the general science journal

Calculating the Binding Energy of Deuteron: 2.21 MeV

by

Javier de Juan

A reader has asked me to clarify the origin of the number 3,0705 contained in the final formula for the binding energy of proton and neutron presented in the previous Article "The Alternative to the Standard Model - The Nuclear Forces":

$$\frac{3{,}0705 \text{ x } 1{,}6019^2 \text{ x } 8{,}9874 \text{ x } 10^{20} \text{ x } 10^{26} \text{ x } 10^6}{2 \text{ x } 10^{40} \text{ x } 10^{13} \text{ x } 1{,}6019} = 2{,}2103 \text{ MeV}$$

I think it's clear enough. I refer the reader to the Article entitled "The Alternative to the Standard Model - The Nuclear Forces" - But I'll try to explain it again. The number 3.0705 is the result of the whole calculation of the binding energy of proton and neutron forming the deuteron. The question is to calculate the forces between the electrical rings of the two particles. These "nuclear" forces are purely electrical and magnetic, with the peculiarity that magnetic force exceeds electric force, which allows electric rings with the same sign to be joined together.

The calculation is laborious and requires the use of rapid calculators. I have done it several times, one of them using a Hewlett Packard HP 65 computer, which incorporates magnetic cards which facilitates the calculations. Anecdotally I note that a reader has indicated me that the computer HP 65 has more than 40 years and this is indeed. I bought in 1973. At that time I was in the USA, just as the Watergate affair took place. Indeed, in June 1972, five men were arrested for spying in the Watergate Hotel in Washington. And in August 1974, Nixon resigned as President. This I experienced it on American television.

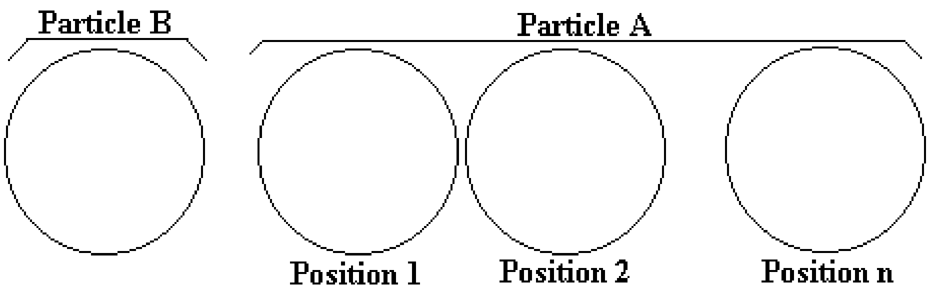
Another reader tells me that being able to calculate the binding energy of the deuteron with the result of 2.21 MeV, which coincides with the experimental value, is very valuable "if true." There are the data. All referring to electric rings forming part of neutron and proton are known. I have done it with a computer 40 years old, but highly accurate and appropriate for this specific job. Complicated formulas are introduced into the magnetic cards and giving values to different variables results are obtained with the number of decimal places you want at the touch of a button. He, who decides to do so, if as I hope succeeds, will have contributed accurately to eradicate the great virus Modern Physics are today suffering. And maybe he will put many members of the scientific community, including a few dozen Nobel Prizes in Physics, in a difficult situation.

In this regard I quote Keith Foote: "There are better models out there than the Standard Model, but the prestigious members of the physics community have tied their reputations to this model. They don't want to lose their grants, the respect of their peers, or to go down in history as misinformed idiots. Some of them have looked over the wall they've built and are beginning to sweat. Real changes will not come from the academics. They will come from technologists and inventors".

Returning to the scientific subject, the issue is to measure the electric force on the one hand and magnetic on the other that **each of the points** on the positive electric ring of the proton exerts **on each of the points** of the two concentric electric rings of the neutron, one positive and the other negative. The issue is laborious, but not difficult if one has the ideas clear. And not so laborious that can be compared to the great works of CERN. Within days of monotonous work it can be done without problem and, if available a computer program, things are quite simplified.

The method consists of positioning the particles at different distances and calculating in each case the total force of attraction. Keep in mind that the particles are very powerful magnetic dipoles, which leads undoubtedly to a position of parallel axes.

In order to clarify ideas, let us imagine the case, for example, of two charge-rings of opposite signs, which consequently must turn in the same direction. The reasoning would be the same if the signs were the same and the turning directions opposite. Let us consider, as shown in the figure, particle B as fixed and let us place particle A in different positions, 1, 2 ..... n. And let us call de_A differential elements of charge of particle A and de_B differential elements of charge of particle B.



The electric forces between the charge-rings will be of attraction, whatever the turning directions may be. The absolute value of the electric force of attraction will depend on distance d between particles. As they move away, electric forces decrease. If we suppose that the position of particle B is sufficiently far away from particle A so to be able to consider negligible the diameter of the rings, in the range of 10^{-13} cm, compared to distance d, it is clear that the calculation of the electric forces between all differential elements of charge de_A and de_B , as calculated in this Work, could be substituted without appreciable error by the electric effect between two punctual charges of absolute value e, placed at a distance d.

The electric force of attraction, when d is much greater than 10^{-13} cm, will be

$$F_e = \frac{e^2\ c^2}{d^2}$$

This is the case of electrostatic action between nucleus and orbital electron.

But let us see what happens to magnetic forces. We can say at first that the right side of particle B, according to the previous figure, and the left side of particle A, that is to say, the two halves of the two rings which are facing each other, produce a magnetic effect of attraction. When distance is very short, much less than the radius of rings, this magnetic effect of attraction is much greater than the electric effect. It is precisely this magnetic effect, when distance is very short, which determines the huge attraction forces between particles, whatever their electric signs may be, but depending on the relative turning directions. If we consider that two particles are moving away, the magnetic effect of the front half of one of the particles on the other particle and the magnetic effect of the back half of the same particle on the other particle will again obviously be, on the one hand, of opposite sign, and on the other hand, these effects will become smaller as the distance increases. That is to say, those opposite magnetic effects will tend to be equal when distance d is sufficiently great as to render negligible the diameter of the ring compared with distance d. When this happens, the magnetic effect of the front half of the ring in question will be practically equal to the magnetic effect of the back half of the same ring, both being of opposite signs. There will be no apparent difference between those effects, which will cancel out one another as their directions are opposite.

We can see that, at very short distances, the magnetic effect of facing halves of rings is much greater than the electric effect. This is what makes the union of protons possible, in spite of their electric signs being equal, with the sole condition that they must turn in opposite directions.

As the particles move away the magnetic effect loses importance, so quickly that it is nearly negligible at the distance of 1 fermi. The electric effect, at very short distances, follows Coulomb's law for each couple of differential elements of charge de_A and de_B . But when distances are great in comparison with the diameter of charge-rings the electric effect follows Coulomb's law as applied to two punctual charges e placed at distance d.

In short, when distances are very short, we have to calculate electric and magnetic effects between each of the differential elements of charge de_A and de_B . Magnetic effect is much higher than electric effect at short distances and when the travelling speeds of the charge elements are higher than the speed of light. When distances d are very great the electric effect obeys Coulomb's law as applied to two punctual charges "e" located at distance d, and the magnetic effect falls very sharply as distance d increases and becomes negligible for values of d over 1 fermi. For greater distances the magnetic effect becomes zero.

The above conclusions are the consequence of the rigorous application of electromagnetic laws. The calculation may be complex but the concepts are simple. Without entering into the quantitative results of the calculations, one has to admit that in principle these conclusions respond qualitatively to the behaviour of nuclear forces in a surprising way: Attraction at distances less than 1 fermi, whatever the electric signs of the particles may be, and exclusively electric effect when distances are much greater than 1 fermi. The fact that the conclusions of this Theory coincide in this way with experimental facts should be sufficient reason to give credit to the Theory. But I think that coincidences of a qualitative kind are not enough. I know that they could not be accepted if quantitative results were absurd. As I have said before, these calculations are moving within a spectrum of figures in the range of 10^{50} , which is the difference between nucleon frequency and Planck's constant. In the calculations forces between particles are measured as the distance between them varies.

As an example, let us see the case when distance d between centres of rings of proton and neutron is d = 0,7175 fermi (1 fermi = 10^{-13} cm). Calculations, I insist they are laborious, lead to a result of the force of attraction F_T = 27,52 e^2 c^2 10^{26} dyne. These calculations are detailed in p.136 of the book "A New Physics for a New Millennium". So the attraction force between a proton and a neutron, when their centres are located at a distance d = 0,7175 fermi and they are turning in the same direction, is equal to 27,52 e^2 c^2 10^{26} dyne. As one can see, we have been using factors like 10^{-40}, 10^{20} , 10^{26} ...... Bearing these factors in mind, and if my calculations were quantitatively coincident with experimental reality, one is presented with the following alternative:

1 - That I have stumbled upon a coincidence of a strange or inexplicable nature or
2 - That this Theory is on the right path towards discerning the true nature of matter, electricity and nuclear forces.

I would regard the first of these options as unacceptable to anyone capable of analysing this subject fully.

We are going to continue the calculations in relation to the binding energy of deuteron. We have calculated the value of the attraction force between proton and neutron, turning in the same direction, when distance d is 0,7175 fermi. The attraction forces F_T for different distances d are shown, following the same system as the one used before:

d = 0,7125 – F = 56,81 e^2 c^2 10^{26} dyne
d = 0,7175 – F = 27,52 e^2 c^2 10^{26} dyne
d = 0,735 – F = 11,66 e^2 c^2 10^{26} dyne

d =0,758 - F = 6,44 $e^2\ c^2\ 10^{26}$ dyne
d = 0,81 – F = 2,77 $e^2\ c^2\ 10^{26}$ dyne
d = 1,01 – F = 0,54 $e^2\ c^2\ 10^{26}$ dyne
d = 1,71 – F = 0,04 $e^2\ c^2\ 10^{26}$ dyne

Being 0,3514 fermi the radius of the electric ring of the proton and 0.3586 fermi the radius of the electric exterior ring of the neutron, their sum is 0,71 fermi. The minimum distance between rings is from 0,0025 to 1 fermi. In the first case the force is huge 56,81 $e^2\ c^2\ 10^{26}$ dyne and in the latter case the force is negligible (relatively) 0,04 $e^2\ c^2\ 10^{26}$ dyne.

The result is that at short distances the magnetic attraction forces far exceed the electrical forces of repulsion and at the distance of a fermi force practically disappears.

If we depict in a graph, as is shown on page 7, the curve determined by ordinates axis measuring the forces in F_T divided by $e^2\ c^2\ 10^{26}$ and abscissas axis measuring the minimum distance between rings, that is to say d - 0,71 fermi, we will get a curve as shown in the figure.

The energy being equal to a force multiplied by a distance, the binding energy between the particles will be the force multiplied by the distance corresponding to that force. As force varies with distance, the binding energy will be $\int F_T\, dx$ where x is the minimum distance between rings. In other words, binding energy will be equal to the sum of the partial products of the force, for each position of the particles, multiplied by the differential element of distance. This means that the binding energy is the area limited by the coordinate's axes and the curve force-distance represented on the figure.

We reach the following values:

$$S = \frac{3{,}0705}{2} \quad ; \quad \text{Value} = \frac{F_T}{e^2\ c^2\ 10^{26}}$$

The binding energy of deuteron, is

$$\frac{3{,}0705}{2}\ \frac{e^2\ c^2\ 10^{26}}{10^{13}}\ \text{erg}$$

The result is:

$$\frac{3{,}0705 \times 1{,}6019^2 \times 8{,}9874 \times 10^{20} \times 10^{26} \times 10^{6}}{2 \times 10^{40} \times 10^{13} \times 1{,}6019} = 2{,}2103\ \text{MeV}$$

Factor 10^{13} in the denominator comes from introducing distance, which must be measured in centimetres. The factor for changing from erg into MeV is10^6 /1,6019. So the above expression given in erg must be multiplied by this factor in order to have it in

MeV.

I have taken: $e = 1,6019 \times 10^{-20}$ and $c^2 = 8,9874 \times 10^{20}$.

THE RESULT IS TOTALLY COINCIDENT WITH THE EXPERIMENTAL DATUM.

The fact that this result is so exactly equal to the experimental datum might be questioned by some, by arguing that, in any case, the calculation is approximate. That is true. On the one hand, the system of calculating integrals through points is necessarily approximate. On the other hand, in the final calculation, based on the measure of the area limited by the coordinate's axes and the curve force-distance, I have considered neither the area between abscissa 0 and 0,0025 fermi nor the one between abscissa 1 and infinity.

The calculation of integrals through points gives us a value slightly greater than the one we would obtain based on the real curves. On the other hand, by disregarding the areas corresponding to asymptotic zones between 0 and 0,0025 fermi, as well as between 1 fermi and infinity, we obtain a smaller result. It is clear that one approximation works in one direction and the other approximation works in the opposite direction. I am not going to say that both are equal, but it is true that they compensate each other partially.

What is really important is the fact that these two effects are very small, practically negligible. I invite the reader to incorporate any intermediate point in the calculation that has been made of the integrals and I can guarantee that the effect on the final result will be negligible. As far as disregarding the areas of the asymptotic zones, I can also guarantee that this effect is negligible. It has been calculated, by using the programs of the computer, the case when d = 0,7101 fermi ; $\alpha = 0^{\circ}$. This disposition implies a minimum distance between the rings equal to 0,0001 fermi. Let us remember that the first point calculated of the curve force-distance for deuteron corresponds to a minimum distance between rings of 0,0025 fermi. So the area limited between abscissas 0,0001 and 0,0025 fermi will give us the order of magnitude of the area which has been disregarded in the asymptotic zone corresponding to the ordinates axis.

In this calculation values of F_e and F_m have only been considered, as the effect of the interior ring of the neutron is negligible in comparison with the huge forces between the ring of the proton and the exterior ring of the neutron, their differential elements of charge being at distances in the range of 0,0001 fermi. I have considered point A for $\alpha = 0^{\circ}$ and as values of α only those very close to $\alpha = 0^{\circ}$, precisely up to $\alpha = 0,5^{\circ}$, the increments of angle α being equal to $0,1^{\circ}$. The remaining values of α will give us a negligible result in comparison with the enormous values of the forces when distances are about 0,0001 fermi. As a second value of α I have taken $\alpha = 5^{\circ}$. In this case the effects for d = 0,7101 fermi are comparable to the effects for d = 0,7125 fermi.

The calculation of the area between abscissas 0,0025 and 0,0001 fermi is equivalent to 0,0027 MeV, which is negligible for the final result.

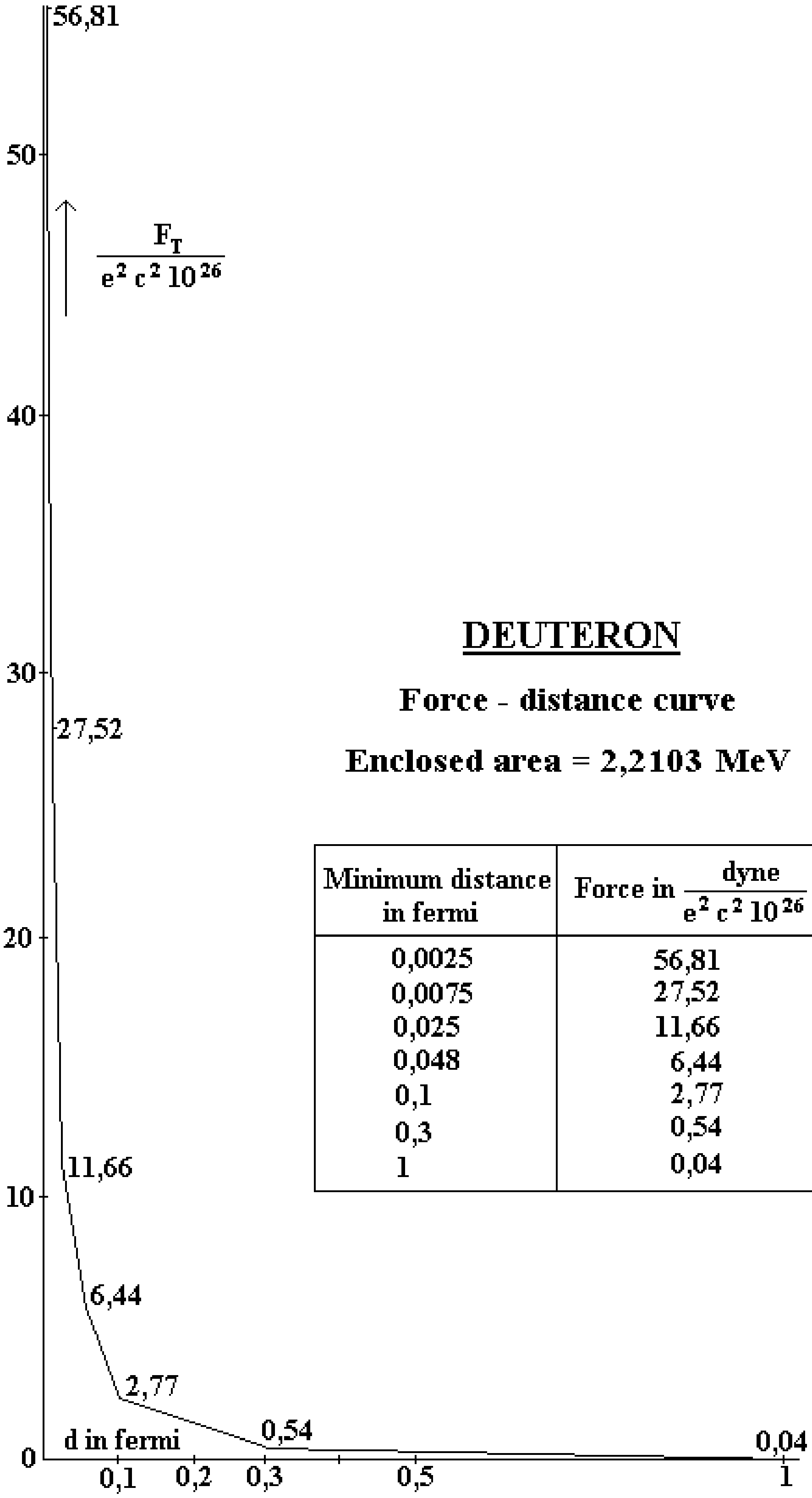
As I have said, my aim, when making all these calculations, was to check that the binding energy of deuteron, as deduced by this Theory, was not in complete disagreement with the experimental datum 2,21 MeV. If the result had been a few MeV the aim would have been accomplished. If it had been very close to 2 MeV, the result would have been considered as excellent. And the result being exactly 2,21 MeV, it must be considered as "really surprising".

I would like some Institution with great facilities to check these figures. Big computers and most sophisticated means and procedures would help to get more reliable results. What would happen if one of these Institutions would reach the result of 2,21 MeV? I do not know but I dare say that the team making the calculations would be very interested in getting to the bottom of this Theory.

In principle one could calculate whether the force between proton and neutron when the distance between their centres is 0,7175 fermi coincides with the advanced in this work $F = 27{,}52\ e^2\ c^2\ 10^{26}$ dyne. If so, there would be a good incentive for further checks.

Ended May, 2015

Mailto: jdejuand@telefonica.net



DEUTERON

Force - distance curve

Enclosed area = 2,2103 MeV

Minimum distance in fermi	Force in $\frac{\text{dyne}}{e^2 c^2 10^{26}}$
0,0025	56,81
0,0075	27,52
0,025	11,66
0,048	6,44
0,1	2,77
0,3	0,54
1	0,04