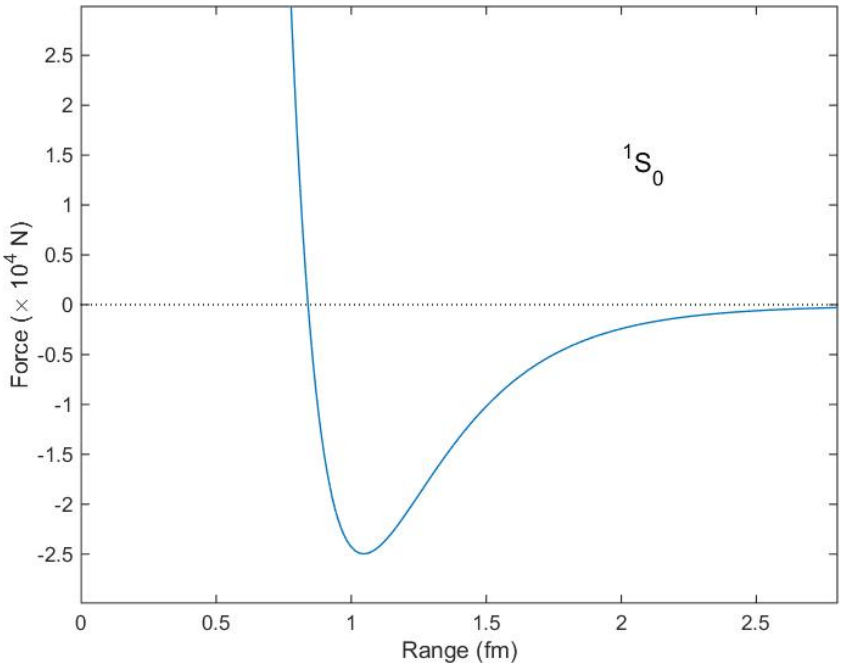
https://en.wikipedia.org/wiki/Nuclear_force
https://commons.wikimedia.org/wiki/File:ReidForce2.jpg



https://chatgpt.com/
"please find equation for curve in <link to above image file>"
essentially rendered:

$$V_{\text{Reid}}(r) = \frac{-10.463e^{-0.7r} - 1650.6e^{-2.8r} + 6484.2e^{-4.9r}}{0.7r}$$

with V in Mev and r in fm.

HR: with such weird numbers, I cannot see anything fundamental in this potential.
It very much looks like curve-fitting that cannot have been deduced from ascertained truths.
This is neither ***science***[1] nor ***understanding***, but merely some kind of 🎻🎼♪♪♪♬♫😎

$$F_{SN} = -\frac{dV_{\text{Reid}}}{dr}$$

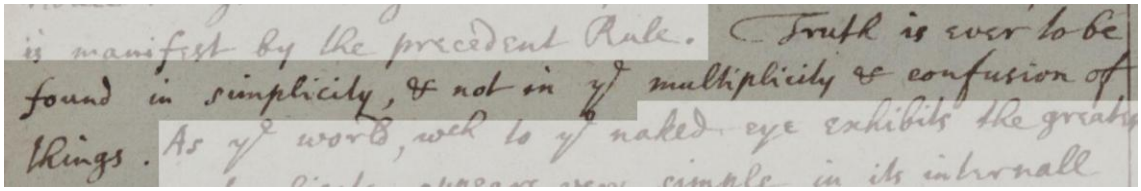
$$F_{SN} = \frac{10.463(1+r)e^{-0.7r} + 1650.6(1+4r)e^{-2.8r} - 6482.2(1+7r)e^{-4.9r}}{r^2}$$

in Mev/fm.

1 Mev/fm = 160.217663 N.

Proton *diameter* ≈ 0.84 fm, which roughly equals the *radius*
where the total *force* (i.e. SNF + Coulomb) would become repulsive.
But wouldn't both nucleons then meanwhile overlap by half their radius?
Shouldn't the minimal *radius* roughly equal 1.7 fm, yielding $\left|\frac{F_{SN}}{F_C}\right|_{\max} \approx 70$?

Sir Isaac Newton:



[1] Lat. **scientia** = ***know***ledge.

Strong Nuclear Force, ***Coulomb Force*** & ***total force*** in **newtons**, ***r*** in **femtometres**,
according to Reid potential as used in https://commons.wikimedia.org/wiki/File:ReidForce2.jpg

r	SNF	FC	tot	graphical
0.70	+113000	+471	+113000	C
0.75	+59100	+410	+59600	C
0.80	+25100	+360	+25400	C ST
0.85	**+3720**	**+319**	**+4040**	C ST
0.90	-9160	+285	-8880	ST C
0.95	-16500	+256	-16200	T C

r	SNF	FC	tot	graphical
1.00	-20200	+231	-20000	T C
1.05	-21600	+209	-21400	T C
1.10	-21500	+191	-21300	ST C
1.15	-20600	+174	-20400	T C
1.20	-19200	+160	-19000	T C
1.25	-17500	+148	-17300	T C
1.30	-15800	+137	-15600	ST C
1.35	-14100	+127	-13900	T C
1.40	-12400	+118	-12300	T C
1.45	-10900	+110	-10800	ST C
1.50	-9580	+103	-9480	T C
1.55	-8360	+96.0	-8260	T C
1.60	-7270	+90.1	-7180	T C
1.65	-6310	+84.7	-6230	T C
1.70	**-5470**	**+79.8**	**-5390**	T C
1.75	-4740	+75.3	-4660	ST C
1.80	-4100	+71.2	-4030	T C
1.85	-3550	+67.4	-3480	T C
1.90	-3070	+63.9	-3000	T C
1.95	-2650	+60.7	-2590	T C

r	SNF	FC	tot	graphical
2.00	-2290	+57.7	-2240	T C
2.05	-1990	+54.9	-1930	T C
2.10	-1720	+52.3	-1670	T C
2.15	-1490	+49.9	-1440	T C
2.20	-1300	+47.7	-1250	T C
2.25	-1130	+45.6	-1080	T C
2.30	-980	+43.6	-937	T C
2.35	-855	+41.8	-813	TC
2.40	-747	+40.1	-706	TC
2.45	-653	+38.4	-615	TC
2.50	-573	+36.9	-536	TC
2.55	-503	+35.5	-468	TC
2.60	-443	+34.1	-409	ST
2.65	-391	+32.9	-359	T
2.70	-346	+31.6	-315	T
2.75	-307	+30.5	-277	T
2.80	-273	+29.4	-244	T
2.85	-244	+28.4	-216	T
2.90	-218	+27.4	-191	T
2.95	-196	+26.5	-169	T

r	SNF	FC	tot	graphical
3.00	-176	+25.6	-150	T
3.05	-159	+24.8	-134	T
3.10	-144	+24.0	-120	T
3.15	-130	+23.3	-107	T
3.20	-119	+22.5	-96.1	T
3.25	-108	+21.8	-86.4	T
3.30	-99.0	+21.2	-77.8	T
3.35	-90.7	+20.6	-70.2	T
3.40	-83.4	+20.0	-63.5	T
3.45	-76.9	+19.4	-57.5	T
3.50	-71.0	+18.8	-52.2	T
3.55	-65.7	+18.3	-47.4	T
3.60	-61.0	+17.8	-43.2	T
3.65	-56.7	+17.3	-39.4	T
3.70	-52.8	+16.9	-36.0	T
3.75	-49.3	+16.4	-32.9	T
3.80	-46.1	+16.0	-30.1	T
3.85	-43.1	+15.6	-27.6	T
3.90	-40.4	+15.2	-25.3	T
3.95	-38.0	+14.8	-23.2	T

r	SNF	FC	tot	graphical
4.00	-35.7	+14.4	-21.3	T
4.05	-33.6	+14.1	-19.5	T
4.10	-31.7	+13.7	-17.9	T
4.15	-29.9	+13.4	-16.5	T
4.20	-28.2	+13.1	-15.1	T
4.25	-26.7	+12.8	-13.9	T
4.30	-25.2	+12.5	-12.7	T
4.35	-23.9	+12.2	-11.7	T
4.40	-22.6	+11.9	-10.7	T
4.45	-21.4	+11.7	-9.80	T
4.50	-20.3	+11.4	-8.95	T
4.55	-19.3	+11.1	-8.17	T
4.60	-18.3	+10.9	-7.44	T
4.65	-17.4	+10.7	-6.76	T
4.70	-16.6	+10.4	-6.13	T
4.75	-15.8	+10.2	-5.54	T
4.80	-15.0	+10.0	-4.98	T
4.85	-14.3	+9.81	-4.47	T
4.90	-13.6	+9.61	-3.98	T
4.95	-12.9	+9.42	-3.53	T

r	SNF	FC	tot	graphical
5.00	-12.3	+9.23	-3.11	T
5.05	-11.8	+9.05	-2.71	T
5.10	-11.2	+8.87	-2.34	T
5.15	-10.7	+8.70	-1.99	T
5.20	-10.2	+8.53	-1.66	T
5.25	-9.72	+8.37	-1.35	T
5.30	-9.28	+8.21	-1.06	T
5.35	-8.85	+8.06	-0.794	T
5.40	-8.45	+7.91	-0.541	T
5.45	-8.07	+7.77	-0.303	T
5.50	-7.71	+7.63	-7.97e-2	T
5.55	**-7.36**	**+7.49**	**+0.13**	T

I think the *SNF* values might actually apply to *twice* the *radius* as given above.

The actual Reid potential given by chatGPT is:

$$V_{\text{Reid}}(r) = \frac{-10.463e^{-\mu r} - 1650.6e^{-4\mu r} + 6484.2e^{-7\mu r}}{\mu r}$$

with $\mu = 0.7\ \text{fm}^{-1}$, V in Mev and it doesn't actually say r is in fm.

Of course we have $1\ \text{Mev} = 1.60217663 \times 10^{-13}$ J, so we obtain:

$$V_{\text{Reid}}(r) = \frac{1.60217663}{0.7} \cdot \frac{-10.463e^{-0.7r/\text{fm}} - 1650.6e^{-2.8r/\text{fm}} + 6484.2e^{-4.9r/\text{fm}}}{r/\text{fm}} \times 10^{-13}\ \text{J}$$

$$V_{\text{Reid}}(r) = \frac{-23.948e^{-0.7r/\text{fm}} - 3777.9e^{-2.8r/\text{fm}} + 14841e^{-4.9r/\text{fm}}}{r/\text{fm}} \times 10^{-13}\ \text{J}$$

WolframAlpha finds a *minimum* at $r \approx 0.844816$ fm.

In a large core, V_{Reid} would be the potential energy per nucleon.

I now completely ignore that neutrons must follow the Pauli Principle, forbidding them to all be at the same (lowest) energy level. It would severely reduce the end result I am now going to derive.

When close-packed, each sphere has 12 neighbours,
so a core of N nucleons would end up with:

$$V_{\text{Reid,tot,cp}} = 12NV_{\text{Reid}}(r)$$

Or would we now count every neutron twelve times?
Well, I'll leave this factor of twelve out
and consider the end result a lower estimate.

Based on my calculations in https://henk-reints.nl/HR-Existance-postulate.pdf ,
where I come with the conjecture:

$\frac{d}{\lambda_C} \approx \frac{4}{\pi}$ (where d is the diameter of a nucleon),

I ***choose***: $r = \frac{4\lambda_C}{\pi} = \frac{4h}{\pi mc}$ as the particle distance,

& using the ***neutron*** *mass*, this yields: $r \approx 1.68$ fm,

and: $V_{\text{Reid}} \approx -2.2419 \times 10^{-12}$ J.

Division by the *neutron mass* then yields:

$\frac{V_{\text{Reid,tot}}}{M} = \frac{-2.2419 \times 10^{-12}}{m_n}$ J/kg $\approx -1.3385 \times 10^{15}$ J/kg.

For the solar mass (fully made of neutrons!), this renders: $\approx -2.66 \times 10^{45}$ J.

Given the fact I ignored the Pauli Principe, this is to be considered a wide upper bound.
For larger cores, it would in reality grow (it's negative!) towards zero (er even above it!)
and then a blob of neutronium can no longer be kept together by only the *SNF*.
This is the reason why very heavy atomic nuclei do not exist and why nuclei
can have too many neutrons, turning them into radioactive β-sources.

But, keeping it (too) simple, it should keep a core together and
since the *Strong Nuclear Force* becomes repulsive at a very short *radius*,
the thing cannot collapse significantly further.
It lives in a potential well.

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