Atomic nuclei modelled without magic particles

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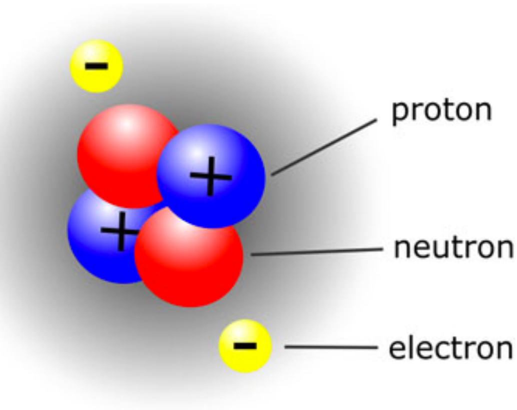
Abstract-Atomic nuclei are normally drawn as a combination of protons and neutrons grouped together as close as possible. Given the enormous repulsive force between two protons such a configuration cannot represent reality. Quantum physics pretends to solve this problem by means of quarks, hold together by gluons. This article presents a model without magic particles.

Introduction

The author asked himself the question whether the introduction of the exotic particles called quarks are indeed necessary to hold neutrons and protons in atomic nuclei together, given the enormous repulsive forces between protons. On their turn these quarks need even more exotic particles, called gluons, to hold them together in these protons and neutrons. Such a solution appears to create more problems than solutions for the original problem.

Generally accepted configuration of the Helium nucleus

The nucleus of the Helium atom is normally drawn as a combination of two protons and two neutrons grouped together as close as possible. See figure below, being one of a countless number of similar representations.



Important parameter values are:

Atomic number	Z	2	
Electric charge electron	q	$1{,}6*10^{-19}$	C
Electric charge proton	q	$1{,}6*10^{-19}$	C
Coulomb's constant	k_C	$9*10^{9}$	Nm^2C^{-2}
Gravitational constant	G	$6.7*10^{-11}$	Nm^2kg^{-2}
Mass proton	m_P	$1.7*10^{-27}$	kg
Mass neutron	m_N	$1.7*10^{-27}$	kg
Mass electron	m_e	$9.1*10^{-31}$	kg
Diameter proton	d_P	$8*10^{-16}$	m
Diameter neutron	d_N	$8*10^{-16}$	m

The possible radii of the orbiting electrons are represented by $r_n = n^2 a_0/Z$, with n is an integer and a_0 the so-called Bohr's radius: $a_0 = h^2/(4\pi^2 k_C q^2 m_e)$, $h = 6.626*10^{-34}$ kg m^2 s^{-1}.

Variables following from these parameters are:

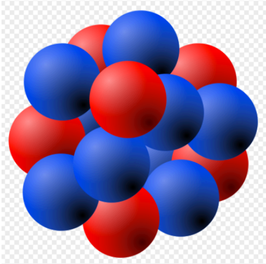
Smallest radius of Helium atom		$r_1 = 2.7*10^{-11}$	m
Centripetal force between orbiting electron and nucleus:	$k_C Z q^2/r_1^2$	$= 6.6*10^{-7}$	N
Centrifugal force electron	$m_e v^2/r_1$		N
Orbital velocity of electron $v = q\sqrt{k_C Z/r_1/m_e}$		$v = 3.1*10^{6}$	m/s
Radius of grouped protons and neutrons		$r_N \approx 10^{-15}$	m
Repulsive force F_C between protons $\approx k_C q^2/r_N^2$		$F_C \approx 2*10^{2}$	N
Gravitational force F_G between protons or neutrons $G m_N m_P/r_N^2$		$F_G \approx 10^{-34}$	N

Preliminary conclusions: gravitational forces don't play any role; the radius of the atom is about 30thousand times larger than the radius of the nucleus (on the scale of the figure above, the nucleus has to be drawn as 1 micro meter!) and last but not least: the nucleus as presented has to "explode" due to the enormous repulsive force, compared with the centripetal force.

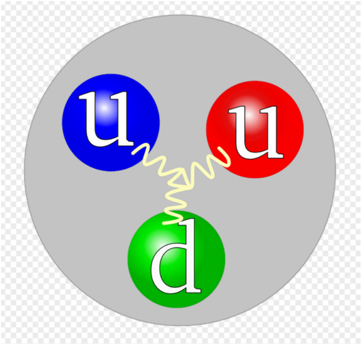
Solution of quantum physics to prevent the "explosion" of nuclei

Reference [1] presents the following information:

"An atomic nucleus is shown here as a compact bundle of the two types of nucleons, protons (red) and neutrons (blue). In this picture, the protons and neutrons are shown as distinct, which is the conventional view in chemistry, for example. But in an actual nucleus, as understood by modern nuclear physics, the nucleons are partially delocalized and organize themselves according to the laws of quantum chromodynamics."

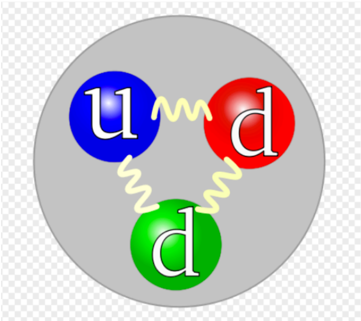


Reference [2] explains what is meant with quarks in a proton



"Three colored balls (symbolizing quarks) connected pairwise by springs (symbolizing gluons), all inside a gray circle (symbolizing a proton). The colors of the balls are red, green, and blue, to parallel each quark's color charge. The red and blue balls are labeled "u" (for "up" quark) and the green one is labeled "d" (for "down" quark).
A proton is composed of two up quarks, one down quark, and the gluons that mediate the forces "binding" them together. The color assignment of individual quarks is arbitrary, but all three colors must be present. Electric charge +2/3 e, −1/3 e"
*Net electric charge: 2*2/3 e-1/3 e=1e.*

Reference [3] explains what is meant with quarks in a neutron



"The quark structure of the neutron. There are two down quark in and one up quark. The strong force is mediated by gluons (wavey). The strong force has three types of charges, the so called red, green and the blue. Note that the choice of blue for the up quark is arbitrary; the "color charge" is thought of a circulating between the three quarks.
Electric charge 0 e $(-2\pm8)\times10^{-22}$ e (experimental limits)"
*Net electric charge is +2/3 e -2*1/3 e=0.*

The mentioned net electric charge of the proton resp. neutron thus is still 1e resp. 0, so the problem under consideration is not yet solved, in fact magnified, because now the quarks, at a mutual even shorter distance, have to be hold together also. If gluons would solve the last mentioned problem, the question arises why these magic particles are not applied directly to the proton and neutron in the nucleus.

In the next chapter a philosophy is presented that might solve the problem with conventional physics.

[1] https://en.wikipedia.org/wiki/Nucleon#/media/File:Nucleus_drawing.svg
[2] https://en.wikipedia.org/wiki/Quark
[3] https://en.wikipedia.org/wiki/Neutron

Philosophy about an alternative solution for the “explosive” nucleus

The atomic model of Bohr in principle solves an equivalent but opposite problem as the one in the nucleus of the atom: electrons and protons are close together but do not merge.
So the unavoidable conclusion seems to be that the protons in a nucleus cannot exist in a fixed mutual position. Therefor it is assumed that the protons orbit the neutrons and that a neutron is a proton around which an electron orbits with a radius much smaller than the radius of the smallest orbit of the electron in the atom. N.B. The mass of a neutron is equal to the mass of a proton plus a mass of the order of magnitude of that of the electron.
An important condition in this model is that the velocity of the orbiting electron in the neutron is much higher than the orbital velocity of the here so-called outside proton, from now on shortly expressed as P_O. In conformity with this notation the inside proton, so the one of the neutron, will be presented by P_I. The reason for this condition is that from the point of view of P_O, the electron has to function as a kind of shield between both protons.
As long as this condition is fulfilled it is assumed that the distance between the electron and P_O determines the attractive force between these two particles. So if the radius of the orbit of the electron is represented by r_e and the one of P_O by r_P, the meant distance is $r_P - r_e$.
As a result there are now effectively three centripetal forces acting on P_O: the repulsive one of P_I ($-k_CZq^2/r_P^2$), the attractive one of the electron ($+k_CZq^2/(r_P - r_e)^2$) and the fully negligible gravitational one between both protons. The net result of these two remaining forces has to keep P_O in its orbit, balanced by the centrifugal force as the result of its orbiting velocity v_P.
This centrifugal force is: $m_Pv_P^2/r_P$. So given r_e and r_P, v_P can be calculated from the equation:

$$m_Pv_P^2/r_P = k_CZq^2/(r_P - r_e)^2 - k_CZq^2/r_P^2$$

The orbital velocity of the electron follows from the chosen r_e, by means of $m_ev_e^2/r_e = k_CZq^2/r_e^2$.
The minimum value of r_e is considered as at least half the diameter of the proton plus half the diameter of the electron. The last one is calculated based on the assumption that the specific mass of the electron will equal the specific mass of the proton. The result is: $d_e = 6.5*10^{-17}$ m.
The first chosen example is the Deuterium atom (Z=1) of which the minimum atomic orbit has a radius of $5*10^{-11}$. Two tables are shown, I with the minimum possible r_e, II with the maximum r_e.

$\mathbf{r_e}$	$\mathbf{F_e}$	$\mathbf{v_e}$	$\mathbf{r_{PO}}$	$\mathbf{F_{POPI}}$	$\mathbf{F_{POe}}$	$\mathbf{F_{net}}$	$\mathbf{v_{PO}}$
5,0E-16	9,2E+02	7,1E+08	5,0E-15	9,2E+00	1,1E+01	2,2E+00	2,5E+06
5,0E-16	9,2E+02	7,1E+08	4,0E-15	1,4E+01	1,9E+01	4,4E+00	3,2E+06
5,0E-16	9,2E+02	7,1E+08	3,0E-15	2,6E+01	3,7E+01	1,1E+01	4,5E+06
5,0E-16	9,2E+02	7,1E+08	2,0E-15	5,8E+01	1,0E+02	4,5E+01	7,3E+06
5,0E-16	9,2E+02	7,1E+08	1,0E-15	2,3E+02	9,2E+02	6,9E+02	2,0E+07

Table I Z=1 and r_e has to minimum possible value

$\mathbf{r_e}$	$\mathbf{F_e}$	$\mathbf{v_e}$	$\mathbf{r_{PO}}$	$\mathbf{F_{POPI}}$	$\mathbf{F_{POe}}$	$\mathbf{F_{net}}$	$\mathbf{v_{PO}}$
5,0E-12	9,2E-06	7,1E+06	5,0E-11	9,2E-08	1,1E-07	2,2E-08	2,5E+04
5,0E-12	9,2E-06	7,1E+06	4,0E-11	1,4E-07	1,9E-07	4,4E-08	3,2E+04
5,0E-12	9,2E-06	7,1E+06	3,0E-11	2,6E-07	3,7E-07	1,1E-07	4,5E+04
5,0E-12	9,2E-06	7,1E+06	2,0E-11	5,8E-07	1,0E-06	4,5E-07	7,3E+04
5,0E-12	9,2E-06	7,1E+06	1,0E-11	2,3E-06	9,2E-06	6,9E-06	2,0E+05

Table II Z=1 and r_e has to maximum possible value

r_e	orbital radius electron	m/s	F_e	centripetal force electron	N
v_e	orbital velocity electron	m/s	r_{PO}	orbital radius P_O	m
F_{POPI}	repulsive force P_O versus P_I	N	F_{POe}	attractive force P_O versus el.	N
F_{net}	net force on P_O	N	v_{PO}	orbital velocity P_O	m/s

In all results the condition: $v_e >> v_{PO}$ is fulfilled!

The next orienting 2 tables are realized for an atom with Z=100. See table III and IV
The minimum radius of the atomic orbit equals $a_0/100 = 5*10^{-13}$.

r_e	F_e	v_e	r_{PO}	F_{POPI}	F_{POe}	F_{net}	v_{PO}
5,0E-16	9,2E+04	7,1E+09	5,0E-15	9,2E+02	1,1E+03	2,2E+02	2,5E+07
5,0E-16	9,2E+04	7,1E+09	4,0E-15	1,4E+03	1,9E+03	4,4E+02	3,2E+07
5,0E-16	9,2E+04	7,1E+09	3,0E-15	2,6E+03	3,7E+03	1,1E+03	4,5E+07
5,0E-16	9,2E+04	7,1E+09	2,0E-15	5,8E+03	1,0E+04	4,5E+03	7,3E+07
5,0E-16	9,2E+04	7,1E+09	1,0E-15	2,3E+04	9,2E+04	6,9E+04	2,0E+08

Table III *Z=100 and r_e has to minimum possible value*

r_e	F_e	v_e	r_{PO}	F_{POPI}	F_{POe}	F_{net}	v_{PO}
5,0E-14	9,2E+00	7,1E+08	5,0E-13	9,2E-02	1,1E-01	2,2E-02	2,5E+06
5,0E-14	9,2E+00	7,1E+08	4,0E-13	1,4E-01	1,9E-01	4,4E-02	3,2E+06
5,0E-14	9,2E+00	7,1E+08	3,0E-13	2,6E-01	3,7E-01	1,1E-01	4,5E+06
5,0E-14	9,2E+00	7,1E+08	2,0E-13	5,8E-01	1,0E+00	4,5E-01	7,3E+06
5,0E-14	9,2E+00	7,1E+08	1,0E-13	2,3E+00	9,2E+00	6,9E+00	2,0E+07

Table IV *Z=100 and r_e has to maximum possible value*

The next question is: having created protons and neutrons much larger than the current ones, do all these particles fit in the volume created by the minimum atomic orbit of the atom? The most extreme example is the atom with Z≈100.
The volume of this minimum orbital sphere is: $(4/3)*\pi*R^3$, with $R=5*10^{-13}$, resulting in $6*10^{-37}$ m^3.
The smallest proton-neutron combination in Table IV has a diameter of 10^{-13} m, representing a volume of $4*10^{-39}$ m^3. There are about 100 of these combinations and each combination has to be taken twice as large in order to decide whether they will fit in the atomic volume. The result of such a multiplication is $3*10^{-36}$, so significant larger than $6*10^{-37}$ m^3. However there is much more choice, because table IV shows the results for the maximum possible r_e. If r_e would be chosen $5*10^{-15}$ the maximum r_{PO} is $(1 \text{ to } 5)*10^{-14}$. The volume per proton-neutron pair is then: $(4 \text{ to } 500)*10^{-42}$ m^3. So the total required volume is at least 1000 times smaller than $6*10^{-37}$ m^3.

An interesting phenomenon accompanied by this model is the extremely strong magnetic field of the neutron.
For $r_e = 5*10^{-15}$ this field strength is ≈ 10^{17} [A/m], multiplied by μ_0 ($4\pi*10^{-7}$ [NA^{-2}]) resulting in a so-called magnetic flux density of ≈ 10^{11} [N/A.m] or [V.s/m^2] or Tesla.
A comparable situation is the strength of a magnetar (“a type of neutron star with an extremely powerful magnetic field) 10^8 - 10^{11} Tesla”.

The presented model of the neutron in principle shows an equivalent model of the hydrogen atom ^1_1H: 1 proton and 1 electron. If the Rydberg expression would also be applicable to this neutron model, a jump of its electron to an outer orbit would result in a “photon”, read: EM-pulse with a frequency around 10^{19} Hz.

> “X-rays make up X-radiation, a form of electromagnetic radiation.
> Most X-rays have a frequency in the range 3×10^{16} Hz to 3×10^{19} Hz” !
> Gamma rays typically have frequencies >10^{19} Hz

Conclusion / Question

What might be wrong with the model of an atomic nucleus as presented above?