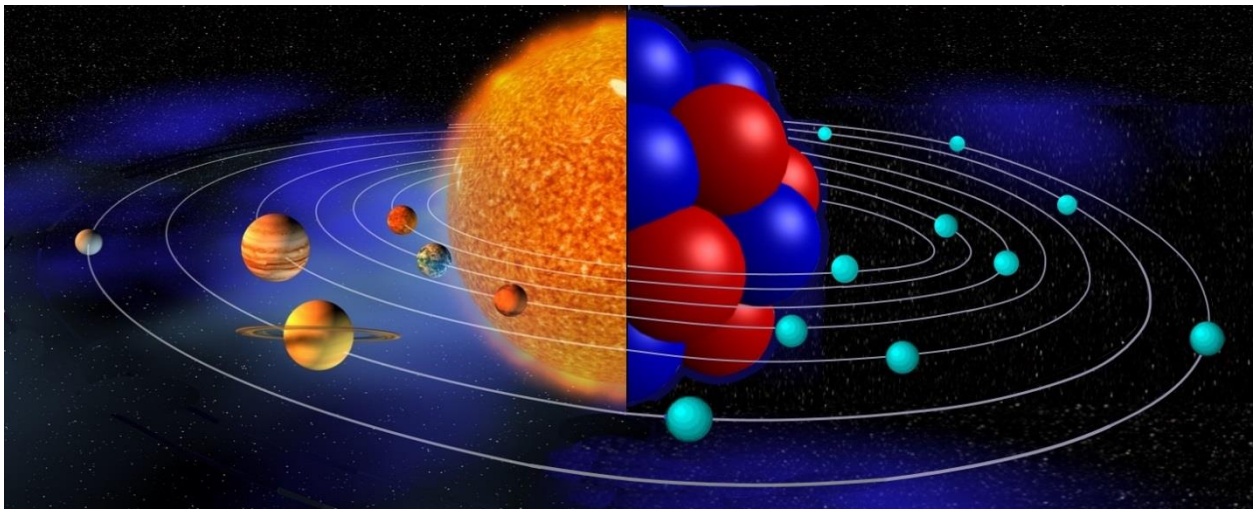
The split of personality

or why gravity and strong interaction are twins



“The subject of physics is the fundamental interactions in nature,” says Wikipedia. Scientists have already counted four such forces or interactions: gravity, electromagnetism, strong interaction and weak interaction, but they do not rest on this and continue to look for the fifth force in colliders, so that later they can use it to find the sixth.
But I wonder why all these forces are called fundamental. In the end, there must be one basis. And here we have the foundation of the Universe consisting of four separate foundations that are in no way connected with each other. This is a very unreliable design.

Fig.1

It seems to me that we should go in the opposite direction: reduce the number of forces known to us, finding related connections between them, until we reach the physical root of the dynastic tree of forces. And this root, as we will see later, will turn out to be not only the physical, but also the historical progenitor of the forces known to mankind.
As you guessed, we will talk about gravity. And here we will look for related connections between this weakest of all forces, oddly enough, with its opposite - the strong nuclear interaction.

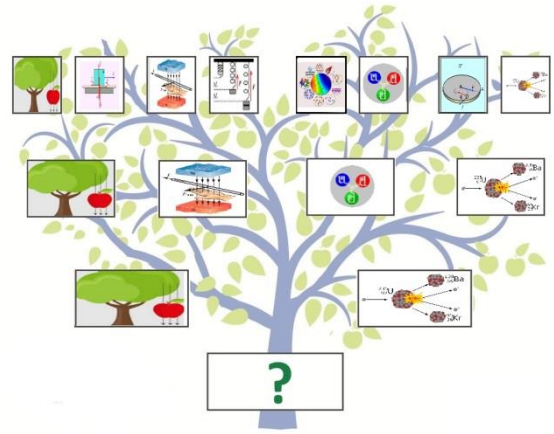


Fig.2

To begin with, all forces have one thing in common - their value at a given point in space is inversely proportional to the square of the distance from the source of force. So science says.

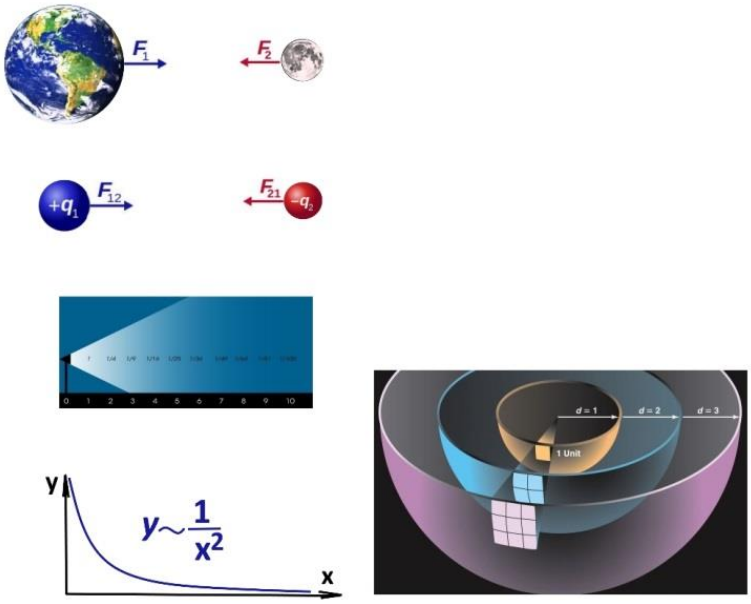


Fig.3

As proof, we are given the following diagram:

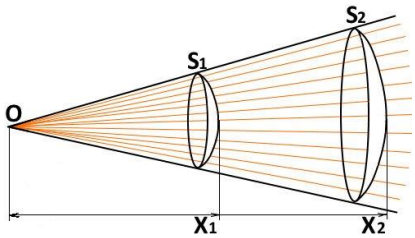
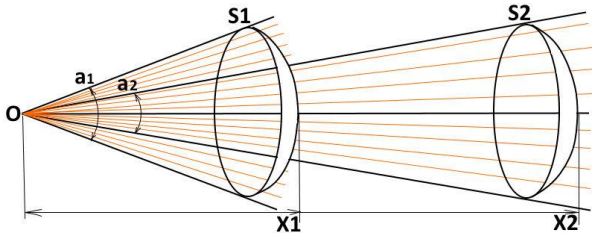


Fig.4

It can be seen that the density of field lines emanating from the source of force O and intersecting the segments of the spheres S1 and S2 actually decreases with increasing distance in an inverse-quadratic relationship. But, note that the task was to find the dependence of the force (that is, **the total number** of lines of force) acting on the **same arbitrary body** on the distance to it.

In this case, three inaccuracies are allowed here. We are shown the dependence of the **density** of lines of force (inaccuracy №1) passing through **different-sized** segments (**S2** is greater than **S1** – inaccuracy №2) segments of **spheres** (why, say, not through a flat triangle –inaccuracy №3) on the distance to them.
The correct illustration of this dependency should look like this.

Fig.5

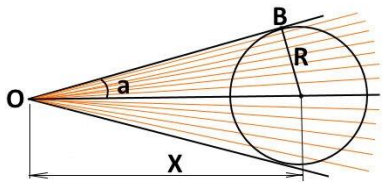


Here, instead of a segment of a sphere, one can take a body of arbitrary shape, since the shape does not matter for the solid angle. In this case, the dependence of the force on the distance is expressed by the well-known formula of the solid angle.

$$F \sim 2\pi \cdot \left(1 - \cos\frac{\alpha}{2}\right), \qquad (1)$$

where α is the solid angle at which the field lines of the source **O** fall on an arbitrary body.
Let us immediately reduce this formula to the usual form of the dependence of force on distance x. To do this, consider the flow of field lines through a specific particle that determines basic physical properties of bodies, namely proton or neutron.

Fig.6



$$\cos\alpha = OB/X = \frac{\sqrt{x^2 - R^2}}{x} \qquad (2)$$

Thus, after transformations, the formula for the dependence of force on distance (1) will take the form:

$$F \sim 1 - \sqrt{1 - \frac{R^2}{x^2}} \qquad (3)$$

where **R** is the proton radius

The behavior of this function at distances greater than 10^{-14} **m** does not differ from the inverse quadratic dependence. But, nevertheless, it is important to note that the degree of inverse relationship for all distances will **always** be more than two! Strength decreases with distance faster than we thought.

$$F \sim \frac{1}{x^{2+}} \qquad (4)$$

For example, at a distance of 1m, the degree of inverse relationship is $2+10^{-30}$. This, of course, is a very small correction.
However, there is a difference, and it is strongly manifested at small distances of intranuclear interaction $R = 10^{-15}$, where the degree of inverse dependence of our red curve (Fig.7) reaches a thousand! That is, the dependence of the force on the distance will not $1/x^2$ (blue curve), but there will be $1/x^{1000}$!

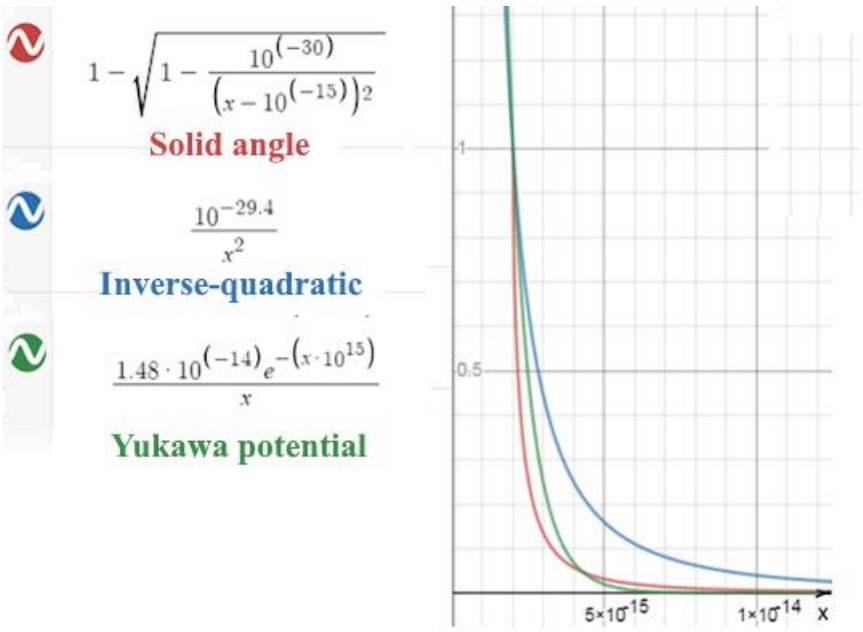
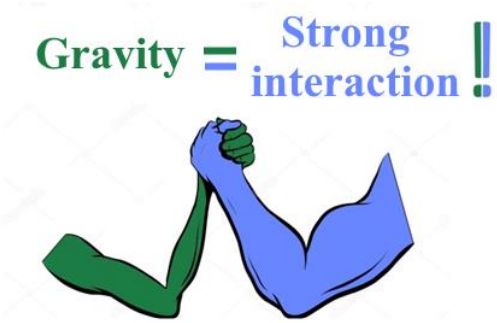


Fig.7

And here we come to the main thing. This is exactly how the strong nuclear interaction, described by the Yukawa potential, behaves that sharply decreases with distance (green curve).

So, at a distance of only 6 proton diameters, namely $\mathbf{R = 6 \cdot 10^{-15} m}$, it decreases as much as **200** times while gravity decreases only by **36** times!

Thus, our red curve behaves at small distances as a strong interaction, and at all other distances - as a force of universal gravitation.



This strange behavior of nuclear forces led scientists to invent bulky and complex physical and mathematical constructions to explain this simple phenomenon.

In fact, this is one and the same force, which, due to a small inaccuracy, was divided into two forces that are diametrically opposed in strength.

“Entities should not be multiplied unnecessarily,”- the principle of simplicity says (Occam’s razor).