e-Nut or Shape of Spinning Electron:

how to extract Fine Structure Constant from

Proton-to-Electron Mass Ratio

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Abstract

Article describes a contour of spinning electron and derives a value of the Fine Structure constant from Proton-to-Electron mass ratio on basis of the facts that both electron and proton have equal spin angular momentum while proton is heavier than electron more than 1836 times.

It appears from the suggested model that the path of rotating electron is shaped as hardware nut (regular polygon) with 137 sides and rounded corners. This figure may be potentially called e-Nut with letter e standing for an electron.

Numerical outcome of the model: electron's spin circumference is 137.035999118… times longer than diameter of spinning proton. It is proven that this ratio is physically the Fine Structure constant. The result is located right on the upper boundary of the CODATA Fine Structure constant reciprocal recommended value range.

Key formula for the number of sides n in polygon formed by electron's spinning body:

$$n = round\_up\_to\_prime\,(\pi \cdot \sqrt{\frac{m_p}{m_e}}) = 137$$

where m_p/m_e is Proton-to-electron mass ratio.

Solution for the Fine Structure constant reciprocal:

$$\alpha^{-1} = n \cdot \frac{Sin\left(\frac{\pi}{n} - \psi\right) + \psi}{Sin\left(\frac{\pi}{n}\right) \cdot Cos\left(\frac{\pi}{n} - \psi\right)} = 137.0359991176 \ldots$$

where

n = 137	-	number of sides in polygon;
$\psi = \pi/(3 \cdot 137)^2$	-	angle of polygon corner rounding.

Starting Point for the Spinning Electron's Shape Hypothesis

Denote next physical paradox: two very different by mass elementary particles, namely proton and electron (proton being approximately 1836 times heavier than electron), both have exactly the same value of spin angular momentum.

Accent here is set on perfect equality of spin value for proton to that of electron and not on the value of proton or electron spin itself which is a half of the reduced Planck constant $\hbar/2$.

Physicists are convinced: angular momentum for a particle can take only certain discrete values. They call this phenomenon "quantization of angular momentum" and attribute its nature to existence of standing waves (states) of matter where only states with integer number of wavelength can sustain endlessly.

Spin is a quantum property of a particle but for its understanding it is easier to resort to spin's classical analog – rotation of a body with mass m around center of mass at distance of radius r with angular frequency ω. Angular momentum L for the body can be expressed as follows

$$L = m \cdot r^2 \cdot \omega \qquad (1)$$

For proton with mass m_p and radius of rotation r_p and time of observation Δt the angular momentum is

$$\frac{\hbar}{2} = m_p \cdot r_p^2 \cdot \frac{2\pi}{\Delta t} \qquad (2)$$

Respectively, for electron with mass m_e and radius of rotation r_e and the same time of observation Δt the angular momentum is

$$\frac{\hbar}{2} = m_e \cdot r_e^2 \cdot \frac{2\pi}{\Delta t} \quad (3)$$

Dividing expression (2) by expression (3) it is possible to determine that the ratio of radii of spinning body of electron and that of proton should be proportional to square root of Proton-to-electron mass ratio $\boldsymbol{\mu}$.

$$\frac{r_e}{r_p} = \sqrt{\frac{m_p}{m_e}} = \sqrt{\mu} = \sqrt{1836.1527\ldots} = 42.85\ldots \quad (4)$$

It means that effective radius of electron's spinning body should be almost 43 times bigger than effective radius of spinning proton in order for electron to achieve the same angular momentum as proton.

Let's assume the diameter of spinning proton is ***1*** unit of length (see Fig.1), respectively radius of proton $r_p = ½$ unit and the value of $r_e = ½ \cdot 42.85\ldots$ units due to expression (4).

The circumference of electron's spinning body should be no less than $2\pi \cdot r_e = \pi \cdot 42.85\ldots$ units which is around 134.6… units. But due to discrete nature of standing waves the number of nodes (units) has to be an integer number. The first suitable integer is ***135*** followed by ***136, 137, 138,*** etc.

Integer ***135*** is not prime number because it can be expressed as the product of primes ***135 = 3 · 3 · 3 · 5.*** Therefore, a standing wave with ***135*** nodes cannot materialize. The same consideration applies to non-prime ***136***. The closest prime, which exceeds circumference of electron's spinning body $2\pi \cdot r_e = \pi \cdot 42.85\ldots$ is number ***137.***

Consequently, number ***137*** appeared directly from Proton-to-electron mass ratio $\mu = m_p/m_e \approx 1836.1527\ldots$ as follows:

$$137 = round\_up\_to\_prime\ (\pi \cdot \sqrt{\mu}) \quad (5)$$

Fig. 1 illustrates a spinning body of electron taking shape of regular polygon. For simplicity a decagon or 10-sided regular polygon is used to illustrate expected 137-sided polygon and only 3 upper sides of polygon are shown with symbolical representation for standing waves of electron's matter.

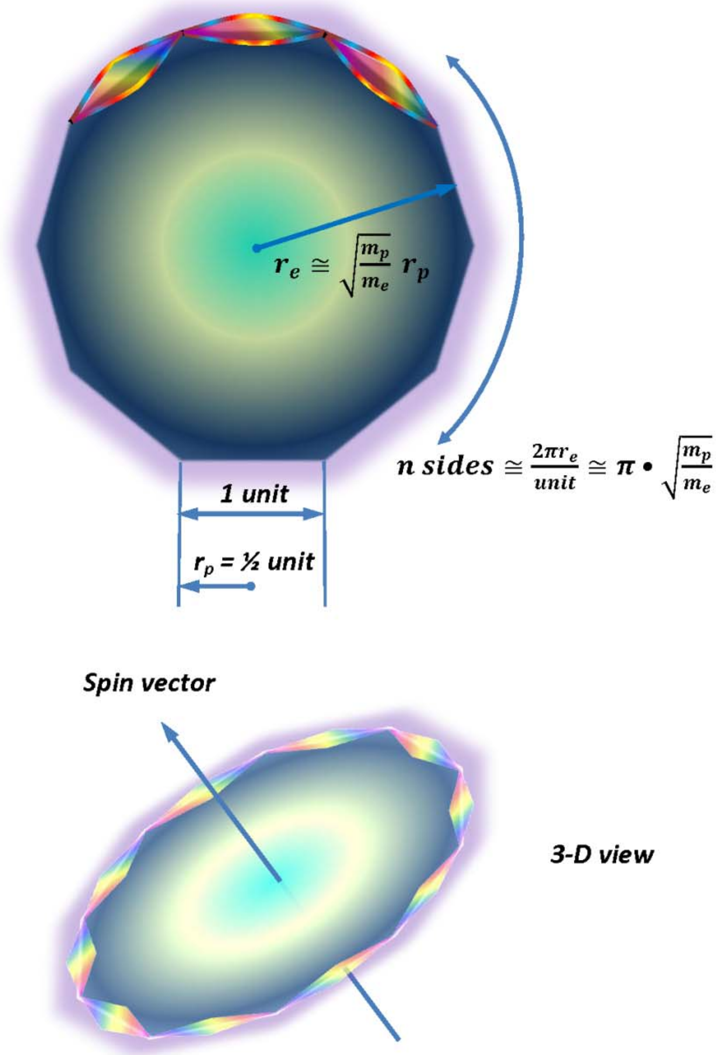

Fig. 1. Electron's spinning matter forms n-sided regular polygon with number of sides n determined by Proton-to-Electron mass ratio.

It’s not said yet that expression (5) can be associated with the Fine Structure constant reciprocal value for two reasons:

1) Fine structure constant is typically used to describe orbital movements of electron in atom with characteristic distances about 250000 diameters of proton while expression (4) confines spinning electron to a space equal approximately 43 diameters of proton.
2) Expression (5) outcome 137 is pure integer and this result is different from experimental value for the Fine Structure constant reciprocal (generalized by 2010 CODATA to the range 137.035999074(44)).

It was not planned to search Fine Structure constant value. Author was mostly curious in quantization and equivalence of angular momentum for particles with extremely different masses. However, surprising materialization of familiar number of 137 from the Proton-to-electron mass ratio motivated further research to obtain precise value for the Fine Structure constant.

Calculation of Electron’s Spinning Body Circumference

Assuming that photons interact with electrons on external boundary of electron’s spinning body a simple geometrical model Fig. 2 can be developed as a continuation of standing waves model Fig. 1.

Fig.2 contains two regular convex polygons: internal and external in one plane. Plane (two dimensional) depiction of electron’s spin is justified by angular momentum equivalence of any symmetrical 3-dimentional body rotating around an axis and respective central symmetrical 2-dimentional body around center dot.

Internal polygon is essentially a copy of Fig.1 representing standing wave of electron with 137 nodes. For simplicity the polygon is shown as decagon – 10-sided polygon. 137-sided polygon is too close to a circle to depict fine details.

The idea to introduce the external polygon is following: photon (quant of light) cannot penetrate through electron’s wave of matter, thus photon interacts only with external side of electron’s spinning body. Therefore, external polygon represents the regions of interaction with photon. External polygon has the same number of sides as internal polygon. The middles of the external sides are touching the vertices of the internal polygon. The corners of external polygon should be rounded because electron cannot change the direction of movement instantly. Fig.2 shows rounding only for 3 top corners to avoid excessive representation.

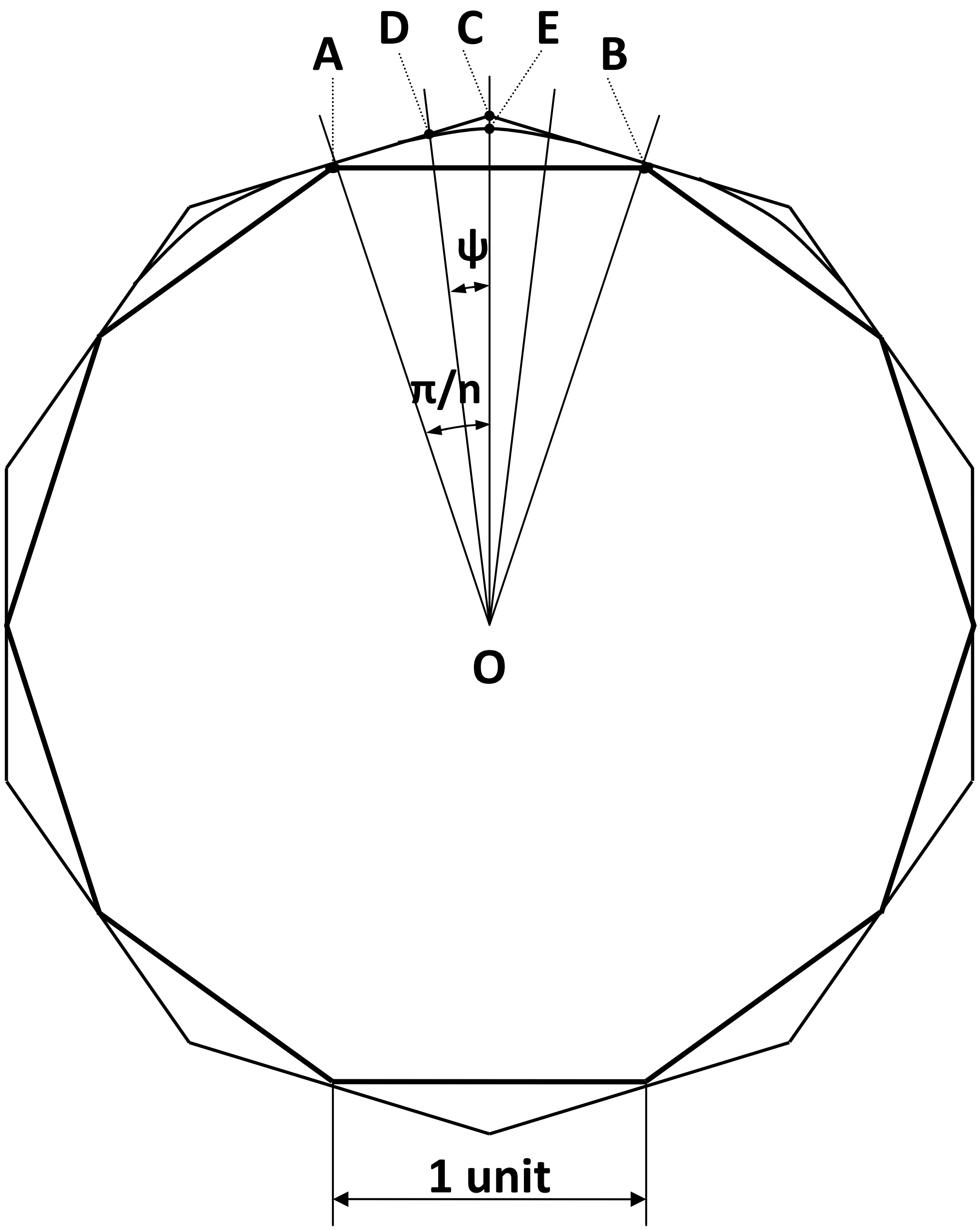

Fig. 2. Geometrical model of spinning electron: n-sided polygon with rounded corners.

Given: internal polygon (representing electron's spinning matter) has $n=137$ sides (comes from expression (5)). Each side is 1 unit of length long (approximately diameter of spinning proton). Angle of polygon corner's rounding sector (formed by points DOE on Fig.2) is denoted by parameter ψ.

Goal: calculate geometrically the circumference Λ of external polygon.

Calculation steps:

1) Every n-sided polygon consists of n equally sized triangles (one of triangles is marked by points AOB on Fig.2). Angle formed by points AOB $= 2\pi/n$ while angle AOC $= \pi/n$.

2) The length of line segment |AD| = |AO|$\cdot\tan(\pi/n - \psi)$ where |AO|= ½·|AB|$/\sin(\pi/n)$. Note, |AB| = 1 unit of length. Therefore |AD| = ½$\cdot\tan(\pi/n - \psi) / \sin(\pi/n)$.

3) The length of arc segment |DE| = |DO|$\cdot\psi$ where |DO|= |AO|$/\cos(\pi/n - \psi)$. Using above expression for |AO| we receive |DE| = ½$\cdot\psi/(\sin(\pi/n) \cdot \cos(\pi/n - \psi))$.

4) The combined length of line segment |AD| and arc segment |DE| equal |AE| = |AD|+|DE| =

½$\cdot\tan(\pi/n - \psi) / \sin(\pi/n) +$ ½$\cdot\psi / (\cos(\pi/n - \psi) \cdot \sin(\pi/n))$ is doubled for path |AE| + |EB| and multiplied by number n of sides for whole polygon.

Final expression for the length of external polygon with rounded corners divided by the unit of length is

$$\Lambda = n \cdot \frac{Sin\left(\frac{\pi}{n} - \psi\right) + \psi}{Sin\left(\frac{\pi}{n}\right) \cdot Cos\left(\frac{\pi}{n} - \psi\right)} = 137.0359991176\ldots \qquad (6)$$

where

$n = 137$ - number of sides in polygon formed by electron's spinning body from expression (5);

$\psi = \pi/(3\cdot 137)^2$ - angle of polygon corner rounding sector (derived below in expression (10)).

If angle of rounding is equal $\psi = \pi/(3\cdot 137)^2$ the numerical result of the expression (6) (137.0359991176…) resides in the boundaries of 2010 CODATA recommended value for the Fine Structure constant reciprocal.

For $\psi=0$ (no corner rounding) expression (6) is simplified to approximation (7):

$$\Lambda^* = \frac{137}{Cos\left(\frac{\pi}{137}\right)} \tag{7}$$

However, rounding of corners is necessary because without rounding electron would experience infinite acceleration in the vertices of polygon.

e-Nut Height above the Plane of Rotation and Calculation of Rounding Sector Angle

For calculation of rounding sector angle ψ let's first make an estimation of length for the arch DE on Fig.2. The length of |DE| should be half of the radius δ of cross section measured transversely to electron's spinning body (the same as height of e-Nut above the plane of rotation). Considering density for proton's matter and electron's matter the same next equality is emerging

$$\frac{m_e}{\Lambda \cdot \pi \delta^2} = \frac{m_p}{\frac{4}{3}\pi r_p^3} \tag{8}$$

where radius of proton r_p is ½ unit.

Simplifying expression (8) and using constant values, the estimate for the radius of cross section is obtained in expression (9):

$$\delta = \frac{1}{\sqrt{6 \cdot \Lambda \cdot \frac{m_p}{m_e}}} \approx \frac{1}{1229} \approx \frac{1}{9 \cdot 137} \tag{9}$$

The distance |DE| can be estimated as $\frac{1}{2}\delta = 1/(18 \cdot 137)$.

Now we can calculate angle ψ for corner rounding sector as ratio (10) of arch with length |DE| to radius of electron's spinning body r_e:

$$\psi = \frac{|DE|}{r_e} = \frac{\frac{\delta}{2}}{\frac{137}{2\pi}} = \frac{1}{9 \cdot 137^2} \tag{10}$$

Physical relationship between Electron's Spinning Body Circumference and the Fine Structure Constant reciprocal

Material affiliation of polygon circumference $\boldsymbol{\Lambda}$ with reciprocal of the Fine Structure constant can be confirmed by next physical formula.

Quantum of electrostatic energy for electron with charge $\boldsymbol{e}$ is proportional to $\boldsymbol{e^2}$ and inverse proportional to the distance. The coefficient of proportionality is Coulomb constant $\boldsymbol{k_e}$. Thus, energy of electrostatic quantum is $\boldsymbol{k_e \cdot e^2/unit}$ of length.

Quantum of electromagnetic energy for photon traveling at speed of light $\boldsymbol{c}$ the same distance $\boldsymbol{\Lambda \cdot unit}$ as electron on Fig.2 has energy of $\boldsymbol{\hbar \cdot c/(\Lambda \cdot unit)}$.

Two above quanta (electrostatic and electromagnetic) should be equal because electrostatic and electromagnetic energies are related. This assertion leads to expression (11):

$$\frac{k_e \cdot e^2}{unit} = \frac{\hbar \cdot c}{\Lambda \cdot unit} \qquad (11)$$

Therefore, circumference $\boldsymbol{\Lambda}$ is in fact the reciprocal of the Fine Structure constant

$$\alpha^{-1} = \frac{k_e \cdot e^2}{\hbar \cdot c} = \frac{1}{\Lambda} \qquad (12)$$

Author also would like to present Fig. 3 as an illustration of actual proportions between sizes of spinning electron and proton.

Calculations show that electron forms a very thin ring (torus) of plasma with minor diameter of cross section about $\boldsymbol{2/(9 \cdot 137)}$ of proton's diameter. Major diameter of electron's ring is $\boldsymbol{137/\pi}$ diameters of proton.

Resulting torus aspect ratio (major diameter/minor diameter) equals $\boldsymbol{(3 \cdot 137)^2/2\pi}$.

Closer (magnified) look reveals the fine structure of the ring consisting of 137 strait segments forming regular polygon. Corners of polygon (near vertices) are rounded (as depicted on Fig,2) with characteristic angle $\boldsymbol{\pi/(3 \cdot 137)^2}$.

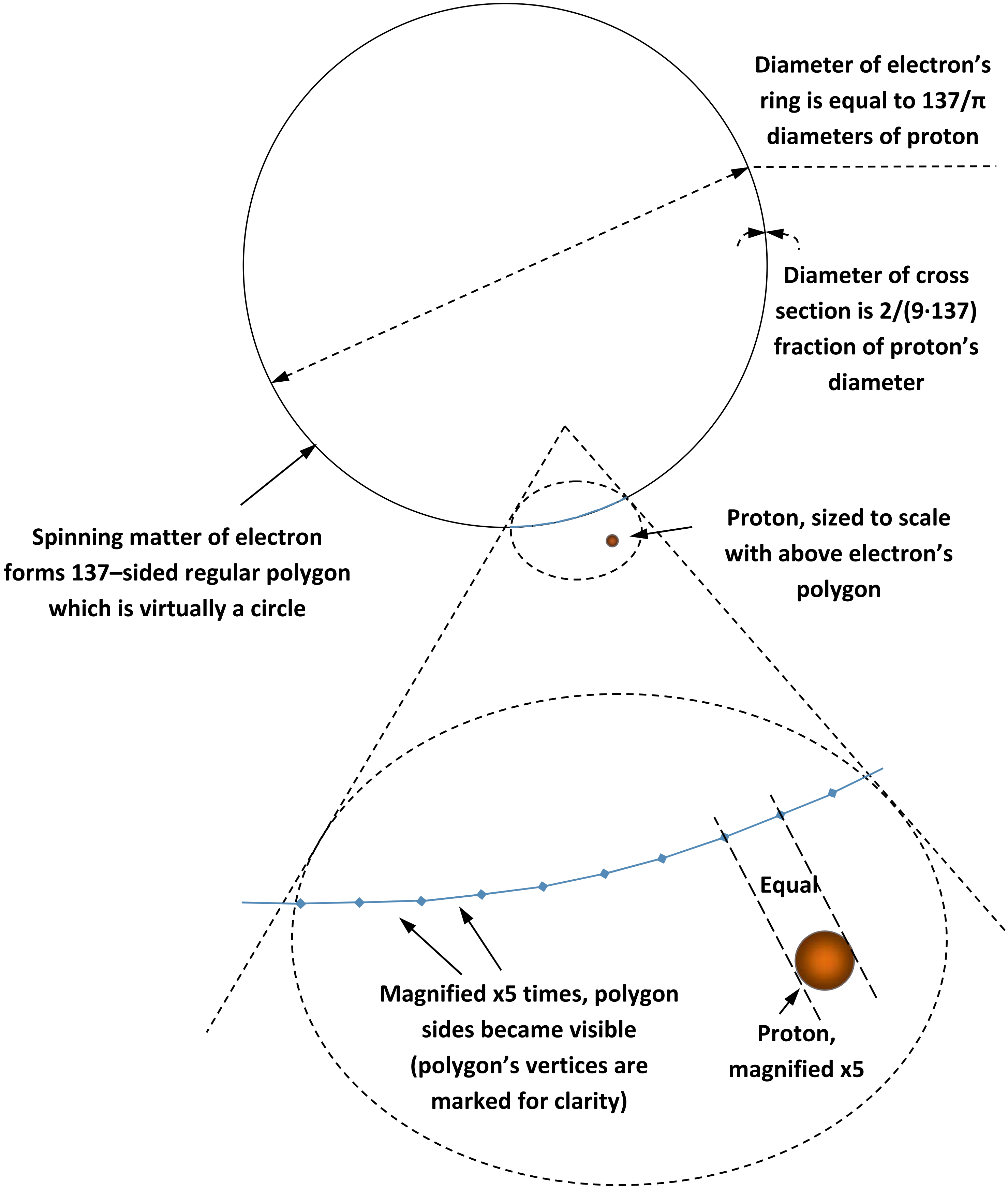

Fig. 3. Spinning electron's contour and proton on the same scale.

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