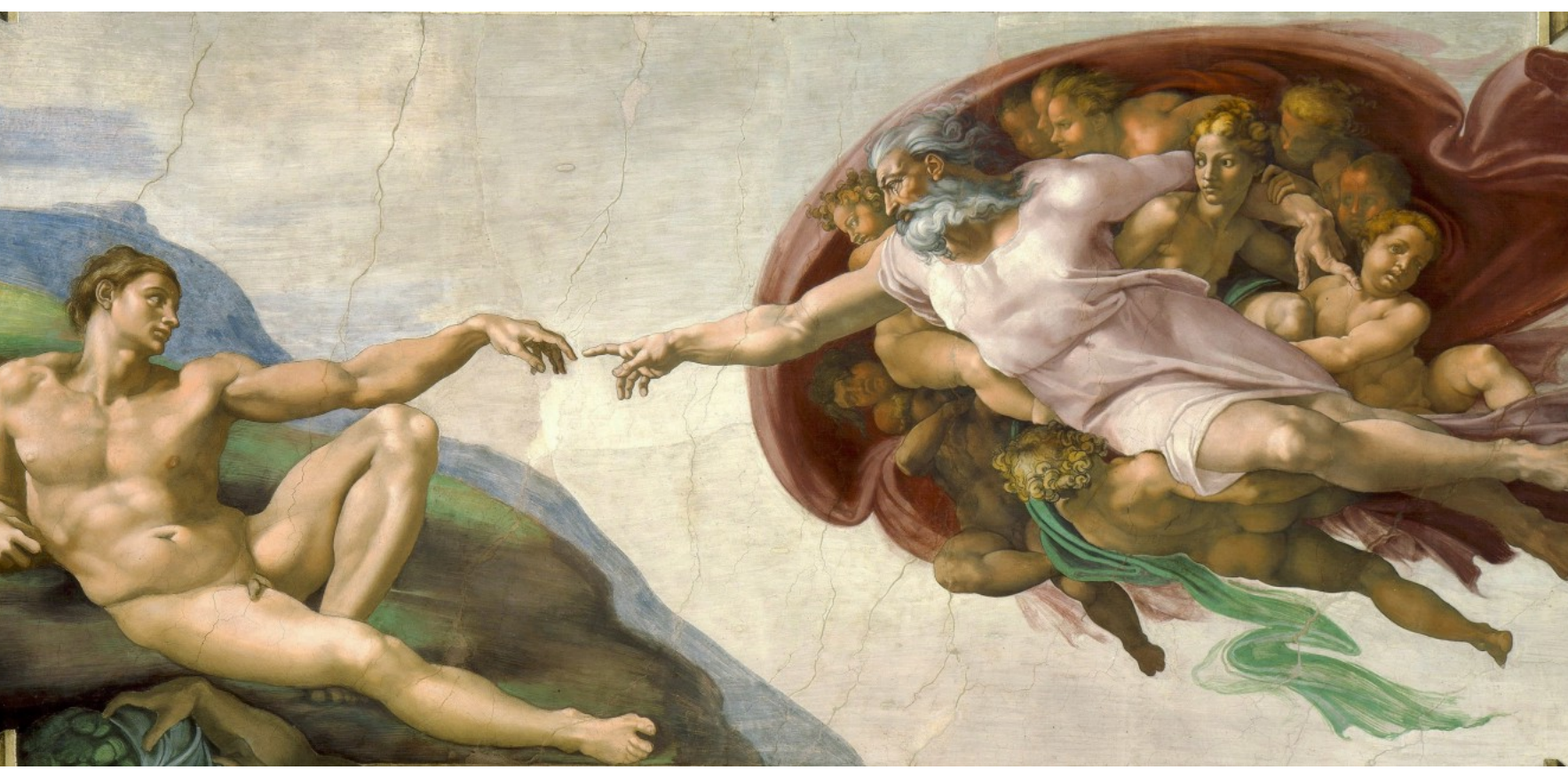
Why things never really touch

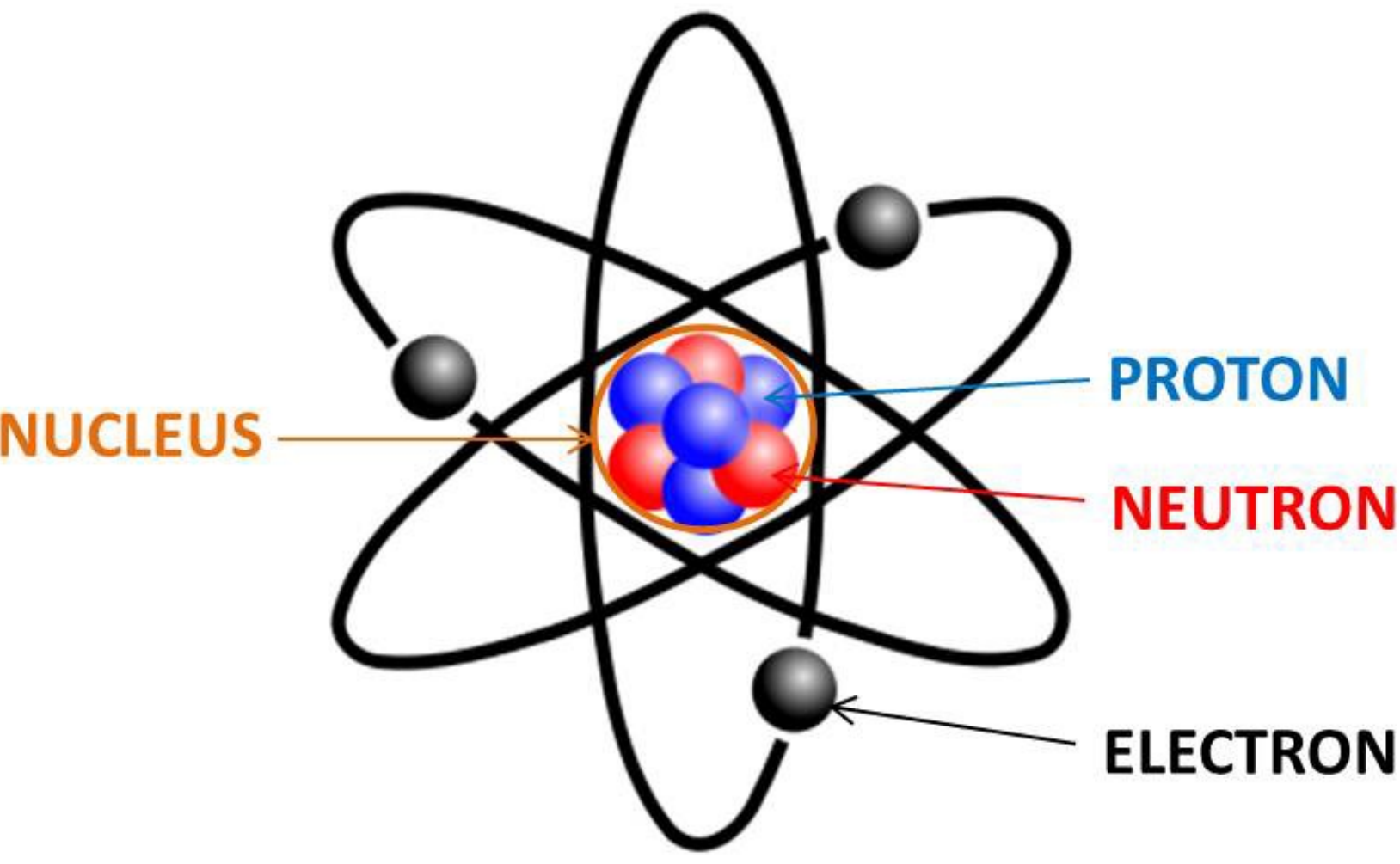
We Talk Physics



The Creation of Adam by Michelangelo

When we move two objects close together, we say that they touch. But do they really? How close can two objects get to each other? What do we really mean by touching? In this post, we will explore the physics of contact, right down to the atomic level.

When you sit down in a chair, you are not really touching the chair — at least not at the atomic level! If we take “touch” to mean the usual definition — actual contact between matter — then we indeed never really do touch anything; we can only get very close to something. The reason for this is that all things are made up of atoms, which are nuclei surrounded by outer shells of electrons. When atoms get close to each other (and don’t react), the electrons surrounding one atom repel the electrons from the other atoms for multiple reasons.



Simplistic model of an atom, where electrons orbit a central nucleus composed of protons and neutrons.

The first is that all electrons are negatively charged, and opposite charges repel according to Coulomb’s law. This keeps two electrons apart by minuscule amount — roughly a billionth of a meter! The second is that the Pauli Exclusion Principle, a quantum mechanical concept, forbids two electrons from occupying the same quantum state. What results from this principle is a pressure against the compression of matter into small volumes that is especially relevant for ultra-dense objects like white dwarf stars. But if electrons never touch each other, then how do they communicate things like force? How do we feel things?

$$\left|\boldsymbol{F}_1\right| = \left|\boldsymbol{F}_2\right| = k_\mathrm{e} \frac{\left|q_1 \times q_2\right|}{r^2}$$

Coulomb’s Law

When electrons come close to each other, they do not touch. When we poke something really hard, we aren’t actually touch the thing. What is actually happening is that we are pushing it out of the way using the previously mentioned repulsive forces. In fact, touching is not even necessary for the communication of forces — the way that electrons communicate is via photons. Two electrons that move towards each other in a collision actually never need to touch in order to experience a force, or a change in momentum, because force-carrying particles — photons, in the case of electrons — are enough to cause this. What we are really feeling when we “touch” things, then, is just the repulsive forces of electrons interacting with our nerve cells.