

What Holds the Nucleus Together?

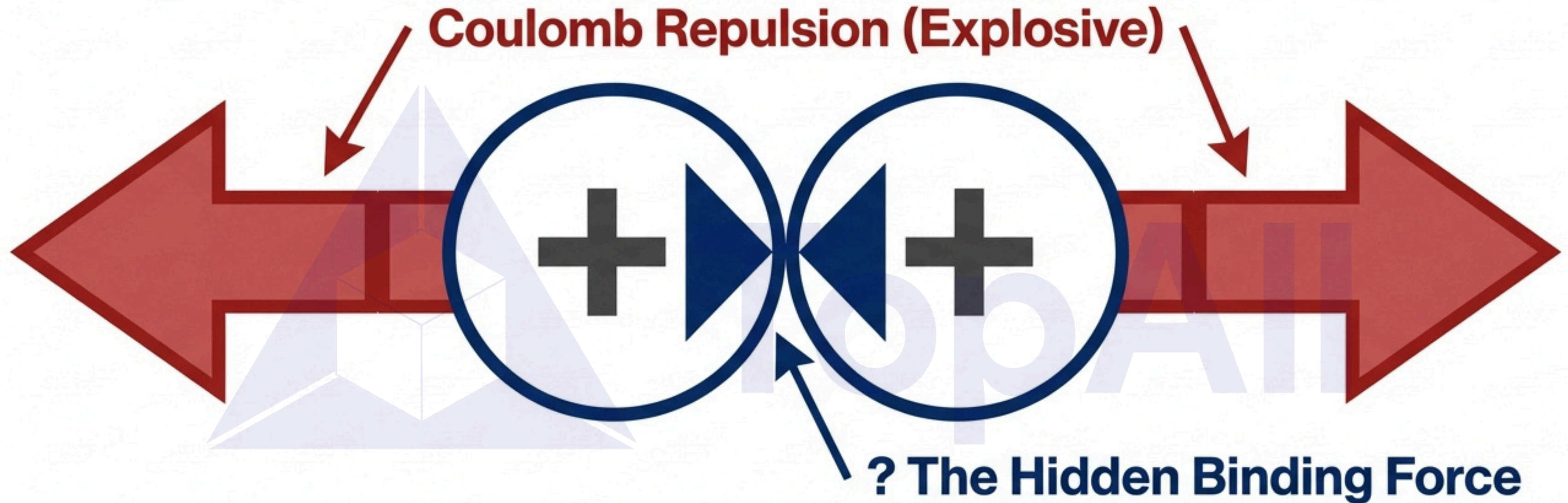
The Subatomic Paradox



Why doesn't the atom explode?

At a scale of 10^{-15} meters, dozens of positively charged protons are packed tightly together. According to the laws of electrostatics, they should violently repel each other.

The Coulomb Threat at 10^{-15} m



The Coulomb force dictates that like charges repel. Inside the tiny nuclear volume, this repulsion is staggeringly high. For the nucleus to remain stable, a completely different kind of force must exist—one that is strictly attractive and incredibly strong.

Dominating the Coulomb Repulsion



Gravitational Force

(Negligible at this scale)

Coulomb Force

(Outward repulsive push)

Strong Nuclear Force

(Inward attractive bind)



Force > Coulomb

The nuclear force is much stronger than both the Coulomb force and gravitational force. It is the dominant force of the universe at the subatomic scale, perfectly engineered to overpower proton-proton repulsion and hold the tiny nuclear volume intact.



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$$E=mc^2$$



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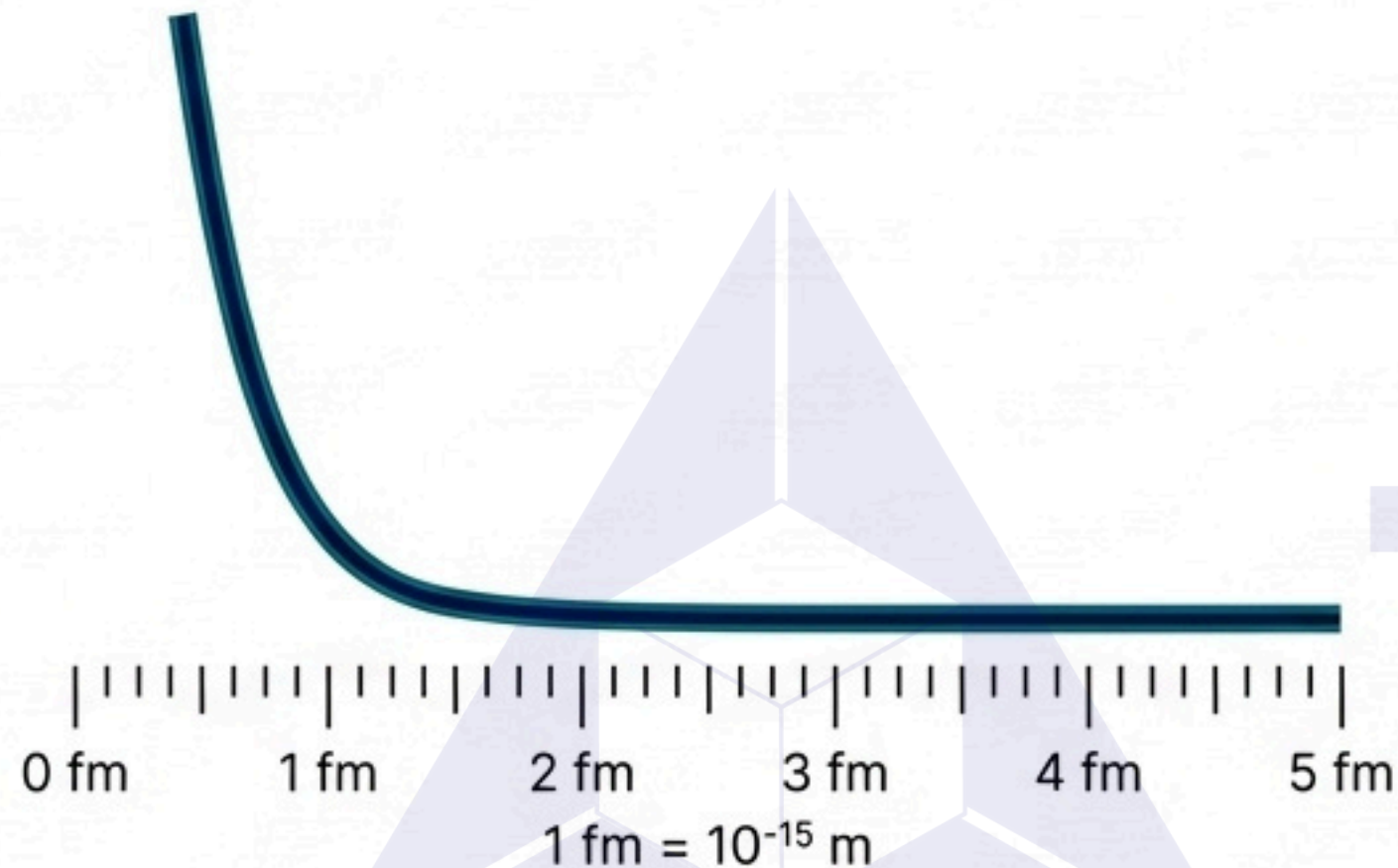
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Key Highlights

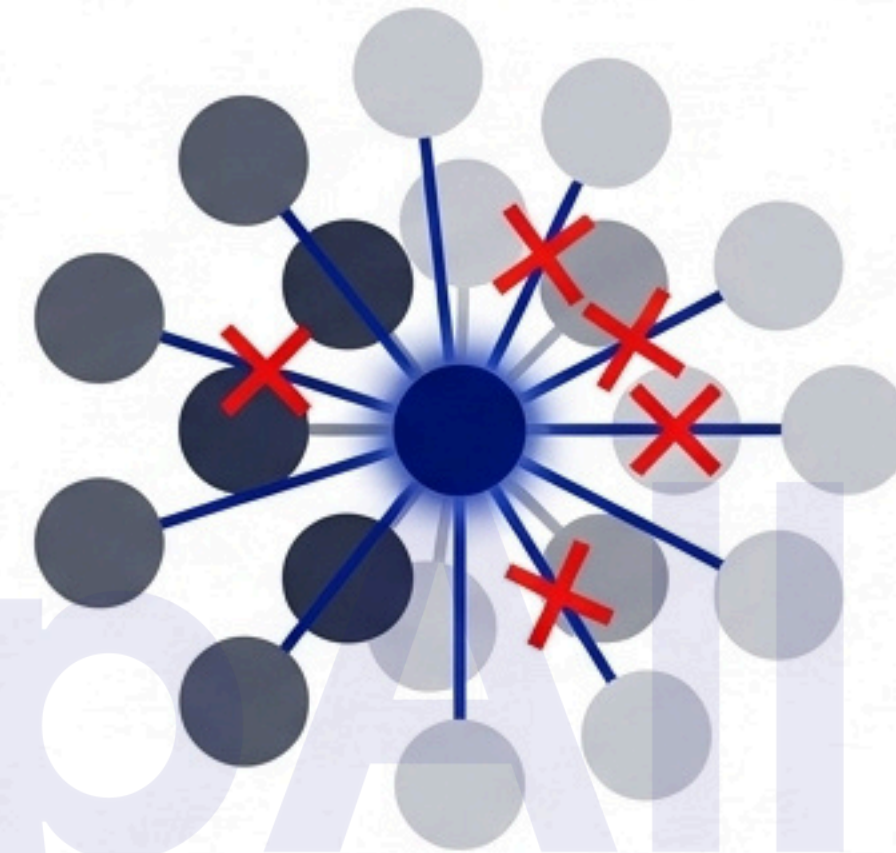
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Short-Range and the Saturation Effect



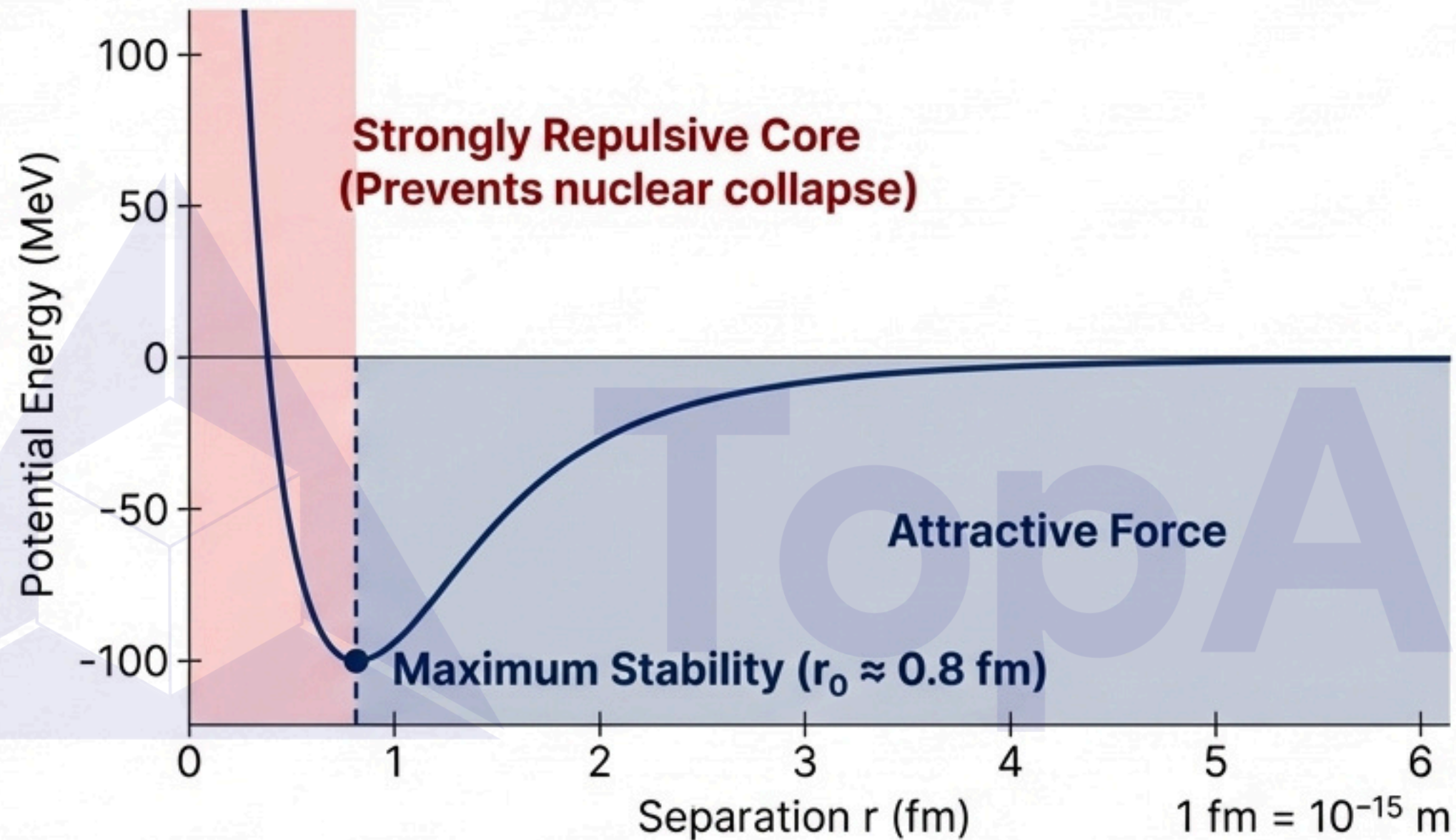
Falls rapidly to zero beyond a few femtometres.



Saturation: A nucleon only feels the force of its closest neighbors.

Because the strong force has a strict distance limit, it cannot interact with every nucleon in a large nucleus. This **saturation** is the reason the binding **energy per nucleon plateaus at approximately 8 MeV** for medium-mass nuclei.

The Delicate Balance of Potential Energy

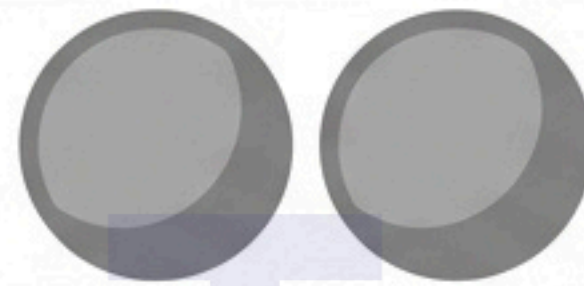


The nuclear force is a balancing act. At distances greater than 0.8 fm, the force pulls nucleons together. But if they get too close (under 0.8 fm), the force becomes strongly repulsive, preventing the nucleus from crushing in on itself.

The Force is Blind to Electric Charge



Proton-Proton
(p-p)



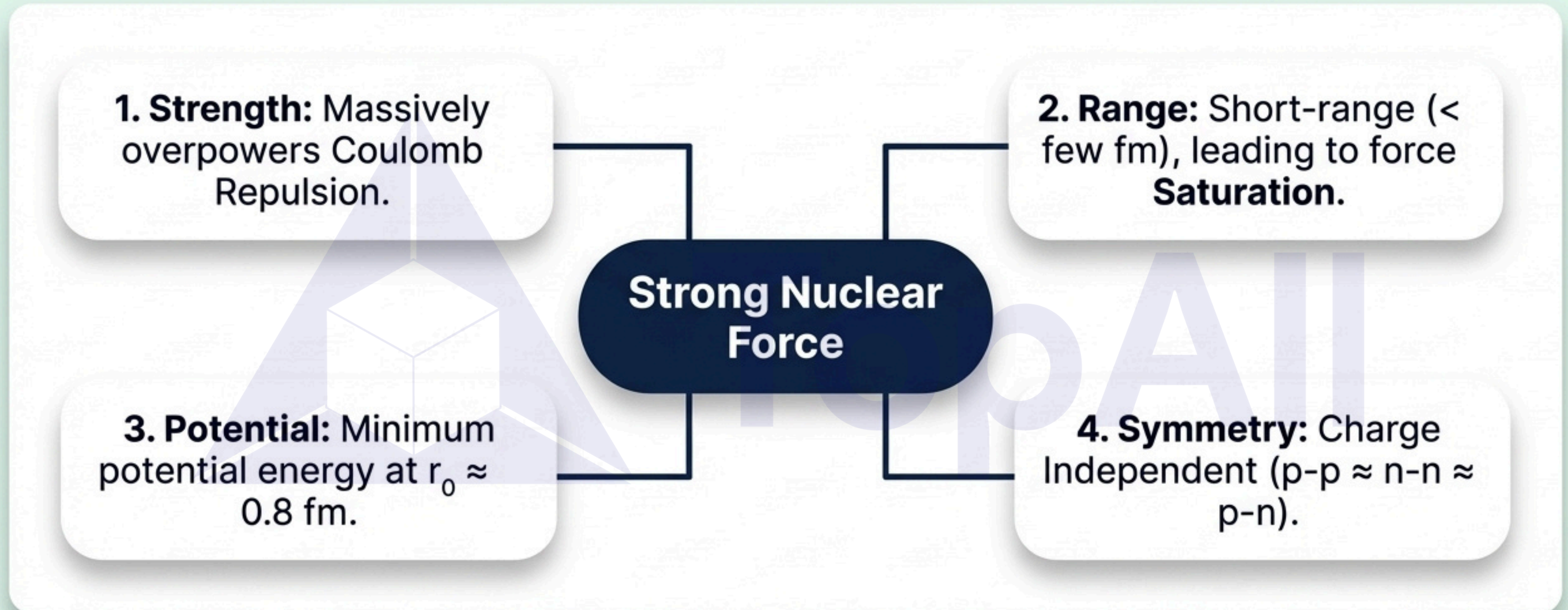
Neutron-Neutron
(n-n)



Proton-Neutron
(p-n)

Unlike the Coulomb force, which strictly depends on positive and negative charges, the **strong nuclear force is charge-independent**. It exerts approximately the same binding strength between any two nucleons, regardless of whether they are protons or neutrons.

Key Takeaways: The Strong Nuclear Force



The strong nuclear force is the bespoke mechanism of the universe designed strictly to bind the atomic nucleus against explosive electrostatic odds.



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