency appears in the values because the unit for angle has been suppressed in giving the unit for magnetic moment. A better practice is to express magnetic moment in joules per tesla-radian and thus assign dimension to angle.[1] The dimension of torque is then changed from that given above to ML^2T^{-2} rad^{-1}. Thus its dimensional identity with energy is eliminated, and torque multiplied by angle, which is equivalent to energy, has the dimension of energy.

Reference

1. A. G. McNish, "Dimensions, Units and Standards," Physics Today, 10, 19 (1957).

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Interdisciplinary information

The recent survey of information networks published in PHYSICS TODAY (Jan. 1966) performs a most valuable service in apprising AIP members of some major problems of literature organization, and in informing physicists of government (and AIP) plans to deal with those problems. Thanks are due particularly to Dr. Pepinsky for calling attention to the fact that all plans now being implemented are on too small a scale to be truly effective, as well as for suggesting a full-sized division of APS to deal with information problems.

The purpose of this letter is to increase the scale of Pepinsky's suggestion. Because of the interdisciplinary nature of much of today's research, I believe that such an increase is necessary and will become more so in the future. This statement needs no amplification. An information-handling system set up to cover all of physics may be satisfactory to most physicists for a while—but within a few years it probably will not be.

Therefore I respectfully suggest that an APS division for documentation ought to consider of utmost importance the promoting of similar divisions in other professional societies, such as the American Chemical Society, the American Mathematical Society, societies for psychology and psychiatry, and perhaps such humanities societies as those in history and economics (econometricists, for example, deal in higher mathematics).

The next step, of course, would be for the various divisions, preferably in coöperation with the American Library Association, to organize a cross-disciplinary Society for Information and Documentation. While remaining part of their sponsoring organizations, the divisions would also be members of the new society. The function of that society, like the function of the Encyclopedists, would be to do for information developed by the parent societies what present AIP programs attempt to do for information about physics.

Only through such a large-scale organization can we hope to handle the growing flood of information in such a way that any person, of whatever background and education, can locate any desired piece of information even if he lacks familiarity with the literature most likely to contain it.

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