

The Meaning of the Fine Structure Constant

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Normally the fine structure constant is seen as a relation between electric and gravitic forces. As we are going to see that is not the true meaning as the forces must be equal.

The inverse of the fine structure constant is the number of times that the wavelength of the electron makes the perimeter of its orbit.

Angular momentum:

$$L = m_e v R = n \frac{h}{2\pi} \quad \text{and} \quad n = 1 \quad \Leftrightarrow$$

$$\Leftrightarrow \quad v = \frac{h}{2\pi R m_e}$$

Electric and centripetal forces between the proton and the electron:

$$F_c = N \frac{m_e v^2}{R} = F_e = N \frac{q_e^2}{4\pi\epsilon_0 R^2}$$

From absolute relativity: $F_e = 7 \times 10^{-3}$

The macroscopic formula for electric force must have an additional factor N for microscopic scales.

$$\frac{m_e v^2}{R} = \frac{q_e^2}{4\pi\epsilon_0 R^2} \quad \text{and} \quad v = \frac{h}{2\pi R m_e} \quad \Leftrightarrow$$

$$\Leftrightarrow \quad R = \frac{h^2 \epsilon_0}{\pi m_e q_e^2} \quad \text{and the electric energy is:}$$

$$E = \frac{q_e^2}{8\pi\epsilon_0 R} \quad \text{so,}$$

$$E = \frac{m_e q_e^4}{8\epsilon_0^2 h^2} \quad \text{and} \quad \frac{E}{hc} = \frac{1}{\lambda}$$

We get the Rydberg constant, which is an experimental confirmed value:

$$R_M = \frac{m_e q_e^4}{8\epsilon_0^2 h^3 c} = 1.0974 \times 10^7 \text{ m}^{-1}$$

So, the radius of the orbit of the electron is:

$$R = \frac{h^2 \epsilon_0}{\pi m_e q_e^2} = 5.3 \times 10^{-11} \text{ m}$$

And the speed:

$$v = \frac{h}{2\pi m_e R} = 2.2 \times 10^6 \text{ ms}^{-1}$$

The wavelength of the electron is: $x_e = 2.426 \times 10^{-12} \text{ m}$

We see that the perimeter:

$$\frac{1}{\alpha} x_e = 2\pi R \quad \Leftrightarrow \quad 137 x_e = 2\pi R$$

The value is not a perfect integer because the orbit is not perfectly circular.