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Deuteron Dimensions

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Abstract: The exact sizes of a Deuteron are extremely important today because deuterons are proposed for use as a raw material for the completion of the merger in the nuclear power station. The work proposes a study in the kinematic and dynamic design of a particle deuteron in motion. Mechanical equations of movement introduced are original and have been already determined for the study of a basic particle located in motion, such as for example the electron. The paper presents all the dimensions of a deuteron in motion, determined with an ultra-high precision depending on its speed of travel. The equation of motion has been deducted and using the theory of the mechanisms and of the classic mechanics because they have been used and moments of mechanical inertia mass of a body when it is in motion.

Keywords: Deuteron Dimensions, Deuteron Kinematics, Deuteron Dynamics, Deuteron Velocity, Proton

Introduction

Deuterium (having the symbol D or 2 H, also known as heavy hydrogen) is one of the two stable isotopes of hydrogen together with the antitumor. The first isotope of hydrogen is the atom called the counter, which contains only one nucleus in the nucleus, namely a single proton. As an ion (positive), when it loses its electron, the atom or isotope of the counter is a positive ion, that is, a simple proton known as proton. Protium as well as its ion the proton, are extremely stable elements. Initially, it was desired to carry out the nuclear fusion reaction between two opposites (isotopes), as happens in stars, but due to the very high stability of the anusum, the fusion reaction requires a high energy and temperature to achieve it. The conditions in the stars are extremely difficult to achieve on Earth. Then it went as natural to the next hydrogen isotope, the second, namely deuterium. The deuterium core, called deuteron, contains a proton and a neutron, while the much more common, isotopic hydrogen is not a neutron in the nucleus.

Deuterium has a natural abundance in the Earth's oceans of about one hydrogen atom in 6420. Thus, deuterium represents about 0.0156% (or 0.0312% by mass) of the total hydrogen in the ocean, while the most common isotope Hydrogen-1 or antitumor) represents more than 99.98%. The abundance of deuterium changes easily from one kind of natural water to another (see the standard ocean Mean Ocean Water in Vienna). The name of the deuterium isotope is made up of the Greek deuteros, which means "the second", to designate the two particles that make up the nucleus. Deuterium was discovered and named in 1931 by Harold Urey. When the neutron was discovered in 1932, this made the nuclear deuterium structure obvious and Urey won the Nobel Prize in 1934 for this discovery. Shortly after the discovery of deuterium, Urey and others succeeded in producing "heavy water" samples in which deuterium content was highly concentrated. In this way, deuterium has become a readily available raw material from the water by transforming it into the heavy water. If the deuterium-based fusion process succeeds, the required fuel, heavy water, can be obtained very simply with current technologies in unlimited quantities, quite cheap. The nuclear fusion reaction having deuterium as fuel is simpler to achieve on earth than the one that uses the counter, since deuterium, although very stable, is much more unstable than the antimatter. Nuclear fusion can be made more easily between two more unstable cores. In the fusion processes in stars, deuterium is destroyed inside the stars faster than it is produced. It is believed that other natural processes produce only an insignificant amount of deuterium. Almost all forms of deuterium found in nature were produced in the Big Bang 13.8 billion years ago because the natural or primordial ratio of hydrogen-1 (protium) and hydrogen-2 (deuterium) (which is about 26 atoms of deuterium per million hydrogen atoms) originates at that time (Big Bang). As evidence, this is the ratio found in giant gas planets such as Jupiter. However, it is found that other astronomical organisms have different ratios of hydrogen-1 deuterium. This is thought to be the result of natural isotopic separation processes that arise from the sun's warming of comets in comets. Like the cycle of water in the Earth's weather, such heating processes can enrich the amount of deuterium. Analysis of the deuterium/protium ratio in comets found results very similar to the average ratio in the Earth's oceans (156 atoms of deuterium per million hydrogen). This reinforces the theories that a large part of the Earth's oceanic water is of cometary origin. The deuterium/protium ratio of the 67P/Churyumov-Gerasimenko comet, measured by the Rosetta space probe, is approximately three times higher than that of the earth. This figure is the largest measured in a comet (at least until now). The deuterium/protium ratios thus continue to be an active subject of research in astronomy and climatology.

As a first observation, it should be noted that of all hydrogen isotopes known today (over seven), only the first three, protium, deuterium and tritium are found in nature due to the fact that they have some stability, the others being observed only by their production In some nuclear reactions and generally having a very low life span. That is why we can only speak of the first three isotopes of hydrogen today. However, if the first, the Protium is extremely stable, the second, the deuterium is also stable (but less than the protium), the third tritium is more unstable. For a long time, it was considered to be a nuclear unstable element. That is precisely why we would justify reconsidering today's feasible fusion reactions on Earth and pointing our attention to tritium, abandoning the decades of deuterium (heavy water) trials as more feasible than with Protium, but more difficult than with tritium.

However, because today there are some encouraging results in attempts to achieve industrial nuclear fusion on Earth with heavy water, it is good to continue these experiments, which is why the theme of this paper is still justified, to study carefully the dimensions of the deuterium atom (isotope), or those of the deuterium nucleus (deuterium positive ion), called deuteron.

In general, for the determination of the size of the particles and atomic subatomic particles are used their diameters static (i.e., when the particles are in the rest position), which is calculated by the various methods approximated (Halliday and Robert, 1966). These dimensions are approximately the dimensions of the nano, pico or slightly smaller.

The actual phenomena appear when these particles are in motion dynamics and therefore it is necessary to know the actual dimensions of the particles in the motion.

This work proposes to achieve this. Will be calculated the parameters required for the fusion of two particles of ions positive deuterium (cores of deuterium).

The parameters of the known to the nano-static fusion will be replaced with the parameters of the dynamics of a merger.

The first time will determine the required speed of the particles accelerated to start the merger when cold when they collide.

Secondly, it will determine the radius of the nucleus of deuterium in motion.

In the third row will calculate the potential energy of the two particles (cores of deuterium) for the merger.

This is the kinetic energy which must reach a core of fast deuterium to produce the merger by collision (Petrescu *et al.*, 2016a; 2016c; Petrescu and Calautit, 2016a; 2016b; Petrescu, 2012).

In the process of the fusion, two or more atomic nuclei join, or "merging", to form a single core heavier.

During this process, the raw material is not preserved, as part of the earth de cores' fusion is converted into energy which is released.

The energy of the tying of the core is greater than the energy the tying of each of the cores of which are melted to produce.

This produces an enormous quantity of energy.

Create the necessary conditions of the merger on the ground is very difficult, up to the point at which has not yet been reached no scale for protium, the first common isotope of hydrogen, which shall be subject to the natural merger of stars.

Today we know that not only the second isotope of hydrogen (deuterium) produces energy to the merger, but also the third (hard) isotope of hydrogen (tritium) may produce energy by nuclear fusion.

Materials and Methods

Any elementary particle mobile has the kinetic energy Equation 1 (composed of two components: The kinetic energy of the movement of translation and the direction of rotation):

$$E_c = \frac{1}{2} m \cdot v^2 + \frac{1}{2} J \cdot \omega^2 \tag{1}$$

One may determine the mass of a particle with the Lorentz relationship, Equation 2 (Lorentz transformation, Wikipedia):

$$m = \frac{m_0 \cdot c}{\sqrt{c^2 - v^2}} \tag{2}$$

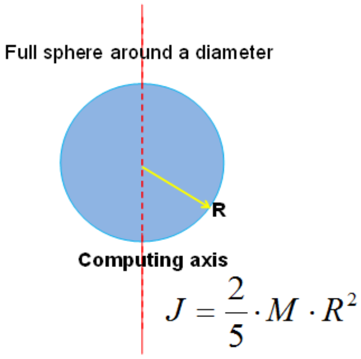

Fig. 1. Mass moment of inertia to a full sphere, determined around a diameter

The mechanical (mass inertia), of the particle around its axis of rotation, is determined with Equation 3 (Petrescu *et al*., 2016b):

$$J = \frac{2}{5} m \cdot R^2 \tag{3}$$

This is the moment of inertia of the mechanical or the mass of a sphere (Fig. 1), (Petrescu *et al*., 2016b).

Using the expressions 2 and 3, the Equation 1 takes on a new shape, Equation 4:

$$\begin{cases} E_c = \frac{1}{2} m \cdot v^2 + \frac{1}{2} \cdot \frac{2}{5} \cdot m \cdot R^2 \cdot \omega^2 \\ E_c = \frac{1}{2} \frac{m_0 \cdot c \cdot v^2}{\sqrt{c^2 - v^2}} + \frac{1}{2} \cdot \frac{2}{5} \cdot \frac{m_0 \cdot c \cdot R^2}{\sqrt{c^2 - v^2}} \cdot \omega^2 \end{cases} \tag{4}$$

The momentum (pulse) of the particle it is written using the Equation 5:

$$p = m \cdot v = \frac{m_0 \cdot c \cdot v}{\sqrt{c^2 - v^2}} \tag{5}$$

The wavelength particle associated may be determined by Equation 6, according to the Louis Broglie, the impulse is conserved, (Louis de Broglie, Wikipedia):

$$\lambda = \frac{h}{p} = \frac{h \cdot \sqrt{c^2 - v^2}}{m_0 \cdot c \cdot v} \tag{6}$$

The frequency of the wave associated with the particle can be determined by Equation 7:

$$\gamma = \frac{c}{\lambda} = \frac{c \cdot m_0 \cdot c \cdot v}{h \cdot \sqrt{c^2 - v^2}} = \frac{m_0 \cdot c^2 \cdot v}{h \cdot \sqrt{c^2 - v^2}} \tag{7}$$

The angular speed of the particle and the square thereof may be calculated with Equation 8:

$$\begin{cases} \omega = 2\pi\gamma = \frac{2\pi \cdot m_0 \cdot c^2 \cdot v}{h \cdot \sqrt{c^2 - v^2}} \\ \omega^2 = \frac{4\pi^2 \cdot m_0^2 \cdot c^4 \cdot v^2}{h^2 \cdot (c^2 - v^2)} \end{cases} \tag{8}$$

Using expressions 8 the relationships 4 take forms 9 (Equation 9):

$$\begin{cases} E_c = \frac{1}{2} \frac{m_0 \cdot c \cdot v^2}{\sqrt{c^2 - v^2}} + \frac{1}{2} \cdot \frac{2}{5} \cdot \frac{m_0 \cdot c \cdot R^2}{\sqrt{c^2 - v^2}} \cdot \frac{4\pi^2 \cdot m_0^2 \cdot c^4 \cdot v^2}{h^2 \cdot (c^2 - v^2)} \\ E_c = \frac{1}{2} \frac{m_0 \cdot c \cdot v^2}{\sqrt{c^2 - v^2}} \cdot \left[1 + \frac{8}{5} R^2 \cdot \pi^2 \frac{m_0^2 \cdot c^4}{h^2 \cdot (c^2 - v^2)} \right] \end{cases} \tag{9}$$

The kinetic energy of the particles in motion can be determined by Equation 10.

Of the total energy of the particle in motion, shall be reduced the total energy of the particles in rest, potential (energy) (Petrescu *et al*., 2016a; 2016c; Petrescu and Calautit, 2016a; 2016b; Petrescu, 2012):

$$\begin{cases} E_c = E - E_0 = m \cdot c^2 - m_0 \cdot c^2 \\ = m_0 \cdot c^2 \cdot \frac{c - \sqrt{c^2 - v^2}}{\sqrt{c^2 - v^2}} \end{cases} \tag{10}$$

Identifying the Equation 9 and 10 are obtained Equation 11, which may cause the radius of a particle elementary in motion:

$$\begin{cases} \frac{1}{2} \frac{m_0 \cdot c \cdot v^2}{\sqrt{c^2 - v^2}} \cdot \left[1 + \frac{8}{5} R^2 \cdot \pi^2 \frac{m_0^2 \cdot c^4}{h^2 \cdot (c^2 - v^2)} \right] \\ = m_0 \cdot c^2 \cdot \frac{c - \sqrt{c^2 - v^2}}{\sqrt{c^2 - v^2}} \\ R = \sqrt{\frac{10}{8}} \cdot \frac{h \cdot \sqrt{c^2 - v^2} \cdot \sqrt{c^2 - \frac{v^2}{2} - c \cdot \sqrt{c^2 - v^2}}}{\pi \cdot m_0 \cdot c^2 \cdot v} \end{cases} \tag{11}$$

For a Deuteron, the nucleus of a Deuterium atom, we know the static radius of a nucleon (proton or neutron, Fig. 2) and their range can be determined when the deuteron moves at a linear velocity v, using the Equation 11.

The radius of the nucleus of deuterium in the rest position has been determined in Fig. 2 according to the following Equation 12 (Petrescu *et al*., 2016a; 2016c; Petrescu and Calautit, 2016a; 2016b; Petrescu, 2012):

$$\begin{cases} R_D = r_0 \cdot A^{1/3} \\ r_0 = 1,45E - 15[m] \text{the average radius} \\ \text{of a nucleon fixed} \\ \text{A = the atomic mass} \end{cases} \tag{12}$$

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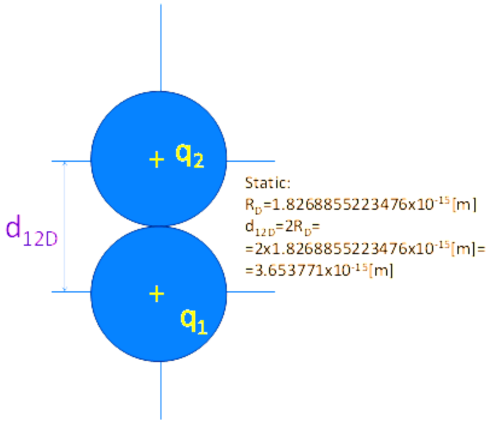

Fig. 2. Two adjacent particles of core of Deuterium

With the Equation 11 can be determined with an ultra-high precision the radius of the Deuteron (the nucleus of one Deuterium atom), or any other particles in motion, depending on the speed of its linear movement, *v*.

Results

Table 1 shows the dimensions of the radius of a nucleon belonging to a Deuteron, depending on the beta ratio, determined with the original Equation 11.

Where beta β, is the ratio between particle velocity and the speed of light in vacuum. You can compare the dynamic values in Table 1 with the static value, $R_D = 1{,}826\times10^{-15}$[m].

Discussion

The exact dimensions of a deuterium nucleus are very important in the fields of physics, chemistry, material science and so on.

A special application is the one used in nuclear power, with the obvious aim of starting the industrial nuclear fusion reaction. In this case the radius of Deuteron takes the below values (Petrescu *et al.*, 2016a; 2016c; Petrescu and Calautit, 2016a; 2016b; Petrescu, 2012):

R_D dynamic = 1.91788E-19 [m] (dynamic at v = 0.002307088c)
Static R_D = 1.827E-15 [m].

Potential energy has the below values (Petrescu *et al.*, 2016a; 2016c; Petrescu and Calautit, 2016a; 2016b; Petrescu, 2012):

Dynamic: U = Ep = 6.01333E-10 [J] = 3753521838 [eV] = 3753521.838 [KeV] = 3753.521838 [MeV] = 3.753521838 [GeV]
Static: U = Ep= 6.31284E-14 [J] = 3,94E5 [eV] = 394 [KeV]

Table 1. The Deuteron radius in function of β

β	0.000009	0.00002	0.0001
R[m]	1.35E-14	1.11E-14	2.22E-15
β	0,001	0,01	0,1
R[m]	8.32E-16	8.32E-14	8.30E-13
β	0,2	0,3	0,4
R[m]	1.65E-12	2.44E-12	3.18E-12
β	0,5	0,6	0,7
R[m]	3.86E-12	4.44E-12	4.85E-12
β	0,8	0,9	0,99
R[m]	4.99E-12	4.54E-13	2.04E-12
β	0,999	0,9999	0,99999
R[m]	7.11E-13	2.32E-13	7.41E-14
β	0,999999	0,9999999	0,99999999
R[m]	2.35E-14	7.44E-15	2.35E-15

As you can see the difference between the static and dynamic calculations presented is very high.

To achieve cold fusion, we need to accelerate Deuterium ions (Deuterium nuclei; the Deuterons) until they reach the necessary kinetic energy, E_c = 3.75 [GeV].

Using static calculations, this potential energy was much smaller, E_c = 394 [KeV].

In the process of the fusion, two or more atomic nuclei join, or "merging", to form a single core more heavy.

During this process, the raw material is not preserved, as part of the earth de cores' fusion is converted into energy which is released.

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Today we know that not only the second isotope of hydrogen (deuterium) produces energy to the merger, but also the third (hard) isotope of hydrogen (tritium) may produce energy by nuclear fusion.

The first reaction is possible between two cores of deuterium, from which it may obtain a nucleus of tritium, a proton and energy power or an isotope of helium with a neutron and energy Equation 13 and 14:

$$\begin{aligned} &{}_1^2D + {}_1^2D \to {}_1^3T + 1.01MeV + {}_1^1H + 3.02MeV \\ &= {}_1^3T + {}_1^1H + 4.03MeV \end{aligned} \tag{13}$$

$$\begin{aligned} &{}_1^2D + {}_1^2D \to {}_2^3He + 0.82MeV + {}^1n + 2.45MeV \\ &= {}_2^3He + {}^1n + 3.27MeV \end{aligned} \tag{14}$$

Comments: A core of deuterium has a proton and a neutron; a nucleus of tritium has a proton and two neutrons.

The merger may occur and between a core of deuterium and one of tritium Equation 15:

$$\begin{aligned} & {}_1^2D + {}_1^3T \rightarrow {}_2^4He + 3.5MeV + {}^1n + 14.1MeV \\ & = {}_2^4He + {}^1n + 17.6MeV \end{aligned} \tag{15}$$

Another reaction to the merger can be produced between a core of deuterium and an isotope of helium Equation 16:

$$\begin{aligned} & {}_1^2D + {}_2^3He \rightarrow {}_2^4He + 3.6MeV + {}_1^1H + 14.7MeV \\ & = {}_2^4He + {}_1^1H + 18.3MeV \end{aligned} \tag{16}$$

Conclusion

As a first observation, it should be noted that of all hydrogen isotopes known today (over seven), only the first three, protium, deuterium and tritium are found in nature due to the fact that they have some stability, the others being observed only by their production In some nuclear reactions and generally having a very low life span. That is why we can only speak of the first three isotopes of hydrogen today. However, if the first, the Protium is extremely stable, the second, the deuterium is also stable (but less than the protium), the third tritium is more unstable. For a long time, it was considered to be a nuclear unstable element. That is precisely why we would justify reconsidering today's feasible fusion reactions on Earth and pointing our attention to tritium, abandoning the decades of deuterium (heavy water) trials as more feasible than with Protium, but more difficult than with tritium.

However, because today there are some encouraging results in attempts to achieve industrial nuclear fusion on Earth with heavy water, it is good to continue these experiments, which is why the theme of this paper is still justified, to study carefully the dimensions of the deuterium atom (isotope), or those of the deuterium nucleus (deuterium positive ion), called deuteron.

To achieve cold fusion, we need to accelerate the Deuterons until they reach the necessary kinetic energy, $E_c = 3.75$ [GeV].

With the Equation 11 can be determined with an ultra-high precision the radius of the Deuteron (the nucleus of one Deuterium atom, only for the nucleons positioned in nucleus as shown in Fig. 2), or any other particles in motion, depending on the speed of its linear movement, v.

As you can see the difference between the static and dynamic calculations presented is very high.

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Author's Contributions

All the authors contributed equally to prepare, develop and carry out this manuscript.

Ethics

Authors declare that are not ethical issues that may arise after the publication of this manuscript. This article is original and contains unpublished material.

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Nomenclature

ε_0 = The permissive constant (the permittivity)
ε_0 = 8.85418 E-12 [C^2/Nm^2]
h = The Planck constant
h = 6.626 E-34 [Js]
q = Electrical elementary load
q_e = -1.6021 E-19[C]
q_p = 1.6021 E-19[C]
c = The light speed in vacuum
c = 2.997925 [m/s]
m_0[kg] = The rest mass of one particle
$m_{0electron}$ = 9.11E-31 [kg]
$m_{0proton}$ = 1,6726219E-27 [kg]