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Not even wrong

TEXTS IN ENGLISH

The Rolling Stones effect
In certain situations, two particles that have interacted become entangled, or highly correlated, meaning that they have a link that distance, however big, cannot break. This "inseparability", as it is called, reminds one of the Rolling Stones. Their solo careers have been disastrous, and no member of the band can carry on his own the symbolic halo of the Rolling Stones. However, as a band, the Stones are able to create a whole that is greater than the sum of each of its members. They don't have to look at each other, or speak to one another, but they play as if their instruments were mutually linked, correlated despite the distance. Keith Richards described this in his own words: "I have no idea how it happened, but a bond was created among us, and it still holds despite everything, like a very strong alliance."
The pair formed by two particles possesses global properties that each individual particle lacks. The whole exceeds the sum of its parts.
This is a rather good description of quantum entanglement, which one could also call the "Rolling Stones effect".

Head Banging
One of my professors at university told us, during one of his lectures, that a colleague of his used to put his head inside the particle accelerator, as the magnets it contained would induce hallucinations. It also appears that psychiatrists conduct experiments with oscillating electromagnetic fields to determine whether they could replace electroshock treatments.

Whodunit?
The eventuality that there are several universes leads to the possibility that our universal constants differ from one universe to the next.
It therefore appears that if our universal constants had been different, life as we know it would not have occurred. For example, if the nuclear interactions that bind the protons to the neutrons in the nucleus of an atom were slightly more intense, stars would survive only a few seconds instead of billions of years.
Based on these coincidences, some physicists conclude that our universe is much more complex than most. According to them, in our universe, the conditions necessary for life were established because certain physical parameters were finely tuned. They speak

of a transcendent being, who determined these values so that Man could, and would, appear (this is the anthropic principle): God, if there really is a God, is a nothing more than a mighty handy man, a clever adjuster of universal constants. In fact, God is more of a semi-God, with an engineer's diploma and a calculator, deprived of much of his prestige and glory.
But did this adjustment actually take place? Some cosmologists prefer to see these coincidences as just that: coincidences. All the different universes would have had to appear somewhere and we were lucky enough to exist in a locally viable and fairly welcoming one.
Others refute both theories and consider that such questions shouldn't be asked: things are as they are and it's not up to us to explain why.

PHYSICS IN CRISIS?

Wow! Scientists at the CERN have discovered the **Higgs Boson**. But what does that mean for the rest of us?

It's the last of the particles predicted by the famous, already four-decade old **Standard Model**, which perfectly describes the world of particles of matter. These particles include fermions, which are, for example, electrons, quarks, etc. Other particles, called "gauge bosons" (of which the photon is one), describe the way they interact electromagnetically. These nuclear interactions are considered to be "weak" or "strong".

And what about Higgs? He's active behind the scenes, pulling the mathematical strings that provide a mass to each particle (except for the photon). Without Higgs, we wouldn't understand anything, although we still fail to comprehend whether the Higgs-Boson is truly necessary, whether it's alone, or if there are any other particles of matter and force...

In any case, the Standard Model works well in its current state, and each experiment conducted at the CERN and other laboratories by experimental physicists only serves to confirm its many predictions, which were calculated by theoretical physicists. It's a momentous victory for Science (with a capital S).

A few names are worth mentioning: Salam, Weinberg, Glashow, 't Hooft and Higgs of course, but let us not forget Brout, Englert and Kibble.

Is the field of physics really undergoing a crisis? The answer is that the Standard Model works **too** well. It does contain many major faults: it's a bit too complicated, and it describes various forces as if they were independent, although there are strong indications that at a very high level of energy (billions of times greater than what the LHC is able to produce...) they should be united (in the same way that the electric and magnetic forces are two aspects of a single electromagnetic force). Furthermore, the mass of particles is not predicted (all that the Higgs does is confirm that they have a mass).

And finally the force of gravity is lacking! Gravity was described in Newton's theory in the 18th century, and later by Einstein's **General Relativity** theory in 1915. It's a splendid theory; it makes very accurate predictions that have been verified by astronomers and space explorers, it enables the GPS system to work, it foretells the existence of the famous **Black Holes**, and it describes the evolution of the Universe starting with the equally famous **Big Bang**. It's a theory at least as valuable as the Standard Model!

But here's the thing: the Standard Model is a *quantic* theory that describes phenomena that occur at a microscopic scale, from the size of an atom to dimensions billions of times smaller (phenomena that have been tested with the LHC for example). The theory of General Relativity is a *classical* theory that describes phenomena that occur at a larger scale, from the millimetre to the size of the universe, which is 10 billion light years wide, roughly hundreds of thousands of millions times bigger than the solar system.

You might feel that there is little point in uniting these two theories into one single theory, as both explore highly different areas. But there are the Black Holes, and the Big Bang, which are both observable facts! At the centre of a black hole, or at the exact moment of the creation of the universe, the theory of General Relativity predicts a *singularity*, which is an infinite concentration of mass or energy. This causes the theory to fail, as it is unable to clearly describe what happens at that very instant.
However, we must tread carefully now, because the scale is microscopic and we have just entered into the realm of **Quantum Mechanics**. We have indeed stumbled upon a gaping hole in our knowledge: we lack a *quantum gravity theory*. I must add that we are also lacking experimental and observational data, as the amount of energy in play exceeds by a billion-fold that produced by the LHC.

In fact, the theory of quantic gravity has been lacking for nearly a century. The first attempts to develop the theory were made by Dirac, DeWitt, and Archibald in the 50s and 60s. Then, towards the end of the 70s, Green and Schwartz come up with the **String Theory**, which is not only a theory of quantum gravity, but it also unites the three forces of the Standard Model and the force of gravity into one single quantic theory, the **Theory of Everything**, which was something that Einstein was already fervently hoping for.

The theory was an immediate and huge hit among *theoretical* physicists, with thousands of articles dedicated to the subject, and it yielded many important contributions to mathematics, by Witten for example. At its early stages, the theory seemed unique, or nearly unique, for purposes of mathematical consistency. Although experimental data is lacking, the near-uniqueness of the Theory of Everything was particularly attractive; was it a triumph of Pure Thought?

But, some 30 years and thousands of articles later, the enthusiasm has died down, and the number of string theories has reached astronomical levels, a fact that seriously undermines the predictive power of the theory.

However, two predictions do exist. The first is that the number of dimensions of space is 9 (or 10). This goes against our common sense: we only know of three dimensions: height, width and length. It is however possible that the remaining six or seven dimensions cannot be observed as they are intertwined at a microscopic level. The many possible manners for these dimensions to interact has laid waste to the uniqueness of the theory.

The second prediction is **Supersymmetry**, which describes the existence of a partner-particle for each particle described in the Standard Model. These **super-particles** are thought to be very heavy, and therefore require a great quantity of energy (Supersymmetry could theoretically exist independently from the String Theory). The currently held hope is that the LHC will detect some of these super-particles. Sadly, to this day, the LHC has found nothing of the kind. Maybe we'll have a pleasant surprise when the energy level of the LHC is doubled next year? Otherwise, Supersymmetry will undergo a true identity crisis.

There is another way that leads towards **Quantic Gravity**: it is the **LQG**, short for **Loop Quantum Gravity**. LQG started with a new formulation of the General Relativity theory by Ashtekar in 1986 and allows for its quantification, although mathematical issues are yet to be resolved. The purpose of this theory is not to unite all the forces the way the String Theory aimed to do, but it does offer some very accurate predictions.

One of its predictions is that space has a discrete structure, like any ordinary matter has a discrete structure made of atoms and molecules. It is currently impossible to verify this prediction by means available to us.

Another prediction of the LQG concerns the Big Bang. In reality there was no Big Bang, but rather a “ricochet”: the universe predates the so-called Big Bang, and was contracted until it reached a state of immense but finite density. At that moment, a repulsive force of quantic nature prevented the contraction to proceed further and initiated the expansion phase that we are currently able to observe.

The LQG is a highly attractive theory, and a great number of theoretical physicists are working on it.

So, are we undergoing a crisis? Yes, due to the lack of experimental results that support or contradict current theories, or that give clues towards new and better theories.

Yes, because of something that may seem shocking: the matter described in the Standard Model that we can observe (quarks, electrons, atoms, planets, stars and even us) only makes up four percent of the matter and energy contained in the universe!

26% is made up by the aptly-named “dark matter”, which is invisible but observable through its gravitational pull on visible matter, i.e. the stars and the galaxies. No one knows what this is! (Some super-symmetrical particles, maybe, if they exist...)

The remaining 70% is made up of “dark energy” or “vacuum energy”, responsible for accelerating the expansion of the Universe, recently observed by astronomers. Even less is known about it than about Dark Matter!

Well, at least we have a pretty good idea of how 4% of the Universe works.