

Resolving the Mystery of the Fine Structure Constant

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Abstract: A quantized magnetic flux version of Planck's reduced constant is deduced from first principles. The magnetic flux quantum can explain the fine structure constant and the “anomalous” magnetic moment of an electron.

INTRODUCTION

The magnetic flux quantum $\Phi_0^{[1], [2], [3]}$ is equivalent to

$$(1) \quad \Phi_0 = \frac{h}{2e},$$

where e is a unit of elementary charge and h is Planck's constant,

$$(2) \quad h = 2\pi\hbar.$$

Planck's reduced constant \hbar can also be defined from Bohr's radius r_B as

$$(3) \quad \hbar = \alpha m_e r_B c,$$

where α is the fine structure constant, m_e is the rest mass of an electron and c is the speed of light in a vacuum. Combining Eqs. (1) through (3) yields

$$(4) \quad 2\pi\hbar^2 = 2e\Phi_0 \alpha m_e r_B c.$$

It is remarkable that the dimensions in Eq. (4) are balanced by the dimensionless quantity \mathfrak{D} ,

$$(5) \quad \mathfrak{D} = \frac{\alpha}{\pi} = \frac{\hbar^2}{e\Phi_0 m_e r_B c}.$$

AN ELECTRON'S ANOMALOUS MAGNETIC MOMENT

The g-factor for an electron's magnetic moment^[4] is

$$(6) \quad g = 2 + \frac{\alpha}{\pi} = 2 + \mathfrak{D},$$

suggesting that the fine structure constant and an electron's “anomalous” magnetic moment may be related to the the magnetic flux quantum Φ_0 . Substituting the g-factor for an electron's magnetic moment μ_e yields,

$$(7) \quad \mu_e = 2 + \mathfrak{D} \frac{-e}{2m_e} \mathbf{L} = \frac{\mathbf{v}\hbar^2}{-\Phi_0 m_e c},$$

where \mathbf{L} is an electron's angular momentum and \mathbf{v} is its tangential speed. A dimensionless proportionality factor is not needed with this classical definition since the electron's magnetic moment is related to the magnetic flux quantum Φ_0 and not the electrostatic charge e . A special relativistic version of Eq. (7) can then be given as

$$(8) \quad \mathbf{v}\hbar^2 = \pm \Phi_0 \boldsymbol{\mu} \gamma m_0 c,$$

where γ is the Lorentz factor and m_0 is a particle's rest mass^[5].

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