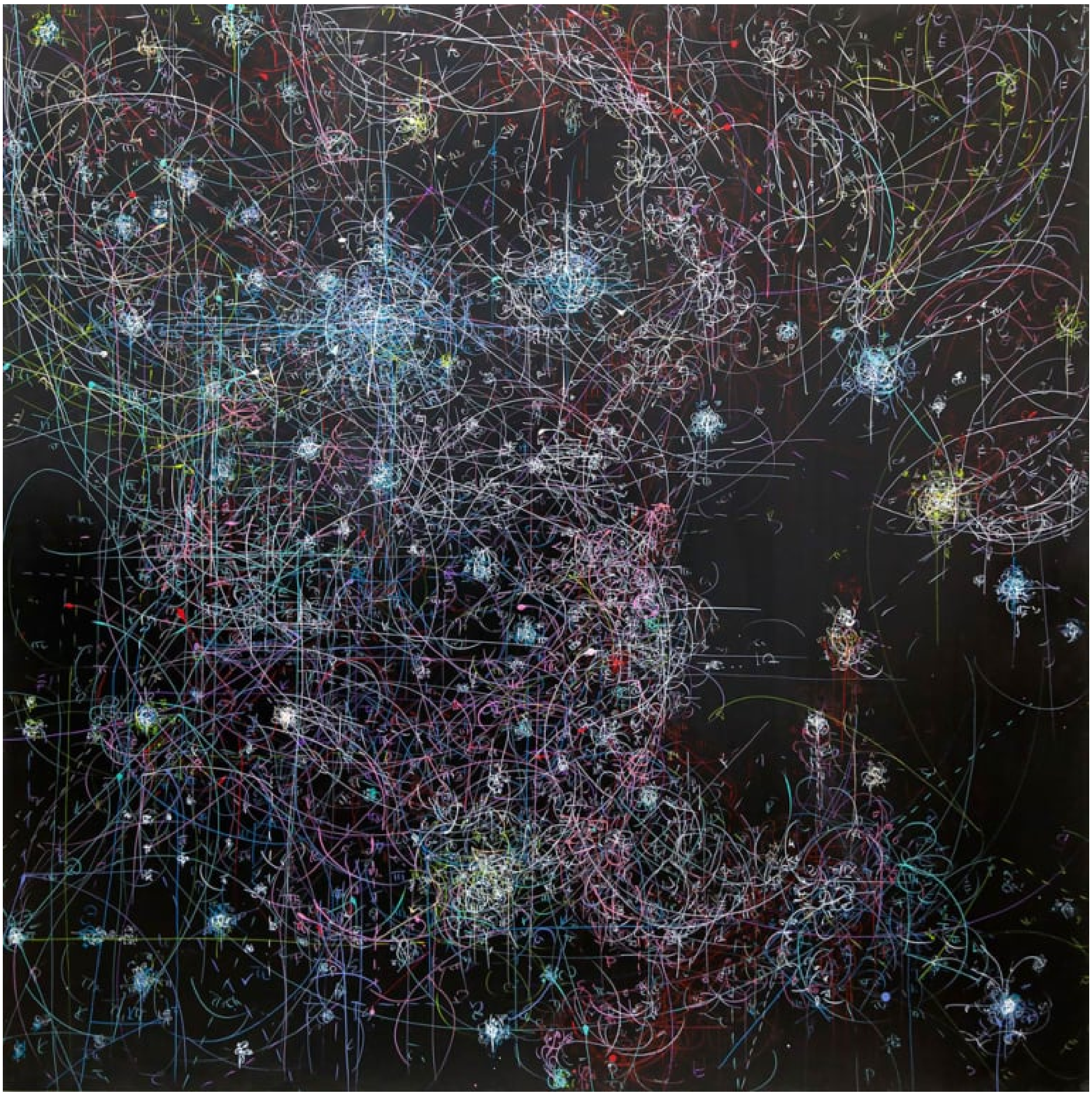
Subatomic juggling?

by Lev Tsitrin (December 2024)



blow up 256 – subatomic decay patterns, R108 and massive young stars (Kysa Johnson, 2015)

They say that third time is a charm. I already tried to address the strange idea of acausality in subatomic world twice, hoping to exorcise it out of my mind, so to speak—only to have it return to my thoughts yet again. So hopefully, this time around I'll get it right.

Having compared nuclear decay to a juggler dropping a ball, and regretting that Bohr and Einstein haven't tried to imagine a model of nucleus that allows for accidental escape of a particle, arguing instead about acausality of the process, my mind apparently took this challenge upon itself. The picture it generated is given below.

Because it obviates the current understanding of forces shaping atomic nucleus (in which the "strong force," acting powerfully at extremely short distances, counters mutual repulsion of the positively-charged protons, binding them together with electrically uncharged neutrons—while the so-called "weak force" causes radioactive decay by occasionally making those neutrons emit from their depths a negatively-charged electron and "antineutrino," turning neutrons into protons—all described, not so much by words as by colored diagrams and forbidding mathematics, in "The Standard Model of particle physics" that was developed in 1950s and 60s by some of the brightest minds in physics), I feel certain trepidation in sharing my thoughts. But the picture is so compelling that I just have to share it.

And what is there to lose? If I am proven wrong, than at least I tried. The surest way to fail is to not try. And I may be right: just half a millennia ago, Ptolemy was all the rage in astronomy—and then Copernicus made a seemingly minor adjustment to the picture, swapping positions of Sun and Earth—which turned out to work much better (and to represent the actual reality). Why not try the same trick on "the Standard Model"?

Of course, given the caliber of people who developed it, I would be nuts to say point-blank, "I think those Nobel winners are wrong." I have to proceed carefully, using allegory rather than being bluntly direct. And, since Einstein debated Bohr decades before "the Standard Model" was put together, let me avoid mentioning it for a while by turning the clock back via the time-honored literary maneuver of imaginary travel—first used by Sir Thomas More in his *Utopia*, (and, brilliantly, two centuries later by Jonathan Swift in his *Gulliver's Travels*) —to convey my thoughts.

So here we go: a space-traveler lands his spaceship in a distant galaxy on a planet exactly like our Earth, but where science is slightly behind. He meets (needless to say, in the most romantic of dangerous circumstances) an enchantingly beautiful graduate student who works on her physics thesis. In it, she plans to articulate her (i.e. my) view on the subject of the structure of atomic nucleus. Seeing how wrong she is, and wishing to save her from an embarrassing error, he runs to his spaceship, pulls out of the trunk the copy of "the Standard Model" textbook (which he took to pass the time while traversing the long light-years that separate galaxies), and hands it to her. She sees the light and rewrites her thesis, earning high accolades—including her planet's Nobel. They marry and live happily thereafter.

So here is the excerpt from the story in which she articulates the outline of her original thesis—and, incidentally, channels my thoughts in the process:

> "Currently, nucleus is thought to consist of protons and neutrons. Since positively-charged protons repel each other, the question arises of what holds a nucleus together. I answer it by rethinking the notion of a "neutron" —and denying that it exists. What we take for a "neutron" is in fact a positively-charged proton with a negatively-charged electron stuck to it—a pairing that mutually offsets the overall electric charge of its component parts, creating the perceived electrostatic "neutrality."
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> "Thus, it is not "neutrons" and protons, but electrons and protons that form the nucleus. Electrons anchor protons

around themselves—which is the real reason why a nucleus does not fall apart. This anchoring effect is purely electrostatic, and is due to a vast difference in physical size of (large) protons and (minuscule) electrons—while their electric charges have the exact same value.

“As we know, the force of electrostatic attraction or repulsion described by Coulomb’s law is in inverse proportion to the square of the distance between charged objects. Because protons are large the distance between centers of two protons that touch, repelling each other (assuming for the sake of argument that protons have spherical shape) is twice the size of a proton’s radius—while the distance between a center of proton and a center of a tiny electron abutting it is only one proton’s radius—the distance is twice smaller. Raise this “twice” to the second power—and here we go: the force of attraction between a proton and an electron is four times greater than a force of repulsion between two protons. (Needless to say, because electrons are tiny, and the division by zero produces infinity, the force of repulsion of electrons brought closely together will exponentially exceed that of protons).

“It is this difference in size that anchors protons in a nucleus. An electron that sits between two protons and, so to speak, divides its force of attraction equally between them will attract each with a force that is twice greater than the force of protons’ mutual repulsion, thus anchoring them together pretty fast. Incidentally, this is “deuterium” —a rare but stable isotope of hydrogen.

“This redefinition of a “neutron” requires changes to basic definitions used in the Periodic table: “atomic number” now represents nucleus’ overall electric charge rather than its number of protons while the latter is represented by a given isotope’s “atomic weight,” and the difference between the two is the number of electrons (rather than “neutrons”) in the nucleus. For instance, a nucleus of helium (which has atomic number of 2 and atomic weight of 4) has four protons and two electrons—rather than two protons and two “neutrons.

“The geometry of a nucleus would thus be determined by mutually-repelling electrons staying at the farthest distance from each other while being closest to the area of the maximum charge of protons.

“I put the Periodic table’s isotopes into a spreadsheet, and found only a few gaps in the running number of element’s protons which goes up to 294. No element has isotopes with 5, 34, or 213 protons; I see nothing in 215-220 range, nor for 273 and 275. Both 8-proton isotopes are unstable. Apparently, those numbers of protons cannot fall into viable geometric shape where electrons would hold them together.

“On the flip side, there is a long list of the numbers of protons—overwhelmingly even-numbered, with just two odd-number exceptions (36, 40, 46, 50, 54, 58, 64, 70, 74, 80, 84, 86, 92, 94, 96, 98, 102, 104, 106, 108, 110, 112, 114, 120, 122, 123, 124, 126, 132, 134, 136, 138, 142, 154, 156, 158, 160, 162, 164, 168, 170, 176, 180, 181, 192, 196, 198, 204) that can combine with two different numbers of electrons to produce stable isotopes of two different elements—like 18 and 20 electrons for 36-proton nucleus. (Those pairs of electron numbers are mostly consecutively even. I found only three exceptions: 71/72 electrons for 123-proton nucleus, 107/108 for 180, and 108/109 for 181).

“The electron-to-proton ratio stays largely above 0.5—which, as we saw, is enough to keep two protons anchored to each other. Of the half-dozen isotopes that have a lower ratio, only one—helium with one electron and three protons—is stable. The higher ratio may be a problem too: when it gets to above 0.6 (the highest is the outlier in hydrogen's "tritium" with 0.666666667, but cut-off ratio for the bulk is 0.61682243), a large proportion of isotopes are unstable.

"There is no magic ratio, though some ratios are repeated—0.5 in a dozen stable isotopes of different elements; 0.555555555 in eight; 0.571428571 in seven; 0.6 in six; 0.533333333 and 0.545454545 in four; 0.56, 0.565217391, 0.583333333 and 0.588235294 in three—and a number of others are shared by two stable isotopes, The rest of ratios in my 673-isotope spreadsheet (of which 251 are stable) are unique.

"The already-mentioned case of a stable isotope of helium in which just one electron holds in place three protons, makes me think that protons are somewhat elastic (like a balloon filled with water) rather than stiff and hard (like a steel ball), and will compress into a baseball shape, so the tips of the now-elongated protons touch the centrally-positioned electron while avoiding any contact with each other, thus forming a three-dimensional star (and if electrons are elastic, they will flatten to a pancake shape, I guess).

"As the numbers of protons and electrons increase, making the resulting geometry of nuclei more and more complex, do the components of such assemblages come to equilibrium and become totally static, or do they keep shifting, the forces of attraction and repulsion constantly changing the geometry and creating a possibility of some electrons or protons getting completely pushed out of the nucleus by the momentary built-up of forces of electrostatic repulsion, resulting in radioactive decay? If the latter is the case, than this is where the "juggling" analogy comes handy.

"Juggling accidents will happen when, say, too many electrons come too close together, their combined electrostatic charge expelling one of them from the nucleus (thus causing the so-called "beta decay.") Once beta decay lowers the number of electrons to where their combined force becomes insufficient to keep protons in place, a proton will be expelled by its positively-charged neighbors—and passing through the orbiting electrons on the periphery of an atom, its positive charge would attract one of them, turning its overall charge (and that of the atom) neutral. “Alpha decay” expels a block of four protons held together by two electrons.

“How do orbiting electrons react to nucleus’s changing charge, and the resulting imbalance in charges between nucleus and orbit, is a question. Do they fall down onto nucleus, attracted by its the stronger positive charge resulting from beta decay (and thus, temporarily offsetting it)? Does the lower positive charge of a nucleus resulting from alpha decay make orbiting electrons escape into surrounding space, thus restoring the equilibrium?

“But why is it that some nuclei are stable in the first place, while others decay?

“Clearly, not because of insufficient number of electrons. The stable nucleus of lead has about the same ratio of protons to electrons as that of the highly unstable radium. So something else must be causing the drastic difference in stability.

“I guess the culprit just has to be geometry. Radium is in itself a product of radioactive decay of thorium or uranium—in other words, a nucleus of radium is that of thorium or uranium minus a few protons and electrons. Once those escaped, one would expect the remaining protons and electrons to shift their positions, filling the gaps—but perhaps this does not happen, resulting in cavities?

“Downstream, those cavities will produce cascading radioactivity in further products of decay—because the absence of protons’ electrostatic attraction will keep electrons away from the cavity areas. In turn, the absence of electrons will result in lesser offsetting of the force of protons' mutual repulsion in that locality, increasing the possibility of those protons escaping. As fewer protons are left, the electrons will become more concentrated, and their mutual electrostatic repulsion will increase the chance of an electron flying out of the nucleus.

"A given geometry of the nucleus, therefore, may increase or decrease its predisposition for decay. An interesting case in point is a radioactive isotope of bismuth-210 with half-life of just 5 days which also exists as a synthetic (i.e. found among products of a nuclear reactor) variety that has a vastly higher half-life of 5 million years. The overall number of protons and electrons in their nuclei being exactly the same, the only reason for their different half-lives that I can think of is that the nucleus of the latter is dense and smooth, while that of the former is full of cavities. (Perhaps some similar geometric difference causes the lighter isotope of uranium to split when absorbing a so-called "neutron" –i.e. a proton/electron pair, rather like a piece of paper torn in the middle that the slightest pull will rip apart–while its heavier isotope absorbs the shock without splitting.)

"This, in a nutshell, is the "juggling," proton-electron model of a nucleus that allows for "accidents" we call "nuclear decay" –thus providing a measure of causality for it."

This was her (i.e. my) soliloquy. And even though the intergalactic traveler in my romantic sci-fi story did manage to persuade her to adopt the "Standard Model," I am not at all convinced that she should have done so. Why use "strong force" as the reason for nucleus' stability when electrostatic forces produced by vast difference in sizes between electrons and protons will have exactly the same effect? Moreover, what goes for my model is that it precludes—even in theory—the very possibility of a nucleus consisting just of multiple protons—while the “strong force” of the “Standard Model” would readily bind them together into a stable nucleus. That no such proton-only nuclei are known is an indirect—though not insignificant—nod in my direction. As to radioactive decay, it can be explained by “juggling” inherent to nucleus’ geometry without invoking “weak force.”

I think “the Standard Model” is so convoluted and “kludgy,” and has to rely on acausality not because it is wrong—but because it solves a wrong problem, the problem of packing a bunch of protons and neutrons together into a nucleus. But change the problem to that of packing a bunch of protons and electrons – and the solution becomes dramatically simpler (and points to causality). It may even cause a purely practical question: do the scientists who try to generate energy through controlled nuclear fusion use the right ingredients?

A “neutron,” to my mind, is the proverbial “fifth wheel” that creates the totally unnecessary complexity which in turn has to be addressed by a correspondingly complex “Standard Model” —exactly like Ptolemy’s geocentric model required extremely convoluted planetary motions to make it work—and Copernicus’ heliocentric model, by merely swapping the positions of the Sun and the Earth, simplified those orbits to plain ellipses. As Einstein famously observed in his debate with Bohr, “subtle is the Lord God, but malicious [meaning “deceptive,” I guess] He is not.” Perhaps He indeed plays it straight, and does hide electrons inside protons?

There may also be another important consequence of switching electrons from the inside to the outside of protons—and it is related to the nature of gravity. To explain, let’s send our just-married couple to a honeymoon on a planet in a nearby galaxy where people discovered laws of electrostatic attraction and repulsion before they discovered gravity—not the other way around as happened on our Earth. While they did their measurements, the instruments of necessity picked up the fact that the force of attraction for opposite-charged objects was greater than that of repulsion for same-charged objects—even though the electric charges themselves were exactly the same. We, of course, attribute this difference to gravity—but they knew nothing about it, so—perfectly reasonably—they concluded that Coulomb's law is not symmetrical—i.e, it's force is not equal for both attraction and repulsion (as we think) but is greater for the attraction than for the repulsion (with a result that, in our Earth's terms, the total of Universe's forces of gravity is simply the difference between totals of electrostatic attraction and repulsion).

Who is right, us or them? Does gravity have a different physical nature, or is just an offshoot of electrostatics? They argue that we attribute weight to the effect of gravity rather than to electrostatic imbalance only because we discovered gravity before discovering electrostatics, calling the difference between asymmetrically-acting electrostatic forces "gravity" without realizing its true nature. The identical mathematical form of Coulomb's and Newton's laws only confirms to them that those are physically identical phenomena. To them, "mass" and "charge" are not the proverbial "apples and oranges," but "mass" is merely a bunch of charged particles subject to electrostatic laws – different words denoting the exact same thing.

(They explain the reason for Coulomb's attraction being stronger than repulsion by the forces' inverse dependence on the square of distance between objects—the shorter the distance, the stronger the force. Opposite charges attract each other, and in doing so bring each other a bit closer together while the repulsion makes them a trifle more distant. Just by acting, electrostatic force automatically changes the distance over which it acts: attraction winds up acting over a shorter distance, repulsion, over longer one, creating the asymmetry in the strength of the force itself. We on Earth assume that distances between particles with the same, and opposite charges contained in the same body are same, and thus assign the same strengths to both repulsion and attraction, The other planet's people don't; they see electrostatics as inherently asymmetric, attraction being stronger than repulsion.)

This said, they readily admit that their view is based on a fundamental assumption that, in the final analysis, all bodies are composed of charged particles acting on each other through electrostatics. If "neutrons" are real uncharged particles, than gravity is not reducible to electrostatics—because electrostatic forces do not act on uncharged bodies. But until this is proven, they maintain that what we call "neutrons" are simply protons with an electron stuck to the outside, and nothing else—and are therefore subject to their, asymmetric, Coulomb's law.

Their logic is perfectly sound, likely making it impossible to figure who is right. This cannot be done analytically, and as to experiments, either side will simply claim that the outcome supports their respective position. Largely like one's religion, it becomes a matter of culture or preference; and (perhaps unpatriotically, for in all other matters I will side with our Earth against other planets—unless they make more sense, of course), on this I am with their planet.

This moving of the electron from the inside to the outside of a proton makes three (out of four) "fundamental forces" of nature unnecessary: "strong" and "weak" force are no longer needed to explain how nucleus is held together (or why it decays), and gravity is reduced to electrostatics—electrostatics alone remaining irreducible, so that what we call space becomes a continuous (though not uniform) electrostatic field filled with moving electric charges. .

Admittedly unsophisticated as the picture is, I wish it would have been something like this that Einstein and Bohr contrived and debated, rather than wasting time in their signally fruitless debate on acausality that brings to my mind a scene from Mark Twain's.*Huckleberry Finn* where Huck and Jim, drifting down the Mississippi on a raft, "used to lay on our backs and look up at [stars], and discuss about whether they was made or only just happened," their opinion on causality divided— "Jim he allowed they was made, but I allowed they happened."

In any event, having articulated my naively-mechanical (in contrast to quantum mechanical) picture of nucleus as, in essence, a three-dimensional tile-work composed of just two types of tiles, one tiny, the other large, in which the tiny tiles cling tightly to the large ones but the large ones touch each other as little as possible, the whole kept in place by distribution of electrostatic force, the possible shifting of "tiles" causing some of them to escape in what is called "radioactive decay," and which does not need "strong" or "weak" forces to explain matters, I hope I now fully exorcised the demons that Bohr's notion of subatomic acausality sowed in my mind—besides (wink-wink) enriching the body of world's literature with a deeply affecting story of inter-galactic love cemented by the love of science.

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