On Feynman's Speculations About the Origin of the Fine-Structure Constant

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When thinking about the origin of the fine-structure constant (the electromagnetic coupling constant), renowned physicist Richard Feynman speculated that it might be related to pi or the base of the natural logarithm. However, he could not envision how pi or the natural logarithm's base could be associated with the constant, noting the following:

> "All good theoretical physicists put this number up on their wall and worry about it…you would like to know where this number for a coupling comes from: is it related to pi or perhaps to the base of natural logarithms? Nobody knows. It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man."[1]

An equation producing the value of the constant, at roughly 0.007297 or 1/137, actually can be established using the base of the natural logarithm, as described below:

$$\alpha \approx \frac{Pl_{mass}{}^2}{(2)(e_{mass})\left[(Pl_{mass})(e)(N_A)\right]}$$

where,

Pl_{mass} = Planck mass at ~ 2.176×10^{-8} kg
e_{mass} = Electron mass at ~ 9.109×10^{-31} kg
e = The base of the natural logarithm at ~ 2.718
N_A = Avogadro's number at ~ 6.022×10^{23}

The equation produces a value for the fine-structure constant that is 100% of the accepted value within 5 significant digits (0.0072973).

Also the equation is the only one for the fine-structure constant that takes a similar format to the gravitational coupling constant equation:

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[1] Feynman RP. QED: The Strange Theory of Light and Matter. Princeton University Press. 1985, p 129.

$$\alpha_g \approx \frac{e_{mass^2}}{Pl_{mass^2}}$$

Note that while Avogadro's number is not a fundamental value, there is already an established mathematical relationship between it (as Avogadro's constant, with units mol^{-1}) and the fine-structure constant. Through this relationship, one value can be derived from the other, supporting the use of Avogadro's number in the first equation as well:

$$N_A \approx \frac{M_u A_r(e)}{m_e} \approx \frac{M_u A_r(e) c_0 \alpha^2}{2 R_\infty h}$$

where,

M_u	=	Molar mass constant at 0.001 kg/mol
$A_r(e)$	=	Relative electron atomic mass at ~ 0.000548597
m_e	=	Electron mass at ~ 9.109×10^{-31} kg
c_0	=	Speed of light at ~ 3×10^8 m/s
R_∞	=	Rydberg constant at ~ 1.097×10^7 m^{-1}
h	=	Planck constant at ~ 6.626×10^{-34} m^2 kg/s

Although neither the first nor third equation, in and of themselves, identifies the origin of the fine-structure constant, the first equation does answer at least the second half of Feynman's question, stated in the quote above — that the fine-structure constant is, or at least can be, related to the base of the natural logarithm. With this knowledge and further investigation, the actual origin of the fine-structure constant may eventually be uncovered, fully answering Feynman's question.

Perhaps more importantly, the fact that the above equation for the fine-structure constant takes a similar form to the gravitational coupling constant equation suggests that it might hold clues to the long-sought link between gravity and electromagnetism, pointing to the Theory of Everything.

About the Author:

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