The Wandering Explorer

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With Yves P. Huin

Foreword

As a corollary or consequence of memory, we all create, use, or refer to milestones: episodes of the past, agendas, schedules –the list is endless and strictly personal. Until you perceive the deliquescence of your body, senses, memory, imagination – even desires. Then it is time to *put your papers* (or your ideas, the ones that matter) *in order.* I am reaching or have already attained that stage.

Since 2014, knowing that I will relinquish my teaching duties soon, suddenly time for myself became available. An unusual feeling, a disturbing occurrence, a frightening sensation; but also, a loud-and-clear message ringing night and day. That's when –thanks to Ciriaco Offedu- I embarked in assembling fragments that seemed relevant, and attempt(ed) to draft essays on diverse essences.

One of these essays (a recent one) was initially titled *The Meaning of Life*. It is posted as *Tracks and Trends*, a better reflection of its content. This one is addressing the same quest, but from an angle required by my involvement with the *Para Limes* Institute on Complexity, of Nanyang Technological University: the program I joined is summarized in the title of the many workshops and a conference scheduled for mid-October 2016: *East of West, West of East*. Trying to link, reconcile and create symbiosis between the post-Bacon scientific revolution of the West and the multi-millennial wisdom of the East. None of my thoughts and assertion is original. Everything is known and published. Claims for thinking *ex nihilo* or *de novo* would be ludicrous, laughable or farcical. Imitation (or plagiarism) being the sincerest form of flattery, I feel safe in my assembled puzzle.

Nor do I claim any pride or wisdom. These senile lucubrations beg for criticism, comments, corrections or suggestions.

My Time Machine

The second World War, the Vichy regime, then the Swiss guards of the camps stole my childhood. Adolescence erupted like a tsunami of testosterone and neurotransmitters when I entered 7th grade. I was the Energizer bunny, the troublemaker, the constant questioner nicknamed *Mr. Why*. Detention, every Thursday, Saturday and most Sundays expanded my weekly schedule at the Lycée Henri IV in 8th, 9th and 10th grade; I accepted these reprimands with scorn and patience. But these days at a desk, often alone with a grad student assigned as prefect helped me discover authors, poets, polemicists, outcasts, anarchists, giants in French -but also English/US, German, Italian- literature; I was bulimic, and I memorized as many texts as I could.

Some of these memorable companions were not in the scholar curriculum: Charles Baudelaire's *Les Fleurs du Mal* (written under ether, alcohol, opium, and probably hashish); *Le Bateau Ivre* composed at age 16 by Arthur Rimbaud who mailed it to Paul Verlaine – who then took him as his lover; the Comte de Lautréamont (a.k.a. Isidore-Lucien Ducasse) only opus *Les Chants de Maldoror*; all and every writing of Alfred Jarry (*Ubu Roi; Ubu Enchaîné; Ubu Cocu; Ubu sur la Butte; Gestes et Opinions du Docteur Faustroll, Pataphysicien)* who launched the College of Pataphysics; Auguste Blanqui's *Ni Dieu Ni Maître*; everything from Pierre-Joseph Proudhon and Mikhail Bakunin; Michel Eyquem de Montaigne's *Essais;* André Breton (who I met several times at the home of Ginette Cachin-Signac, mother of my closest friend Henri Cachin); Italo Calvino's *Il sentiero dei nidi di ragno* (and later *Fiabe Italiane* and *Il barone rampante)*; *El ingenioso hidalgo don Quijote de la Mancha* by Miguel de Cervantes Saavedra; every writing by John Steinbeck, Ernest Hemingway, William Faulkner, Chester Himes, Herman Melville, William Saroyan and many, too many more that sneak back as visitors during the paradoxical phases of my sleep. After >70 years they remain my silent, permanent, nurturing, faithful companions.

In September 1952, knowing that the principal of Henri IV was going to expel me, I registered –alone, without any supporting document- as *élève libre* for the 1st part of the French *Baccalauréat*, and succeeded … with honors. When I arrived at the gate of Henri IV a few days later, the principal stopped me '*You have been kicked out!*'; with an angelic smile I replied: '*I jumped a class and am attending 12th grade*', and I did show him the finger. He called my father (who was his physician) for an emergency consultation, suspecting…a heart attack.

René Maublanc (seated center) with 1948 Class at Henri IV

The professor of Philosophy (my major) was René Maublanc, a nice, gentle (but weak for us) erudite, editor-in-chief of *La Pensée,* the major review on Marxism; he was also one of the intellectual luminaries of the French Communist Party. Unfortunately for Maublanc, on 5 March 1953 Joseph Stalin died (he was devastated) but many in his class –including me- started bugging him with the *Doctors' Plot* led by *Jewish bourgeois-nationalists* as the Pravda and its French meme, L'Humanité, proclaimed. That was unjust, and certainly not deserved by Maublanc. But we felt strength, while our teacher was weak.

However, I remain forever grateful to René Maublanc for his vision of ethics, his introduction to Socrates, Plato, George Berkeley and David Hume and John Locke, the categories of Immanuel Kant, Auguste Comte, the anarchists, and his immense generous love of humanity. I hope that he had forgiven me my noisy interruptions, my stupid puns, my infantile counter-propaganda on the blackboard.

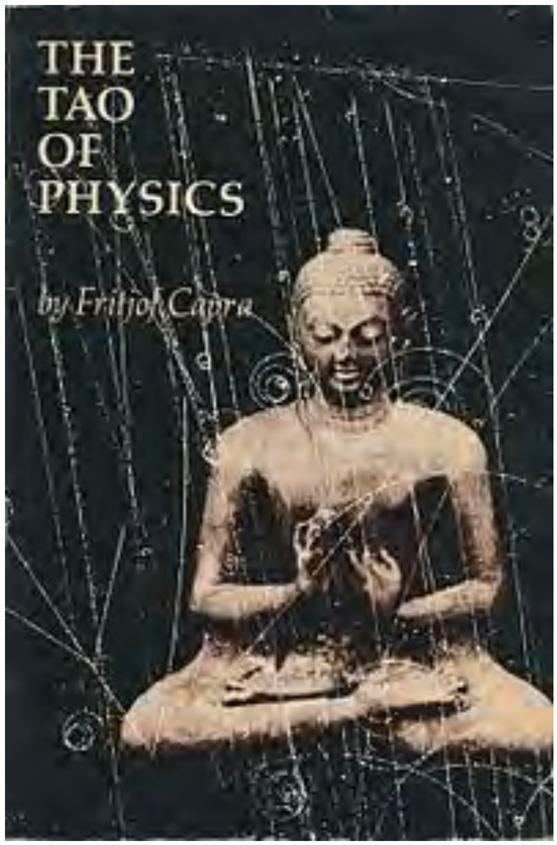
After Henri IV, I spent a year at the Lycée Michelet where I was fascinated and enthused by Emmanuel Peillet. He was the Secretary General of the *Collège de Pataphysique* (of Alfred Jarry), a prolific writer under diverse pseudonyms – including Mélanie le Plumel, Dr. Sandomir, Octav Votka, Anne de Lattis, Elme le Pâle Mutin, etc- ; he was a founding member of *Oulipo* (*ouvroir de littérature potentielle*), a famous photographer-reporter, and an expert in cacti and succulents. His teaching foundation was *rupture emancipation*: one should always free himself; moral freedom is never a final state but a permanent effort.

Emmanuel Peillet

Then, in 1957-1960, I was a resident in Psychiatry and Roger Heim published his first book on *Les Champignons Hallucinogènes du Mexique*. Luck: Roger Heim was a close friend of my father, and I could meet with him and ask this real gentleman everything I wanted to know on the *Psilocybes*! He also gave me instructions on how to organize a *voyage* without risk. The mushrooms were growing in patches after each rain on the racing horse track of Longchamp, within Paris limits. After the first rain, we (other interns and residents joined me) went mushrooming. And we spent a few weekend afternoons in a room of Ste. Anne Hospital describing the best we could our respective visions, auditory sensory hallucinations, magnified unique communion with the World. The good part: you never forget these trips in many unbeknownst dimensions.

Later on, in Africa, South America, Vanuatu, Laos I tried other psychedelics, but psilocybin –for me- remains the most comprehensive and interesting. My exposure to *'magic mushrooms'* prompted me to consider psychopharmacology as my life commitment; that was too early for the conservative brass who ran (and still does) French psychiatry; they believe and recite the gospels according to Freud, Jung or Adler -and that's the mantra. It took several years to get Thorazine (discovered by my father) prescribed, then antidepressant tricyclics, haloperidol, and the many –too many- medications that helped transform Psychiatry, over one century after Philippe Pinel had removed the chains of the patients at La Salpêtrière.

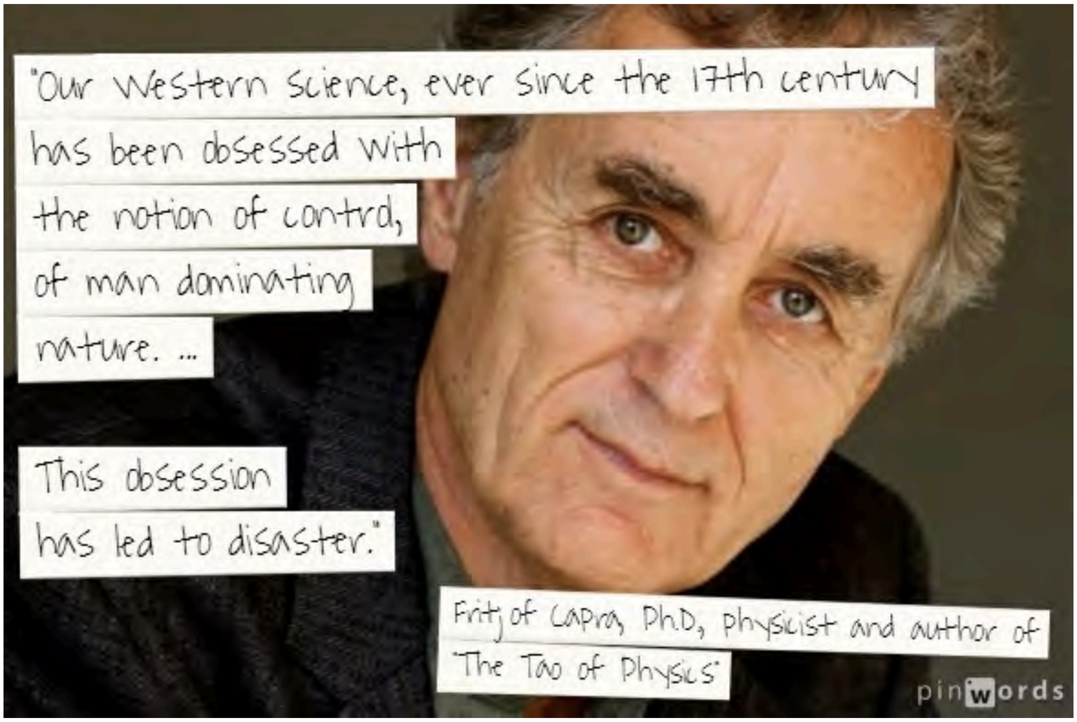
The Hijacking of the Dao and Quantum Mechanics



Courtesy of Amazon.com

In 1975 a book, “*The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism”* by physicist Fritjof Capra was published and was a bestseller in the United States; it was published in 43 editions in 23 languages. The fourth edition in English was published in 2000.

The following excerpt from “*The Tao of Physics”* summarizes Capra’s motivation for writing this book: ‘*Science does not need mysticism and mysticism does not need science, but man needs both.*’



Courtesy of Pinwords

According to the preface of the first edition, reprinted in subsequent editions, Capra struggled to reconcile theoretical physics and Eastern mysticism and was at first "*helped on my way by 'power plants' or psychedelics, with the first experience so overwhelming that I burst into tears, at the same time, not unlike Castaneda, pouring out my impressions to a piece of paper*".

Capra later discussed his ideas with Werner Heisenberg in 1972, as he mentioned in the following excerpt:

"I had several discussions with Heisenberg. I lived in England then [circa 1972], and I visited him several times in Munich and showed him the whole manuscript chapter by chapter. He was very interested and very open, and he told me something that I think is not known publicly because he never published it. He said that he was well aware of these parallels. While he was working on quantum theory, he went to India to lecture and was a guest of Rabindranath Tagore. He talked a lot with Tagore about Indian philosophy. Heisenberg told me that these talks had helped him a lot with his work in physics, because they showed him that all these new ideas in quantum physics were in fact not all that crazy. He realized there was, in fact, a whole culture that subscribed to very similar ideas. Heisenberg said that this was a great help for him. Niels Bohr *had a*

similar experience when he went to China. As a result of those influences, Bohr adopted the yin yang *symbol as part of his family* coat of arms *when he was* knighted *in 1947."*

The book was a best seller in the United States. But there were critics, some quite virulent.

Jeremy Bernstein, a professor of physics at the Stevens Institute of Technology, chastised The Tao of Physics: "At the heart of the matter is Mr. Capra's methodology – his use of what seem to me to be accidental similarities of language as if these were somehow evidence of deeply rooted connections. Thus, I agree with Capra when he writes, "Science does not need mysticism and mysticism does not need science but man needs both." What no one needs, in my opinion, is this superficial and profoundly misleading book."

Leon M. Lederman, a Nobel Prize-winning physicist and current Director Emeritus of Fermilab, criticized both *The Tao of Physics* and Gary Zukav's *The Dancing Wu Li Masters* in his 1993 book *The God Particle: If the Universe Is the Answer, What Is the Question? "Starting with reasonable descriptions of quantum physics, he constructs elaborate extensions, totally bereft of the understanding of how carefully experiment and theory are woven together and how much blood, sweat, and tears go into each painful advance.*"

Peter Woit, a mathematical physicist at Columbia University, criticized Capra for continuing to build his case for physics-mysticism parallels on the bootstrap model of strong-force interactions, long after the Standard Model had become thoroughly accepted by physicists as a better model: "*The Tao of Physics was completed in December 1974, and the implications of the November Revolution one month earlier that led to the dramatic confirmations of the standard-model quantum field theory clearly had not sunk in for Capra (like many others at that time). What is harder to understand is that the book has now gone through several editions, and in each of them Capra has left intact the now out-of-date physics, including new forewords and after words that with a straight face deny what has happened. The foreword to the second edition of 1983 claims, "It has been very gratifying for me that none of these recent developments has invalidated anything I wrote seven years ago. In fact, most of them were anticipated in the original edition," a statement far from any relation to the reality that in 1983 the standard model was nearly universally accepted in the physics community, and the bootstrap theory was a dead idea ... Even now, Capra's book, with* *its nutty denials of what has happened in particle theory, can be found selling well at every major bookstore. It has been joined by some other books on the same topic, most notably Gary Zukav's "The Dancing Wu-Li Masters." The bootstrap philosophy, despite its complete failure as a physical theory, lives on as part of an embarrassing New Age cult, with its followers refusing to acknowledge what has happened."* (N.B. Zukav was a frequent guest on Oprah, who called "*The Seat of the Soul"* her favorite book of all time -except the Bible. According to Zukav, the soul is a product *formed from the vibrational aspect of your name, the vibrational aspect of your relation to the planets at the time of your incarnation, and vibrational aspects of your energy environment, as well as the splintered aspects of your soul that need to interact with physical matter in order to be brought to wholeness.* You can see why "*The Seat of the Soul*" is Oprah's favorite book (next to the Bible). Now, forty years after "*The Tao of Physics*", in the third millennium of the Common Era, we can see unequivocally that this revolution in human consciousness never happened. Nevertheless, its vibrations still find resonance with many of those who have rejected traditional religion and say they are "*not religious but spiritual*."

Instead of humans joining together into one cooperative whole, the 1980s became characterized, in America, anyway, as the "*Me Decade*." Far from recognizing that we are each an inseparable part of the whole, and everyone pitching in to make the world a better place for its inhabitants, life in the 1980s was characterized by an unprecedented level of individual self-absorption. And the 2010s so far show no sign of any abatement in this focus on self, as almost every element of our society is geared to provide maximal short-term self-gratification for its members, while many of those who fail to be gratified view themselves as victims.

In fact, no small portion of the blame for the excessive self-absorption that has characterized America for all this time lies at the feet of the proponents of the new mysticism. Anyone listening to New Age gurus, such as Zukav and Deepak Chopra, and modern megachurch Christian preachers, cannot miss the emphasis on the individual finding easy gratification, rather than sacrificing and selflessly laboring for a better world. Holistic philosophy is the perfect delusion for the spoiled brat of any age who, all decked out in the latest fashion, loves to talk about solving the problems of the world but has no intention of sweating a drop in achieving this noble goal.

Reductionist classical physics did not make people egoists. People were egoists long before reductionist classical physics. In fact, classical physics has nothing to say about humans except that they are material objects like rocks and trees, made of nothing more than the same atoms -just more cleverly arranged by the impersonal forces of self-organization and evolution. This is hardly a philosophical basis for narcissism. The new quantum holism, on the other hand, encourages our delusions of personal importance. It tells us that we are part of an immortal cosmic mind with the power to perform miracles and, as Chopra has said, to make our own reality. Who needs God when we, ourselves, are God? Thoughts of our participation in cosmic consciousness inflate our egos to the point where we can ignore our shortcomings and even forget our mortality. And the modern versions of traditional religions feed on this desire. Where once Christian preachers shouted hell-fire and brimstone from the pulpit, their successors in the very same sects now present the soothing message that we are all perfect, worthy, and destined for infinite happiness. The only sacrifice required is a regular check. Then Jesus will provide all.

The rising number who identify themselves as "*not religious but spiritual*" have not found the new Christianity either sensible or congenial. Unfortunately, the new spirituality they find in quantum mysticism is just as much of a con game. Mystical physics is a grossly misapplied version of ancient Hindu and Buddhist philosophies, which were based on the notion that only by the complete rejection of self can one find inner peace in this world of suffering and hopelessness. However, you won't find selflessness in these religions as they are practiced in America today. Modern physics is even more reductionist than classical physics. Ironically, the same year, 1975, that "*The Tao of Physics*" appeared, the highly successful standard model of elementary particles was developed and the holistic ideas such as Bootstrap Theory that Capra and others were working on (and he emphasizes in his *Tao*) were tossed in the trash heap. The standard model is based on the notion that the universe is composed of material particles and nothing more. Classical physics still had ethereal fields. Since its inception, the standard model has agreed with all physics data and was crowned in 2012 with the observation of the long-predicted Higgs boson. As for the role of consciousness in quantum mechanics -this is not supported by a scintilla of empirical evidence.

Having said that, it is true indeed that Niels Bohr, a pioneer of quantum mechanics, chose the Taoist yin-yang symbol for his coat of arms. He saw that the polarized states of particles, for example, complement each other the way the two extremes of yin and yang create a balance in the Taoist understanding of the universe. Bohr spoke of the unity of opposites and contradictions in nature.

Left: Niels Bohr, a pioneer of quantum physics - Courtesy of Wikipedia.
Right: Niels Bohr's coat of arms designed by him with the Taoist yin-yang symbol included. - Courtesy of Wikimedia

Many concepts in ancient Chinese science correspond to ideas physicists have only formed in the past century or so. Here's a simple look at a few such concepts.

1. Eight Trigrams and Particle Arrangements

Eight symbols made of different combinations of lines -the eight trigrams- surround the yin-yang symbol.

The eight trigrams are presented in the classic Chinese text "*Book of Changes*" (*I Ching*), an important and fundamental work in Chinese history.

The trigrams each represent essential principles of reality and they are arranged in an octagonal pattern based on the relationships and interactions between them.

2. The Book of Changes and the Elusive Theory of Everything

Modern physics rests on the two pillars of general relativity and quantum mechanics. The problem is: the two are contradictory. In 1999, Brian Greene wrote in his Pulitzer Prize-nominated book "*The Elegant Universe*": "*As they are both currently formulated, general relativity and quantum mechanics cannot both be right. The two* *theories underlying the tremendous progress of physics during the last hundred years - progress that has explained the expansion of the heavens and the fundamental structure of matter—are mutually incompatible.*"

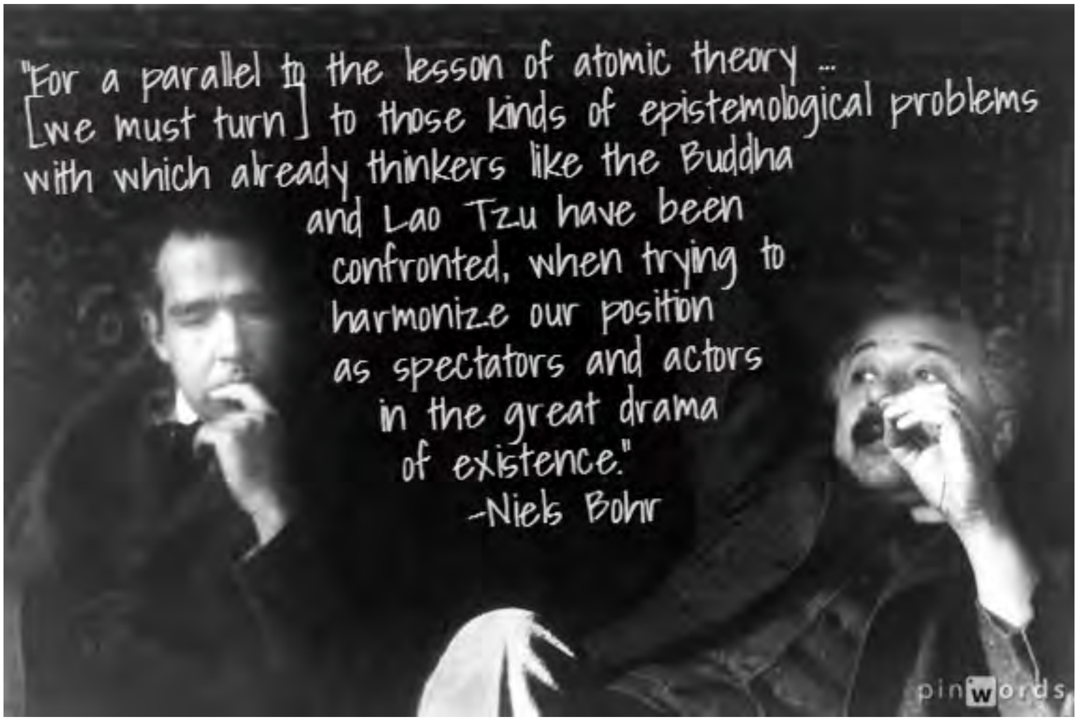
Relativity works well for understanding the universe on the largest scale, that of stars, galaxies, etc. Quantum mechanics works well for understanding the universe on the smallest scale, that of atoms, subatomic particles, etc. Scientists search for the so-called "*theory of everything*," to cover both. String theory attempts to do this. In simplified terms, string theory conceives of the universe as strings rather than separate points. An electron, for example, would not be a point, but rather a part of a string. If the string oscillates one way, it appears to be an electron, if it oscillates another way, it could appear to be a photon or a quark. These strings may originate in another dimension without gravity.

3. Laozi's Understanding Related to Subatomic Particles

Laozi, the founder of Taoism in the 6th century B.C. E., wrote: *"Tao gave birth to one, one gave birth to two, two gave birth to three, three gave birth to all the myriad things. All the myriad things carry the yin on their backs and hold the yang in their embrace."*

Now many say this comment is related to the various levels of particles: molecules, atoms, electrons, and so on. Electrons are subatomic particles with a negative electric charge. Protons are subatomic particles with a positive electric charge. These charges could be related to the *yin* and *yang* polarities of Taoism.

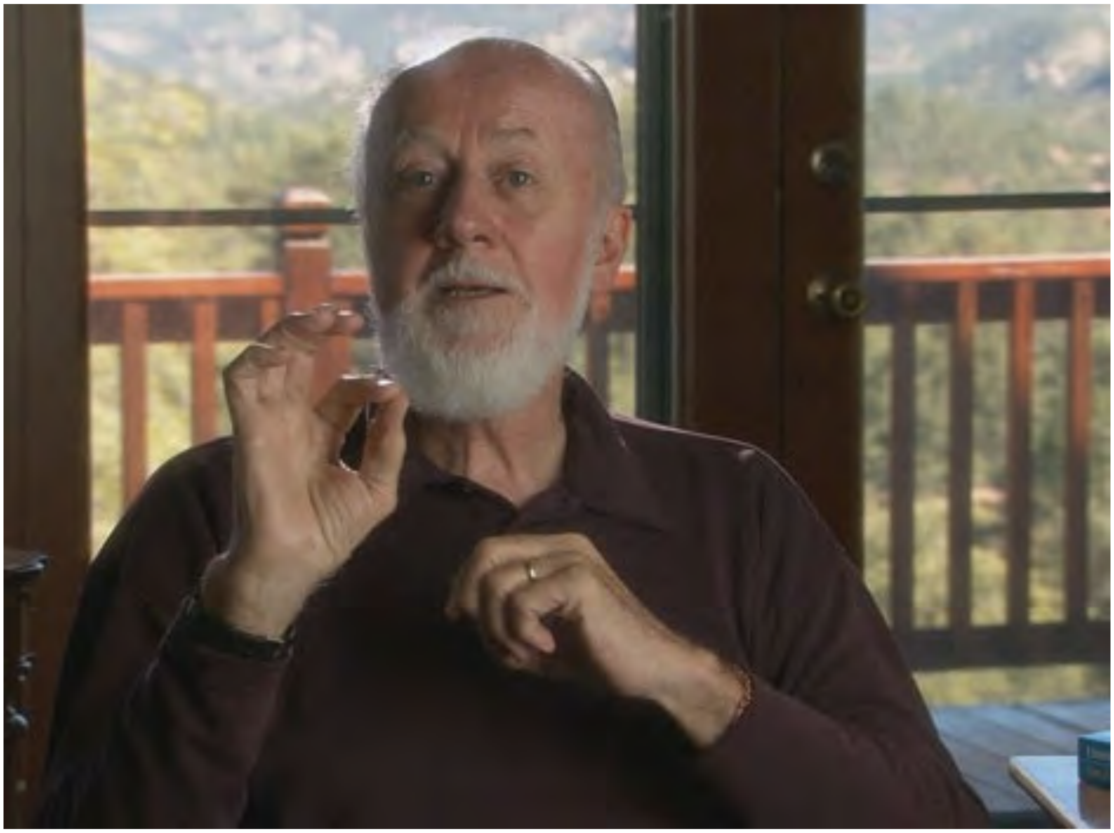
The ancient Greeks also theorized about atoms. Electrons were only discovered in 1897 and the other subatomic particles followed.



Niels Bohr, a pioneer of quantum physics, and Albert Einstein ca. 1925. - Courtesy of Pinwords

The goals of ancient Chinese science were different than those of modern physics. Ancient Chinese science concentrated on the spiritual, and it recognized the incorporeal as well as the corporeal. The comparison between ancient Chinese science and modern physics remains imprecise to a certain extent because the framework and approach are different. Some of modern physicists have nonetheless been inspired by, and have identified with, ancient Chinese science.

Quantum physics has shown that the observer can change the outcome of an experiment simply through the act of observing. It is possible that the intent of the researchers could even influence the outcome of the experiments: Werner Heisenberg wrote *Looking at something changes it*! Some studies have begun to show the effects of human mind-intent on physical reality, though the subject is still highly debatable and has not yet been embraced by mainstream science. But William A. Tiller of Stanford University, for example, is exploring the topic on the spiritual starting point of the ancient science and the materialist starting point of modern science that may produce different results.



William A. Tiller. - Courtesy of YouTube

He has been researching a level of physical reality hitherto undetectable with conventional measurement instruments and says two kinds of substances exist:

1. **The electric atom/molecule level:** Substances on this level can be measured with traditional instruments. We can measure them because they are electric-charge based.

2. **The magnetic information waves level:** Tiller explains in an introduction to his research on his website: *"This new level of substance, because it appears to function in the physical vacuum (the empty space between the fundamental electric particles that make up our normal electric atoms and molecules), is currently invisible to us and to our traditional measurement instruments."*

This second type of substance has great power, and it is affected by human thought.

Tiller put the energy of the magnetic information waves level into perspective in an interview for the documentary "*What the Bleep Do We Know?*" He compared the latent energy of the entire known universe to the latent energy in the vacuum inside a single hydrogen atom. The latent energy in one atom is a trillion times that estimated to exist in the space of the known universe. "*Just that little bit of vacuum outweighs all the mass and all the planets and all the stars,*" he said. This comparison assumes the universe is fairly flat, which astronomers say it is. Tiller said the calculations are not 100 percent accurate, but they are accurate enough to give us an idea of the amount of energy in this second type of substance he talks about in the vacuum. Tiller says he has could detect this hitherto invisible substance, but only when it interacts with the electric molecule/atom type substance we can conventionally measure. Human consciousness spurs this interaction.

An intention projected from a person's mind seems to increase the conductivity between the atom/molecule level and the vacuum level. "*Consciousness lifts the higher thermodynamic free energy state [of the vacuum level], then we can access the physics of the vacuum*," Tiller says. "*Accessing that new physics allows intention to bring forth effects you wouldn't imagine*." The consciousness can, in a way, affect or interact with a power greater than anything conventional instruments have been able to measure thus far. But there is more, and the discussions continue over the apparent order of the universe. Is the seeming law-like "*order*" something that transcends space and time -something timeless and absolute- or is it something that emerged as the universe developed, something perhaps more immanent?

If the laws of physics are to have any sticking power at all, to be real laws, one could argue, they must be good anywhere and at any time, including the Big Bang, the putative Creation. Which gives them a kind of transcendent status outside of space and time.

On the other hand, many thinkers -all the way back to (St.) Augustine- suspect that space and time, being attributes of this existence, came into being along with the universe -in the Big Bang, in modern vernacular. So why not the laws themselves?

On August 10, 2018, ***Scientific American*** published an important warning *cum* reminder by Abraham Loeb, the chair of astronomy department at Harvard University, titled ***Theoretical Physics is Pointless without Experimental Tests***. Here it is, slightly edited:

"A new debate has recently emerged as to whether string theory admits even a single rigorous solution that includes a cosmological constant, as we find observationally in the real universe. The debate follows on a period of several decades during which the mathematical richness of the theory has been advanced considerably but with very limited connection to experimental testing. This experience inspired a new culture of doing theoretical physics without the need for experimental verification. Given our academic reward system of grades, promotions and prizes, we sometimes forget that physics is a learning experience about nature rather than an arena for demonstrating our intellectual power. As students of experience, we should be allowed to make mistakes and correct our prejudices.

Albert Einstein is admired for pioneering the use of thought experiments as a tool for unraveling the truth about the physical reality. But we should keep in mind that he was wrong about the fundamental nature of quantum mechanics as well as the existence of gravitational waves and black holes—which he dismissed late in his career, and which were both confirmed observationally by LIGO in 2015, exactly a century after he formulated the general theory of relativity.

Given this humbling historical lesson, theoretical physicists should be careful of premature hubris in celebrating conjectures and accept the final verdict of experimental guillotines in setting the fate of untested speculations. The feedback from experimental data is essential. At its foundation, physics is a dialogue with nature, not a monologue as some theorists would prefer to believe. On my daily route to work, I am often reminded of the need for empirical verification by the sight of the beautiful house purchased by Charles Ponzi in 1920, just months before his arrest for the fraudulent investment operations now commonly associated with his last name. Ponzi made his fortune by promising investors guaranteed revenues, a desirable theoretical scheme that was socially acceptable until it was brought to an experimental test by the investors asking to cash out their funds. Their shock at the time signified the need for testing theoretical schemes before giving them the stamp of approval as descriptions of reality.

Similar to the way physicians are obliged to take the Hippocratic Oath, physicists should take a "Galilean Oath," in which they agree to gauge the value of theoretical conjectures in physics based on how well they are tested by experiments within their lifetime.

The risk for physics stems primarily from mathematically beautiful "truths," such as string theory, accepted prematurely for decades as a description of reality just because of their elegance. This is a judgement often guided by a social trend within physics to feed off mathematical sophistication and prestige. It is widely accepted today that the study of extra dimensions is part of the mainstream in theoretical physics even though there is no evidence for any extra dimension beyond the 3+1 we witness in our daily life.

At the same time, many of the same scientists that consider the study of extra dimensions as mainstream regard the search for extraterrestrial intelligence (SETI) as speculative. This mindset fails to recognize that SETI merely involves searching elsewhere for something we already know exists on Earth, and by the knowledge that a quarter of all stars host a potentially habitable Earth-size planet around them. This search should be considered well within the boundaries of mainstream research, whereas the conjecture of extra dimensions should be regarded as highly speculative. The experience of subjecting a theoretical conjecture to an experimental test is humbling. If the conjecture turns out to be wrong, it must be adjusted. Becoming a physicist brings with it the privilege of retaining your childhood curiosity throughout your adult life. There is no need to pretend you know more than you do, and you can admit mistakes if proven wrong by experience, just like a child who is seeking to learn about the world. Doing pure theory without worrying about experimental verification deprives one from the pleasure of learning something new about nature. Identifying the boundaries of our knowledge is more exciting than taking pride in past knowledge. And only our contact with reality itself through experimentation can direct our notions into new realms. No one, not even Einstein, would have imagined quantum mechanics without the experimental data that led us to this unexpected notion of reality."

A Brief Survey of Quantum Mechanics

Quantum mechanics (also known as quantum physics or quantum theory), including quantum field theory, is a fundamental branch of physics concerned with processes involving, for example, atoms and photons. In such processes, said to be quantized, the action has been observed to be only in integer multiples of the Planck constant. This is utterly inexplicable in classical physics (Newtonian).

Please watch the video narrated by (my friend) Brian Greene: *https://www.youtube.com/watch?v=P2fNJL2o1gU.*

Quantum mechanics gradually arose from Max Planck's solution in 1900 to the black-body radiation problem (1859) and Albert Einstein's 1905 paper which offered a quantum-based theory to explain the photoelectric effect (1887). Early quantum theory was profoundly reconceived in the mid-1920s. The reconceived theory is formulated in various specially developed mathematical formalisms. In one of them, a mathematical function, the wave function, provides information about the probability amplitude of position, momentum, and other physical properties of a particle. Important applications of quantum mechanical theory include superconducting magnets, light-emitting diodes and the laser, the transistor and semiconductors such as the microprocessor, medical and research imaging such as magnetic resonance imaging and electron microscopy, and explanations for many biological and physical phenomena.

The foundations of quantum mechanics were established during the first half of the 20th century by Max Planck, Niels Bohr, Werner Heisenberg, Louis de Broglie, Arthur Compton, Albert Einstein, Erwin Schrödinger, Max Born, John von Neumann, Paul Dirac, Enrico Fermi, Wolfgang Pauli, Max von Laue, Freeman Dyson, David Hilbert, Wilhelm Wien, Satyendra Nath Bose, Arnold Sommerfeld, and others. The Copenhagen interpretation of Niels Bohr became widely accepted.

In the mid-1920s, developments in quantum mechanics led to it becoming the standard formulation for atomic physics. The entire field of quantum physics emerged, leading to its wider acceptance at the Fifth Solvay Conference in 1927.

Fifth Solvay Conference 1927 - Courtesy of Rare Historical Photos

It was found that subatomic particles and electromagnetic waves are neither simply particle nor wave but have certain properties of each. This originated the concept of wave–particle duality.

By 1930, quantum mechanics had been further unified and formalized. It has since permeated many disciplines including quantum chemistry, quantum electronics, quantum optics, and quantum information science. Its speculative modern developments include string theory and quantum gravity theories. It also provides a useful framework for many features of the modern periodic table of elements and describes the behaviors of atoms during chemical bonding and the flow of electrons in computer semiconductors, and therefore plays a crucial role in many modern technologies.

The word quantum derives from the Latin, meaning "how great" or "how much". In quantum mechanics, it refers to a discrete unit assigned to certain physical quantities such as the energy of an atom at rest. The discovery that particles are discrete packets of energy with wave-like properties led to the branch of physics dealing with atomic and subatomic systems which is today called quantum mechanics. It underlies the mathematical framework of many fields of physics and chemistry including condensed matter physics, solid-state physics, atomic physics, molecular physics, computational physics, computational chemistry, quantum chemistry, particle physics, nuclear chemistry, and nuclear physics. Quantum mechanics is essential to understanding the behavior of systems at atomic length scales and smaller. If the physical nature of an atom was solely described by classical mechanics, electrons would not orbit the nucleus, since orbiting electrons emit radiation (due to circular motion) and would eventually collide with the nucleus due to this loss of energy. This framework was unable to explain the stability of atoms. Instead, electrons remain in an uncertain, non-deterministic, smeared, probabilistic wave–particle orbital about the nucleus, defying the traditional assumptions of classical mechanics and electromagnetism. Quantum mechanics was initially developed to provide a better explanation and description of the atom, especially the differences in the spectra of light emitted by different isotopes of the same chemical element, as well as subatomic particles. In short, the quantum-mechanical atomic model has succeeded spectacularly in the realm where classical mechanics and electromagnetism falter.

Broadly speaking, quantum mechanics incorporates four classes of phenomena for which classical physics cannot account:

- quantization of certain physical properties
- quantum entanglement
- principle of uncertainty
- wave–particle duality

Even with the defining postulates of both Einstein's theory of general relativity and quantum theory being indisputably supported by rigorous and repeated empirical evidence, and while they do not directly contradict each other theoretically (at least with regard to their primary claims), they have proven extremely difficult to incorporate into one consistent, cohesive model.

Gravity is negligible in many areas of particle physics, so that unification between general relativity and quantum mechanics is not an urgent issue in those particular applications. However, the lack of a correct theory of quantum gravity is an important issue in cosmology and the search by physicists for an elegant "Theory of Everything" (TOE). Consequently, resolving the inconsistencies between both theories has been a major goal of 20th and 21st century physics. Many prominent physicists, including Stephen Hawking, have labored for many years in the attempt to discover a theory underlying *everything*. This TOE would combine not only the different models of subatomic physics, but also derive the four fundamental forces of nature - the strong force, electromagnetism, the weak force, and gravity - from a single force or phenomenon.

But Is Gravity Quantum?

All the fundamental forces of the universe are known to follow the laws of quantum mechanics, save one: gravity. Finding a way to fit gravity into quantum mechanics would bring scientists a giant leap closer to a "*theory of everything*" that could entirely explain the workings of the cosmos from first principles. A crucial first step in this quest to know whether gravity is quantum is to detect the long-postulated elementary particle of gravity, the graviton. In search of the graviton, physicists are now turning to experiments involving microscopic superconductors, free-falling crystals and the afterglow of the big bang. Quantum mechanics suggests everything is made of quanta, or packets of energy, that can behave like both a particle and a wave -for instance, quanta of light are called photons. Detecting gravitons, the hypothetical quanta of gravity, would prove gravity is quantum. The problem is that gravity is extraordinarily weak. To directly observe the minuscule effects a graviton would have on matter, physicist Freeman Dyson famously noted, a graviton detector would have to be so massive that it collapses on itself to form a black hole.

"One of the issues with theories of quantum gravity is that their predictions are usually nearly impossible to experimentally test," says quantum physicist Richard Norte of Delft University of Technology in the Netherlands. *"This is the main reason why there exist so many competing theories and why we haven't been successful in understanding how it actually works."*

In 2015, however, theoretical physicist James Quach, now at the University of Adelaide in Australia, suggested a way to detect gravitons by taking advantage of their quantum nature. Quantum mechanics suggests the universe is inherently fuzzy -for instance, one can never absolutely know a particle's position and momentum at the same time. One consequence of this uncertainty is that a vacuum is never completely empty, but instead buzzes with a "*quantum foam*" of so-called virtual particles that constantly pop in and out of existence. These ghostly entities may be any kind of quanta, including gravitons.

Decades ago, scientists found that virtual particles can generate detectable forces. For example, the Casimir effect is the attraction or repulsion seen between two mirrors placed close together in vacuum. These reflective surfaces move due to the force generated by virtual photons winking in and out of existence. Previous research suggested that superconductors might reflect gravitons more strongly than normal matter, so Quach calculated that looking for interactions between two thin superconducting sheets in vacuum could reveal a gravitational Casimir effect. The resulting force could be roughly 10 times stronger than that expected from the standard virtual-photon-based Casimir effect. Recently, Norte and his colleagues developed a microchip to perform this experiment. This chip held two microscopic aluminum-coated plates that were cooled almost to absolute zero so that they became superconducting. One plate was attached to a movable mirror, and a laser was fired at that mirror. If the plates moved because of a gravitational Casimir effect, the frequency of light reflecting off the mirror would measurably shift. As detailed online July 20, 2018 in *Physical Review Letters*, the scientists failed to see any gravitational Casimir effect. This null result does not necessarily rule out the existence of gravitons -and thus gravity's quantum nature. Rather, it may simply mean that gravitons do not interact with superconductors as strongly as prior work estimated, says quantum physicist and Nobel laureate Frank Wilczek of the Massachusetts Institute of Technology, who did not participate in this study and was unsurprised by its null results. Even so, Quach says, this "*was a courageous attempt to detect gravitons*." Although Norte's microchip did not discover whether gravity is quantum, other scientists are pursuing a variety of approaches to find gravitational quantum effects. For example, in 2017 two independent studies suggested that if gravity is quantum it could generate a link known as "*entanglement*" between particles, so that one particle instantaneously influences another no matter where either is located in the cosmos. A tabletop experiment using laser beams and microscopic diamonds might help search for such gravity-based entanglement. The crystals would be kept in a vacuum to avoid collisions with atoms, so they would interact with one another through gravity alone. Scientists would let these diamonds fall at the same time, and if gravity is quantum the gravitational pull each crystal exerts on the other could entangle them together. The researchers would seek out entanglement by shining lasers into each diamond's heart after the drop. If particles in the crystals' centers spin one way, they would fluoresce, but they would not if they spin the other way. If the spins in both crystals are in sync more often than chance would predict, this would suggest entanglement. "*Experimentalists all over the world are curious to take the challenge up,*" says quantum gravity researcher Anupam Mazumdar of the University of Groningen in the Netherlands, co-author of one of the entanglement studies.

Another strategy to find evidence for quantum gravity is to look at the cosmic microwave background radiation, the faint afterglow of the big bang, says cosmologist Alan Guth of M.I.T. Quanta such as gravitons fluctuate like waves, and graviton fluctuations would have imprinted themselves on the structure of the newborn universe. When the cosmos then expanded staggeringly in size within a sliver of a second after the big bang, according to Guth's widely supported cosmological model known as inflation, this evidence of quantum gravity would have been amplified across the universe. It could become visible as swirls in the polarization, or alignment, of photons from the cosmic microwave background radiation. However, the intensity of these patterns of swirls, known as B-modes, depends very much on the exact energy and timing of inflation. "*Some versions of inflation predict that these B-modes should be found soon, while other versions predict that the B-modes are so weak that there will never be any hope of detecting them*," Guth says. "But if they are found, and the properties match the expectations from inflation, it would be very strong evidence that gravity is quantized."

One more way to find out whether gravity is quantum is to look directly for quantum fluctuations in gravitational waves, that are thought to be made up of gravitons that were generated shortly after the big bang. The Laser Interferometer Gravitational-Wave Observatory (LIGO) first detected gravitational waves in 2016, but it is not sensitive enough to detect the fluctuating gravitational waves in the early universe that inflation stretched to cosmic scales, Guth says. A gravitational-wave observatory in space, such as the Laser Interferometer Space Antenna (LISA), could potentially detect these waves, Wilczek adds.

In a paper recently accepted by the journal *Classical and Quantum Gravity*, however, astrophysicist Richard Lieu of the University of Alabama, Huntsville, argues that LIGO should already have detected gravitons if they carry as much energy as some current models of particle physics suggest. It might be that the graviton just packs less energy than expected, but Lieu suggests it might also mean the graviton does not exist. "*If the graviton does not exist at all, it will be good news to most physicists, since we have been having such a horrid time in developing a theory of quantum gravity,*" Lieu says. Still, devising theories that eliminate the graviton may be no easier than devising theories that keep it. "*From a theoretical point of view, it is very hard to imagine how gravity could avoid being quantized*," Guth says. "*I am not aware of any sensible theory of how classical gravity could interact with quantum matter, and I can't imagine how such a theory might work*."

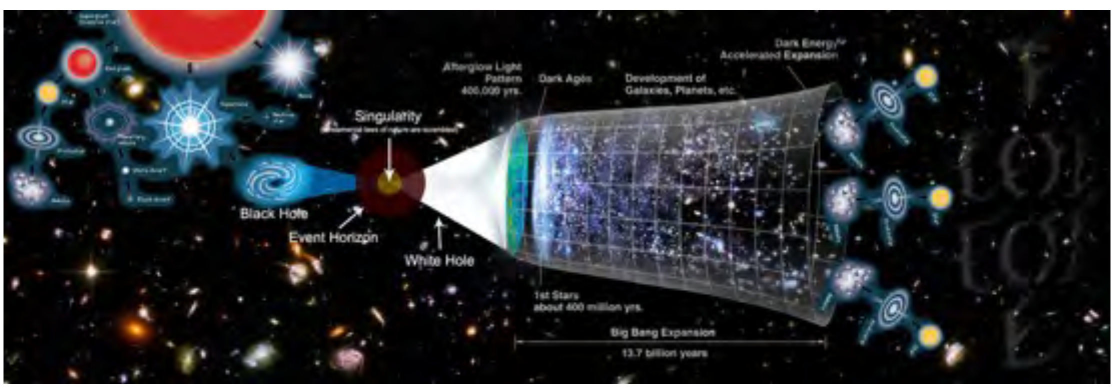
Since its inception, the many counter-intuitive aspects and results of quantum mechanics have provoked strong philosophical debates and many interpretations. Even fundamental issues, such as Max Born's basic rules concerning probability amplitudes and probability distributions, took decades to be appreciated by society and many leading scientists. Richard Feynman once said, *"I think I can safely say that nobody understands quantum mechanics."* According to Steven Weinberg, *"There is now in my opinion no entirely satisfactory interpretation of quantum mechanics."* The Copenhagen Interpretation -due largely to Niels Bohr and Werner Heisenberg - remains most widely accepted amongst physicists, some 75 years after its enunciation.

Werner Heisenberg and Niels Bohr. - Courtesy of physicsworld.com

According to this interpretation, the probabilistic nature of quantum mechanics is not a *temporary* feature which will eventually be replaced by a deterministic theory, but instead must be considered a *final* renunciation of the classical idea of *"causality*." It is also believed therein that any well-defined application of the quantum mechanical formalism must always make reference to the experimental arrangement, due to the conjugate nature of evidence obtained under different experimental situations.

Albert Einstein, himself one of the founders of quantum theory, did not accept some of the more philosophical or metaphysical interpretations of quantum mechanics, such as rejection of determinism and of causality. He is famously quoted as saying, in response to this aspect, *"God does not play with dice".* He rejected the concept that the state of a physical system depends on the experimental arrangement for its measurement. He held that a state of nature occurs in its own right, regardless of whether or how it might be observed. In that view, he is supported by the currently accepted definition of a quantum state, which remains invariant under arbitrary choice of configuration space for its representation, that is to say, manner of observation. He also held that underlying quantum mechanics there should be a theory that thoroughly and directly expresses the rule against action at a distance; in other words, he insisted on the principle of locality. He considered, but rejected on theoretical grounds, a particular proposal for hidden variables to obviate the indeterminism or a causality of quantum mechanical measurement. He considered that quantum mechanics was a currently valid but not a permanently definitive theory for quantum phenomena. He thought its future replacement would require profound conceptual advances and would not come quickly or easily. The Bohr-Einstein debates provide a vibrant critique of the Copenhagen interpretation from an epistemological point of view. In arguing for his views, he produced a series of objections, the most famous of which has become known as the Einstein-Podolsky-Rosen paradox. John Bell showed that this "EPR" paradox led to experimentally testable differences between quantum mechanics and theories that rely on added hidden variables. Experiments have been performed confirming the accuracy of quantum mechanics, thereby demonstrating that quantum mechanics cannot be improved upon by addition of hidden variables. Entanglement, as demonstrated in Bell-type experiments, does not, however, violate causality, since no transfer of information happens. Quantum entanglement forms the basis of quantum cryptography, which is proposed for use in high-security commercial applications in banking and government.

The Everett many-worlds interpretation, formulated in 1956, holds that *all* the possibilities described by quantum theory *simultaneously* occur in a multiverse composed of mostly independent parallel universes. This is not accomplished by introducing some "new axiom" to quantum mechanics, but on the contrary, by *removing* the axiom of the collapse of the wave packet. *All* of the possible consistent states of the measured system and the measuring apparatus (including the observer) are present in a *real* physical - not just formally mathematical, as in other interpretations –quantum superposition. Such a superposition of consistent state combinations of different systems is called an entangled state. While the multiverse is deterministic, we perceive non-deterministic behavior governed by probabilities, because we can only observe the universe (i.e., the consistent state contribution to the aforementioned superposition) that we, as observers, inhabit. Everett's interpretation is perfectly consistent with John Bell's experiments and makes them intuitively understandable. However, according to the theory of quantum decoherence, these "*parallel universes*" will never be accessible to us.

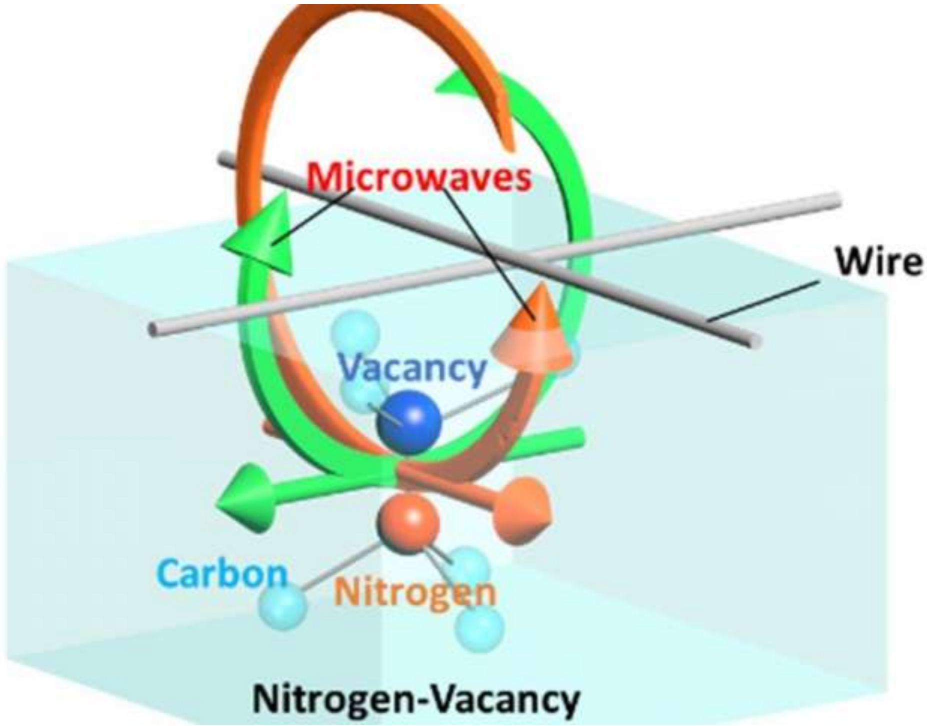


The Big Bang/Bit Bang

Quantum mechanics has had enormous success in explaining many of the features of our universe. Quantum mechanics is often the only tool available that can reveal the individual behaviors of the subatomic particles that make up all forms of matter (electrons, protons, neutrons, photons, and others). Quantum mechanics has strongly influenced string theories, candidates for a Theory of Everything. Quantum mechanics is also critically important for understanding how individual atoms combine covalently to form molecules. The application of quantum mechanics to chemistry is known as quantum chemistry. Relativistic quantum mechanics can, in principle, mathematically describe most of chemistry. Quantum mechanics can also provide quantitative insight into ionic and covalent bonding processes by explicitly showing which molecules are energetically favorable to which others and the magnitudes of the energies involved. Furthermore, most of the calculations performed in modern computational chemistry rely on quantum mechanics.

Many modern electronic devices are designed using quantum mechanics. Examples include the laser, the transistor (and thus the microchip), the electron microscope and magnetic resonance imaging (MRI). The study of semiconductors led to the invention of the diode and the transistor, which are indispensable parts of modern electronics systems, computer and telecommunication devices. Another application is the light emitting diode which is a high-efficiency source of light. Many electronic devices operate under effect of quantum tunneling. Flash memory chips found in USB drives use quantum tunneling to erase their memory cells. Some negative differential resistance devices also utilize quantum tunneling effect, such as resonant tunneling diode. Efforts are being made to more fully develop quantum cryptography, which will theoretically allow guaranteed secure transmission of information.

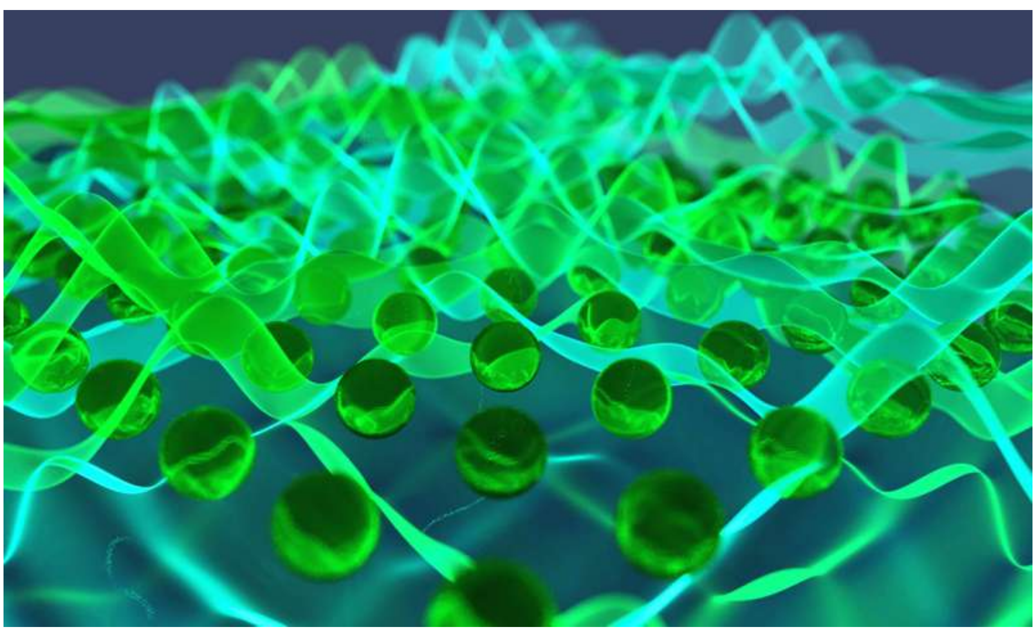
Quantum computers, which are expected to perform certain computational tasks exponentially faster than classical computers, have crossed from the research bench into reality in 2015. Instead of using classical bits, quantum computers use qubits, which can be in superpositions of states. Another active research topic is quantum teleportation, which deals with techniques to transmit quantum information over arbitrary distances.



Nitrogen-vacancy (NV) center in diamond with two crossed wires for holonomic quantum gates over the geometric spin qubit with a polarized microwave. - Credit: Yokohama National University

Researchers have demonstrated holonomic quantum gates under zero-magnetic field at room temperature, which could enable the realization of fast and fault-tolerant universal quantum computers. A quantum computer is a theoretical machine with the potential to solve complex problems much faster than conventional computers. Researchers are currently working on the next step in quantum computing -building a universal quantum computer. The paper, published in the journal *Nature Communications* (August 2018), reports experimental demonstration of non-adiabatic and non-abelian holonomic quantum gates over a geometric spin qubit on an electron or nitrogen nucleus, which paves the way to realizing a universal quantum computer. The geometric phase is currently a key issue in quantum physics. A holonomic quantum gate purely manipulating the geometric phase in the degenerate ground state system is believed to be an ideal way to build a fault-tolerant universal quantum computer. The geometric phase gate or holonomic quantum gate has been experimentally demonstrated in several quantum systems, including nitrogen-vacancy (NV) centers in diamond. However, previous experiments required microwaves or light waves to manipulate the non-degenerate subspace, leading to the degradation of gate fidelity due to unwanted interference of the dynamic phase.

"To avoid unwanted interference, we used a degenerate subspace of the triplet spin qutrit to form an ideal logical qubit, which we call a geometric spin qubit, in an NV center. This method facilitated fast and precise geometric gates at a temperature below 10 K, and the gate fidelity was limited by radiative relaxation," says corresponding author Professor Hideo Kosaka, of Yokohama National University*. "Based on this method, in combination with polarized microwaves, we succeeded in manipulation of the geometric phase in an NV center in diamond under a zero-magnetic field at room temperature."* The group also demonstrated a two-qubit holonomic gate to show universality by manipulating electron-nucleus entanglement. The scheme renders a purely holonomic gate without requiring an energy gap, which would have induced dynamic phase interference to degrade the gate fidelity, and thus enables fast, precise control over long-lived quantum memory, a step toward realizing quantum repeaters interfacing between universal quantum computers and secure communication networks.



Simulating the behavior of quantum particles hopping around on a grid may be one of the first problems tackled by early quantum computers.

State-of-the-art quantum devices are not yet large enough to be called full- scale computers. The biggest comprise just a few dozen qubits -a meager count compared to the billions of bits in an ordinary computer's memory. But steady progress means that these machines now routinely string together 10 or 20 qubits and may soon hold sway over 100 or more.

In the meantime, researchers are busy dreaming up uses for small quantum computers and mapping out the landscape of problems they'll be suited to solving. A paper by researchers from the Joint Quantum Institute (JQI) and the Joint Center for Quantum Information and Computer Science (QuICS), published recently in *Physical Review Letters*, argues that a novel non-quantum perspective may help sketch the boundaries of this landscape and potentially even reveal new physics in future experiments.

The new perspective involves a mathematical tool -a standard measure of computational difficulty known as sampling complexity- that gauges how easy or hard it is for an ordinary computer to simulate the outcome of a quantum experiment. Because the predictions of quantum physics are probabilistic, a single experiment could never verify that these predictions are accurate. You would need to perform many experiments, just like you would need to flip a coin many times to convince yourself that you're holding an everyday, unbiased nickel.

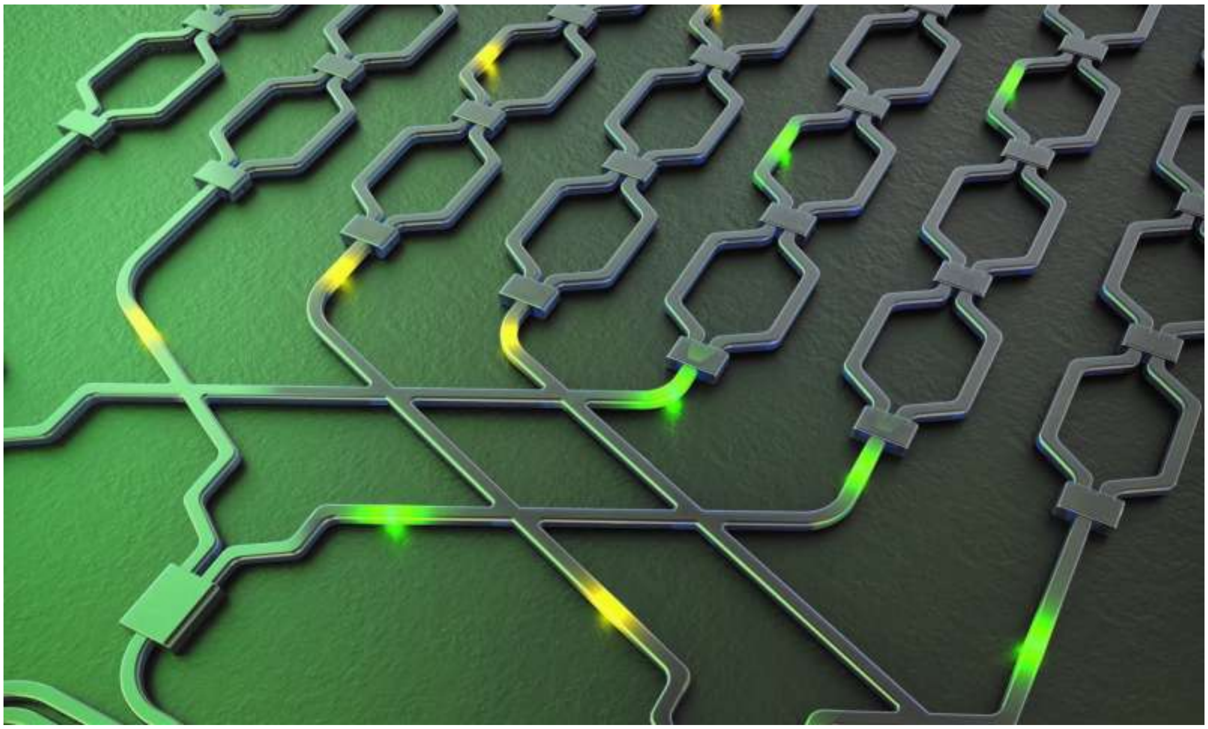
If an ordinary computer takes a reasonable amount of time to mimic one run of a quantum experiment -by producing samples with approximately the same probabilities as the real thing- the sampling complexity is low; if it takes a long time, the sampling complexity is high. Few expect that quantum computers wielding lots of qubits will have low sampling complexity -after all, quantum computers are expected to be more powerful than ordinary computers, so simulating them on your laptop should be hard. But while the power of quantum computers remains unproven, exploring the crossover from low complexity to high complexity could offer fresh insights about the capabilities of early quantum devices, says Alexey Gorshkov, a JQI and QuICS Fellow who is a co-author of the new paper.

"Sampling complexity has remained an underappreciated tool," Gorshkov says, largely because small quantum devices have only recently become reliable. *"These devices are now essentially doing quantum sampling, and simulating this is at the heart of our*

entire field."

To demonstrate the utility of this approach, Gorshkov and several collaborators proved that sampling complexity tracks the easy-to-hard transition of a task that small- and medium-sized quantum computers are expected to perform faster than ordinary computers: boson sampling. Bosons are one of the two families of fundamental particles (the other being fermions). In general, two bosons can interact with one another, but that's not the case for the boson sampling problem. "*Even though they are non-interacting in this problem, bosons are sort of just interesting enough to make boson sampling worth studying,"* says Abhinav Deshpande, a graduate student at JQI and QuICS and the lead author of the paper. In the boson sampling problem, a fixed number of identical particles is allowed to hop around on a grid, spreading out into quantum superpositions over many grid sites. Solving the problem means sampling from this smeared-out quantum probability cloud, something a quantum computer would have no trouble doing. Deshpande, Gorshkov and their colleagues proved that there is a sharp transition between how easy and hard it is to simulate boson sampling on an ordinary computer. If you start with a few well-separated bosons and only let them hop around briefly, the sampling complexity remains low and the problem is easy to simulate. But if you wait longer, an ordinary computer has no chance of capturing the quantum behavior, and the problem becomes hard to simulate.

The result is intuitive, Deshpande says, since at short times the bosons are still relatively close to their starting positions and not much of their "*quantumness*" has emerged. For longer times, though, there's an explosion of possibilities for where any given boson can end up. And because it's impossible to tell two identical bosons apart from one another, the longer you let them hop around, the more likely they are to quietly swap places and further complicate the quantum probabilities. In this way, the dramatic shift in the sampling complexity is related to a change in the physics: Things don't get too hard until bosons hop far enough to switch places. Gorshkov says that looking for changes like this in sampling complexity may help uncover physical transitions in other quantum tasks or experiments. Conversely, a lack of ramping up in complexity may rule out a quantum advantage for devices that are too error-prone. Either way, Gorshkov says, future results arising from this perspective shift should be interesting. "*A deeper look into the use of sampling complexity theory* *from computer science to study quantum many-body physics is bound to teach us something new and exciting about both fields,"* he says.



Tracks called waveguides guide photons in silicon, much like an optical fiber.

An international team of researchers led by the University of Bristol have demonstrated that light can be used to implement a multi-functional quantum processor. This small device can be used as a scientific tool to perform a wide array of quantum information experiments, while at the same time showing the way to how fully functional quantum computers might be engineered from large scale fabrication processes. They did this by engineering a silicon chip that guides single particles of light, called photons in optical tracks called waveguides to encode so-called quantum-bits of information called "qubits".

International effort is growing to develop quantum computers as the next step in computing power, to increase the types of tasks that computers can solve for us.

In today's desktop computers, super-computers and smartphones, bits take the form of either being a "1" or a "0" and they are the fundamental building block on which all computers currently used in society are based. Quantum computers are instead based on "*qubits*" that can be in a superposition of the 0 and 1 states. Multiple qubits can also be linked in a special way called quantum entanglement. These two quantum physical properties provide the power to quantum computers. One challenge is to make quantum computer processors that can be re-programmed to perform different tasks, just as we have computers today that can be re-programmed to run different applications.

A second challenge is how to make a quantum computer in a way that its many parts can be made with very high quality and ultimately at low cost.
The Bristol team has been using silicon photonic chips to try to build quantum computing components on a large scale and today's result, published in the journal *Nature Photonics*, demonstrates it is possible to fully control two qubits of information within a single integrated chip. This means any task that can be achieved with two qubits, can be programmed and realized with the device.

Lead author, Dr. Xiaogang Qiang, who undertook the work whilst studying for a Ph.D. at the University of Bristol, and now works in the National University of Defence Technology in China, said: *"What we've demonstrated is a programmable machine that can do lots of different tasks. It's a very primitive processor, because it only works on two qubits, which means there is still a long way before we can do useful computations with this technology. But what is exciting is that it the different properties of silicon photonics that can be used for making a quantum computer have been combined together in one device. This is just too complicated to physically implement with light using previous approaches."* The integrated photonics effort started in 2008 and was an answer to the growing concern that individual mirrors and optical elements are just too big and unstable to realize the large complex circuits that a quantum computer will be built. Dr. Jonathan Matthews, a member of the research team based at the Quantum Engineering Technology (QET) Labs at the University of Bristol, added: *"We need to be looking at how to make quantum computers out of technology that is scalable, which includes technology that we know can be built incredibly precisely on a tremendous scale. We think silicon is a promising material to do this, partly because of all the investment that has already gone into developing silicon for the micro-electronics and photonics industries. And the types of devices developed in Bristol, such as the one presented today, are showing just how well quantum devices can be engineered. A consequence of the growing sophistication and* *functionality of these devices is that they are becoming a research tool in their own right—we've used this device to implement several different quantum information experiments using nearly 100,000 different re-programmed settings."*

Scientists have just packed 18 qubits -the most basic units of quantum computing- into just six weirdly connected photons. That's an unprecedented three qubits per photon, and a record for the number of qubits linked to one another via quantum entanglement.

So why is this exciting? All the work that goes on in a conventional computer, including whatever device you're using to read this essay, relies on calculations using bits, which switch back and forth between two states (usually called "1" and "0"). Quantum computers calculate using qubits, which similarly waver between two states but behave according to the weirder rules of quantum physics. Unlike conventional bits, qubits can have indeterminate states -neither 1 nor 0, but a possibility of both- and become oddly connected or entangled, so that the behavior of one bit directly impacts the other. This, in theory, allows for all sorts of calculations that regular computers can barely pull off. (Right now, however, quantum computing is in its very early experimental stages, with researchers still testing the waters of what's possible, as in this study.)

The achievement, according to Sydney Schreppler, a quantum physicist at the University of California Berkeley who was not involved in the research, was likely only possible because the team at the University of Science and Technology of China (USTC) managed to pack so many qubits into so few particles. *"If the goal is to make 18, the way groups ... would have done that in the past is to make 18 entangled particles with one [qubit] each,"* she said. *"It's going to be a slow process."*

It takes "many seconds" to entangle just the six particles used in the experiment, she said -already an eternity in computer time, where a new entanglement process must begin for each calculation. And each additional particle added to the entanglement takes longer to join the party than the last, to the point that it would be completely unreasonable to build an 18-qubit entanglement, one qubit at a time. (There are plenty of quantum experiments involving more than 18 qubits, but in those experiments, the qubits aren't all entangled. Instead, the systems entangle just a few neighboring qubits for each calculation.)

To pack each of the six entangled particles (photons, in this case) with three qubits, the researchers took advantage of the photons' "*multiple degrees of freedom*," they reported in a paper that was published June 28 in the journal Physical Review Letters and is also available on the server arXiv.

When a qubit is encoded into a particle, it's encoded into one of the states the particle can flip back and forth between -like its polarization, or its quantum spin. Each of those is a "*degree of freedom*." A typical quantum experiment involves just one degree of freedom across all the particles involved. But particles like photons have many degrees of freedom. And by coding using more than one of those at the same time - something researchers have dabbled in before, but not to this extreme, Schreppler said- a quantum system can pack a lot more information into fewer particles.

"It's as though you took six bits in your computer, but each bit tripled in how much information it could hold," Schreppler said, *"and they can do that pretty quickly and pretty efficiently."*

The fact that the USTC researchers pulled off this experiment, she said, doesn't mean quantum computing experiments elsewhere will start to involve many more degrees of freedom at a time. Photons are particularly useful for certain kinds of quantum operations, she said -most importantly, quantum networking, in which information is transmitted among multiple quantum computers. But other forms of qubits, like those in the superconducting circuits Schreppler works on, might not take to this kind of operation as easily.

One open question from the paper, she said, is whether all the entangled qubits interact equally, or whether there are differences between qubit interactions on the same particle or qubit interactions across different degrees of freedom. Down the road, the researchers wrote in the paper, this sort of experimental setup might allow for certain quantum calculations that, until now, had been discussed only theoretically and had never been put into action.

While quantum mechanics primarily applies to the smaller atomic regimes of matter and energy, some systems exhibit quantum mechanical effects on a large scale. Superfluidity, the frictionless flow of a liquid at temperatures near absolute zero, is one well-known example. So is the closely related phenomenon of superconductivity, the frictionless flow of an electron gas in a conducting material (an electric current) at sufficiently low temperatures. Quantum theory also provides accurate descriptions for many previously unexplained phenomena, such as black-body radiation of electrons in atoms. It has also given insight into the workings of many different biological systems, including smell receptors and protein structures.

The "*chicken or egg*" paradox was first proposed by philosophers in Ancient Greece to describe the problem of determining cause-and-effect. Now, a team of physicists from The University of Queensland and the NÉEL Institute has shown that, as far as quantum physics is concerned, the chicken and the egg can both come first.

Dr. Jacqui Romero from the ARC Centre of Excellence for Engineered Quantum Systems said that in quantum physics, cause-and-effect is not always as straightforward as one event causing another. *"The weirdness of quantum mechanics means that events can happen without a set order,"* she said. "*Take the example of your daily trip to work, where you travel partly by bus and partly by train. Normally, you would take the bus then the train, or the other way around. In our experiment, both of these events can happen first,"* Dr. Romero said. "*This is called `indefinite causal order' and it isn't something that we can observe in our everyday life."*

To observe this effect in the lab, the researchers used a setup called a photonic quantum switch. UQ's Dr. Fabio Costa said that with this device the order of events -transformations on the shape of light- depends on polarization. *"By measuring the polarization of the photons at the output of the quantum switch, we were able to show the order of transformations on the shape of light was not set. This is just a first proof of principle, but on a larger scale indefinite causal order can have real practical applications, like making computers more efficient or improving communication."*

Every generation tends to believe that its views on the nature of reality are either true or quite close to the truth. We are no exception to this: although we know that the ideas of earlier generations were each time supplanted by those of a later one, we still believe that this time we got it right. Our ancestors were naïve and superstitious, but we are objective -or so we tell ourselves. We know that matter/energy, outside and independent of mind, is the fundamental stuff of nature, everything else being derived from it -or do we? In fact, studies have shown that there is an intimate relationship between the world we perceive, and the conceptual categories encoded in the language we speak. We don't perceive a purely objective world out there, but one subliminally pre-partitioned and pre-interpreted according to culture-bound categories.

For instance, "*color words in a given language shape human perception of color*." A brain imaging study suggests that language processing areas are directly involved even in the simplest discriminations of basic colors. Moreover, this kind of "*categorical perception is a phenomenon that has been reported not only for color, but for other perceptual continua, such as phonemes, musical tones and facial expressions*." In an important sense, we see what our unexamined cultural categories teach us to see, which may help explain why every generation is so confident in their own worldview.

The conceptual-ladenness of perception isn't a new insight. Back in 1957, philosopher Owen Barfield wrote: *"I do not perceive anything with my sense-organs alone.... Thus, I may say, loosely, that I 'hear a thrush singing.' But in strict truth all that I ever merely 'hear'—all that I ever hear simply by virtue of having ears—is sound. When I 'hear a thrush singing,' I am hearing ... with all sorts of other things like mental habits, memory, imagination, feeling and ... will." (Saving the Appearances)* As argued by philosopher Thomas Kuhn in his book *The Structure of Scientific Revolutions,* science itself falls prey to this inherent subjectivity of perception. Defining a "paradigm" as an *"implicit body of intertwined theoretical and methodological belief,"* he wrote: *"something like a paradigm is prerequisite to perception itself. What a man sees depends both upon what he looks at and also upon what his previous visual-conceptual experience has taught him to see. In the absence of such training there can only be, in William James's phrase, 'a bloomin' buzzin' confusion.'"*

Hence, because we perceive and experiment on things and events partly defined by an implicit paradigm, these things and events tend to confirm, by construction, the paradigm. No wonder then that we are so confident today that nature consists of arrangements of matter/energy outside and independent of mind. Yet, as Kuhn pointed out, when enough "*anomalies*"-empirically undeniable observations that cannot be accommodated by the reigning belief system-accumulate over time and reach critical mass, paradigms change. We may be close to one such a defining moment today, as an increasing body of evidence from quantum mechanics (QM) renders the current paradigm untenable. Indeed, according to the current paradigm, the properties of an object should exist and have definite values even when the object is not being observed: the moon should exist and have whatever weight, shape, size and color it has even when nobody is looking at it. Moreover, a mere act of observation should not change the values of these properties.

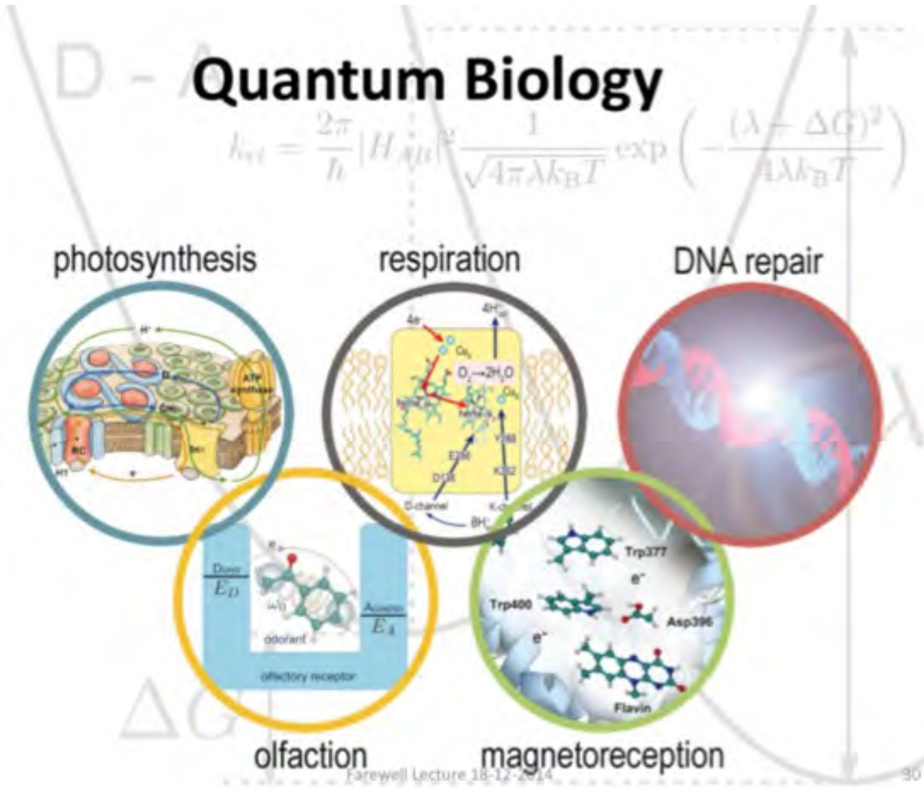
Operationally, all this is captured in the notion of "*non-contextuality*": the outcome of an observation should not depend on the way other, separate but simultaneous observations are performed. After all, what I perceive when I look at the night sky should not depend on the way other people look at the night sky along with me, for the properties of the night sky uncovered by my observation should not depend on theirs. The problem is that, according to QM, the outcome of an observation can depend on the way another, separate but simultaneous, observation is performed. This happens with so-called "*quantum entanglement*" and it contradicts the current paradigm in an important sense. Although Einstein argued in 1935 that the contradiction arose merely because QM is incomplete, John Bell proved mathematically, in 1964, that the predictions of QM regarding entanglement cannot be accounted for by Einstein's alleged incompleteness. So, to salvage the current paradigm there is an important sense in which one must reject the predictions of QM regarding entanglement. Yet, since Alain Aspect's seminal experiments in 1981–82, these predictions have been repeatedly confirmed, with potential experimental loopholes closed one by one. 1998 was a particularly fruitful year, with two remarkable experiments performed in Switzerland and Austria. In 2011 and 2015, new experiments again challenged non-contextuality. Commenting on this, physicist Anton Zeilinger has been quoted as saying that "*there is no sense in assuming that what we do not measure [that is, observe] about a system has [an independent] reality*." Finally, Dutch researchers successfully performed a test closing all remaining potential loopholes, which was considered by *Nature* the "*toughest test yet*."

The only alternative left for those holding on to the current paradigm is to postulate some form of non-locality: nature must have -or so they speculate- observation-independent hidden properties, entirely missed by QM, which are "*smeared out*" across spacetime. It is this allegedly omnipresent, invisible but objective background that supposedly orchestrates entanglement from "*behind the scenes*." It turns out, however, that some predictions of QM are incompatible with non-contextuality even for a large and important class of non-local theories. Experimental results reported in 2007 and 2010 have confirmed these predictions. To reconcile these results with the current paradigm would require a profoundly counterintuitive redefinition of what we call "*objectivity*." And since contemporary culture has come to associate objectivity with reality itself, the science press felt compelled to report on this by pronouncing, "*Quantum physics says goodbye to reality.*"

The tension between the anomalies and the current paradigm can only be tolerated by ignoring the anomalies. This has been possible so far because the anomalies are only observed in laboratories. Yet we know that they are there, for their existence has been confirmed beyond reasonable doubt. Therefore, when we believe that we see objects and events outside and independent of mind, we are wrong in at least some essential sense. A new paradigm is needed to accommodate and make sense of the anomalies; one wherein mind itself is understood to be the essence -cognitively but also physically- of what we perceive when we look at the world around ourselves.

Recent work on photosynthesis has provided evidence that quantum correlations play an essential role in this fundamental process of plants and many other organisms. This field of Quantum Biology also includes respiration (mitochondria), DNA repair, olfaction, magnetoreception by birds (e.g. pigeons), and more are being published every week.

Consciousness



As we go about our daily lives, we tend to assume that our perceptions -sights, sounds, textures, tastes- are an accurate portrayal of the real world. When we stop and think about it -or when we find ourselves fooled by a perceptual illusion - we realize with a jolt that what we perceive is never the world directly, but rather our brain's best guess at what that world is like, a kind of internal simulation of an external reality. Still, we bank on the fact that our simulation is a reasonably decent one.

This brings us first to the XVIIIth century, and George Berkeley, known as Bishop Berkeley (Bishop of Cloyne) who was an Anglo-Irish philosopher whose primary achievement was the advancement of a theory he called "immaterialism" (later referred to as "*subjective idealism*" by others). This theory denies the existence of material substance and instead contends that familiar objects like tables and chairs are only ideas in the mind of perceivers, and as a result cannot exist without being perceived. Berkeley is also known for his critique of abstraction, an important premise in his argument for immaterialism.

George Berkeley - Courtesy of Philosophy Now

According to Berkeley there are only two kinds of things: spirits and ideas. Spirits are simple, active beings that produce and perceive ideas; ideas are passive beings that are produced and perceived. The use of the concepts of "*spirit*" and "*idea*" is central in Berkeley's philosophy. As used by him, these concepts are difficult to translate into modern terminology. His concept of "*spirit*" is close to the concept of "*conscious subject*" or of "*mind*", and the concept of "*idea*" is close to the concept of "*sensation*" or "*state of mind*" or "*conscious experience*".

Thus, Berkeley denied the existence of matter as a metaphysical substance, but did not deny the existence of physical objects such as apples or mountains. ("*I do not argue against the existence of any one thing that we can apprehend, either by sense or reflection. That the things I see with mine eyes and touch with my hands do exist, really exist, I make not the least question. The only thing whose existence we deny, is that* *which philosophers call matter or corporeal substance. And in doing of this, there is no damage done to the rest of mankind, who, I dare say, will never miss it.*", *Principles* #35)

This basic claim of Berkeley's thought, his "idealism", is sometimes and somewhat derisively called "immaterialism" or, occasionally, subjective idealism. In Principles #3, he wrote, using a combination of Latin and English, *"esse is percipi"* (to be is to be perceived).

For Berkeley, we have no direct '*idea*' of spirits, albeit we have good reason to believe in the existence of other spirits, for their existence explains the purposeful regularities we find in experience. ("*It is plain that we cannot know the existence of other spirits otherwise than by their operations, or the ideas by them excited in us*", Dialogues #145). This is the solution that Berkeley offers to the *problem of other minds*. Finally, the order and purposefulness of the whole of our experience of the world and especially of nature overwhelms us into believing in the existence of an extremely powerful and intelligent spirit that causes that order.

John Locke (Berkeley's predecessor) states that we define an object by its primary and secondary qualities. He takes heat as an example of a secondary quality. If you put one hand in a bucket of cold water, and the other hand in a bucket of warm water, then put both hands in a bucket of lukewarm water, one of your hands is going to tell you that the water is cold and the other that the water is hot. Locke says that since two different objects (both your hands) perceive the water to be hot *and* cold, then the heat is not a quality of the water. While Locke used this argument to distinguish primary from secondary qualities, Berkeley extends it to cover primary qualities in the same way.

German philosopher Arthur Schopenhauer once wrote of him: "*Berkeley was, therefore, the first to treat the subjective starting-point really seriously and to demonstrate irrefutably its absolute necessity. He is the father of idealism…"* Berkeley influenced many modern philosophers, especially David Hume. Berkeley's thought made possible the work of Hume and thus Kant.

Every day, it seems, some verifiably intelligent person tells us that we don't know what consciousness is. The nature of consciousness, they say, is an awesome mystery. It's the ultimate hard problem.

Courtesy of newatlas.com

The current Wikipedia entry is typical: Consciousness "*is the most mysterious aspect of our lives*"; philosophers "*have struggled to comprehend the nature of consciousness*."

True, the nature of consciousness remains deeply mysterious and profoundly important, with existential, medical and spiritual implication. We know what it is like to *be* conscious –to have awareness, a conscious '*mind*', but who, or what, are '*we*' who know such things? How is the subjective nature of phenomenal experience – our '*inner life'* - to be explained in scientific terms? What consciousness actually *is,* and how it comes about remain unknown. The general assumption in modern science and philosophy -the 'standard model'- is that consciousness emerges from complex computation among brain neurons, computation whose currency is seen as neuronal firings ('*spikes*') and synaptic transmissions, equated with binary 'bits' in digital computing. Consciousness is presumed to 'emerge' from complex neuronal computation, and to have arisen during biological evolution as an adaptation of living systems, extrinsic to the makeup of the universe. On the other hand, spiritual and contemplative traditions, and some scientists and philosophers consider consciousness to be intrinsic, '*woven into the fabric of the universe*'. In these views, conscious precursors and Platonic forms preceded biology, existing all along in the fine scale structure of reality.

For much of the 20th century, the science of consciousness was widely dismissed as an impenetrable mystery, a morass of a problem that could be safely pursued only by older professors as they thought deep thoughts in their endowed chairs. Beginning in the 1990s, the field slowly became more respectable. There is, after all, a gaping hole in science. The human mind has plumbed the universe, concluding that it is precisely 13.8 billion years old. With particle accelerators like the Large Hadron Collider at CERN, scientists have discovered the vanishingly tiny particles, like the Higgs boson that underpin reality.

But there is no scientific explanation for consciousness -without which none of these discoveries could have been made.

For Locke and the empiricists, the mind begins as a blank slate (a *tabula rasa*) and truth comes to us through our senses. Descartes and the rationalists insisted that some knowledge was innate, prefigured into the mind of every newborn child. But we know exactly what consciousness is -where by "c*onsciousness*" we mean what most people mean in this debate: experience of any kind whatever. It's the most familiar thing there is, whether it's experience of emotion, pain, understanding what someone is saying, seeing, hearing, touching, tasting or feeling. It is in fact the only thing in the universe whose ultimate intrinsic nature we can claim to know. It is utterly unmysterious. The nature of physical stuff, by contrast, is deeply mysterious, and physics grows stranger by the hour. (Richard Feynman's remark about quantum theory -*"I think I can safely say that nobody understands quantum mechanics"* - seems as true as ever.) Or rather, more carefully: The nature of physical stuff is mysterious except insofar as consciousness is itself a form of physical stuff. This point, which is at first extremely startling, was well put by Bertrand Russell in the 1950s in his essay "*Mind and Matter*": *"We know nothing about the intrinsic quality of physical events,"* he wrote, *"except when these are mental events that we directly experience."* In having conscious experience, we learn something about the intrinsic nature of physical stuff, for conscious experience is itself a form of physical stuff. Human conscious experience is wholly a matter of physical goings-on in the body and in particular the brain.

We know what conscious experience is because the having is the knowing: Having conscious experience is knowing what it is. You don't have to think about it. You just must have it. It's true that people can make all sorts of mistakes about what is going on when they have experience, but none of them threaten the fundamental sense in which we know exactly what experience is just in having it.

"*Yes, but what is it?*" Philosophers like to give examples: smelling garlic, experiencing pain, orgasm. Russell mentions "*feeling the coldness of a frog*" (a live frog), while Locke in 1689 considered the taste of pineapple. If someone continues to ask what it is, one good reply is "*you know what it is like from your own case*."

So, we all know what consciousness is. Once we're clear on this we can try to go further, for consciousness does of course raise a hard problem. The problem arises from the fact that we accept that consciousness is wholly a matter of physical goings-on but can't see how this can be so. We examine the brain in ever greater detail, using increasingly powerful techniques like fMRI, and we observe extraordinarily complex neuroelectrochemical goings-on, but we aren't even beginning to understand how these goings-on can be (or give rise to) conscious experiences.

The German philosopher Gottfried Wilhelm Leibniz made the point vividly in 1714. Perception or consciousness, he wrote, is *"inexplicable on mechanical principles, i.e. by shapes and movements. If we imagine a machine whose structure makes it think, sense, and be conscious, we can conceive of it being enlarged in such a way that we can go inside it like a mill".* Leibniz continued, *"Suppose we do: visiting its insides, we will never find anything but parts pushing each other -never anything that could explain a conscious state."* It's true that modern physics and neurophysiology have greatly complicated our picture of the brain, but Leibniz's basic point remains untouched. We don't know the intrinsic nature of physical stuff. Except insofar as we know it simply through having a conscious experience.

We find this idea extremely difficult because we're so very deeply committed to the belief that we know more about the physical than we do, and (in particular) know enough to know that consciousness can't be physical. We don't see that the hard problem is not what consciousness is, it's what matter is -what the physical is.

We may think that physics is sorting this out, and it's true that physics is magnificent. It tells us a great many facts about the mathematically describable structure of physical reality, facts that it expresses with numbers and equations (*e = mc2*, the inverse square law of gravitational attraction, the periodic table and so on) and that we can use to build amazing devices. But it doesn't tell us anything at all about the intrinsic nature of the stuff that fleshes out this structure. Physics is silent on this question. Stephen Hawking made it dramatically in his book "*A Brief History of Time*." Physics is "*just a set of rules and equations*." The question is what "*breathes fire into the equations and makes a universe for them to describe?"* What is the fundamental stuff of physical reality, the stuff that is structured in the way physics reveals? The answer, again, is that we don't know -except insofar as this stuff takes the form of conscious experience.

We can say that it is energy that breathes fire into the equations, using the word "*energy*" as Heisenberg does when he says that "*all particles are made of the same substance: energy*," but the fundamental question arises again: "*What is the intrinsic nature of this energy, this energy-stuff?*" And the answer, again, is that we don't know, and that physics can't tell us. This point about the limits on what physics can tell us is rock solid, and it arises before we begin to consider any of the deep problems of understanding that arise within physics -problems with "*dark matter*" or "*dark energy*," for example- or with reconciling quantum mechanics and general relativity theory. In particular, we don't know anything about the physical that gives us good reason to think that consciousness can't be wholly physical. It's worth adding that one can fully accept this even if one is unwilling to agree with Russell that in having conscious experience, we thereby know something about the intrinsic nature of physical reality. So, the hard problem is the problem of matter (physical stuff in general). If physics made any claim that couldn't be squared with the fact that our conscious experience is brain activity, then I believe that claim would be false. But physics doesn't do any such thing. It's not the physics picture of matter that's the problem; it's the ordinary everyday picture of matter. It's ironic that the people who are most likely to doubt or deny the existence of consciousness (on the ground that everything is physical, and that consciousness can't possibly be physical) are also those who are most insistent on the primacy of science, because it is precisely science that makes the key point shine most brightly: the point that there is a fundamental respect in which ultimate intrinsic nature of the stuff of the universe is unknown to us -except insofar as it is consciousness.

Stuart R. Hameroff (University of Arizona, Tucson) has a theory of consciousness developed over the past 20 years with British physicist Sir Roger Penrose. Called '*orchestrated objective reduction*' ('*Orch OR*'), it suggests consciousness arises from quantum vibrations in protein polymers called microtubules inside the brain's neurons, vibrations which interfere, 'collapse' and resonate across scale, control neuronal firings, generate consciousness, and connect ultimately to '*deeper order*' ripples in space-time geometry: *"Consciousness is more like music than computation".* Hence, the true reality might be forever beyond our reach, but surely our senses give us at least an inkling of what it's really like.

Donald D. Hoffman, a professor of cognitive science at the University of California, Irvine, says '*Not so*'. He has spent the past three decades studying perception, artificial intelligence, evolutionary game theory and the brain, and his conclusion is a dramatic one: The world presented to us by our perceptions is nothing like reality. What's more, we have evolution itself to thank for this magnificent illusion, as it maximizes evolutionary fitness by driving truth to extinction. Getting at questions about the nature of reality, and disentangling the observer from the observed, is an endeavor that straddles the boundaries of neuroscience and fundamental physics. On one side, you'll find researchers trying to understand how a three-pound lump of gray matter obeying nothing more than the ordinary laws of physics can give rise to first person conscious experience. This is the aptly named "hard problem." On the other side are quantum physicists, marveling at the strange fact that quantum systems don't seem to be definite objects localized in space until we come along to observe them -whether we are conscious humans or inanimate measuring devices. Experiment after experiment has shown -defying common sense- that if we assume that the particles that make up ordinary objects have an objective, observer independent existence, we get the wrong answers. The central lesson of quantum physics is clear: There are no public objects sitting out there in some preexisting space. As the physicist John Wheeler put it, "*Useful as it is under ordinary circumstances to say that the world exists 'out there' independent of us, that view can no longer be upheld*."

So, while neuroscientists struggle to understand how there can be such a thing as a first-person reality, quantum physicists must grapple with the mystery of how there can be anything but a first-person reality. In short, all roads lead back to the observer.

Donald H. Hoffman - Courtesy of YouTube.com

People often use Darwinian evolution as an argument that our perceptions accurately reflect reality. They say, *"Obviously, we must be latching onto reality in some way because otherwise we would have been wiped out a long time ago. If I think I'm seeing a palm tree, but it's really a tiger, I'm in trouble."* Evolution has shaped us with perceptions that allow us to survive. But part of that involves hiding from us the stuff we don't need to know. That's pretty much all of reality, whatever reality might be.

The classic argument is that those of our ancestors who saw more accurately had a competitive advantage over those who saw less accurately and thus were more likely to pass on their genes that coded for those more accurate perceptions, so after thousands of generations we can be quite confident that we're the offspring of those who saw accurately, and so we see accurately. That sounds very plausible. But it may well be utterly false. It misunderstands the fundamental fact about evolution, which is that it's about fitness functions -mathematical functions that describe how well a given strategy achieves the goals of survival and reproduction. The mathematical physicist Chetan Prakash proved a theorem that says: "*According to evolution by natural selection, an organism that sees reality as it is will never be more fit than an organism of equal complexity that sees none of reality but is just tuned to fitness.*"

Suppose that in reality there's a resource, like water, and you can quantify how much of it there is in an objective order -very little water, medium amount of water, a lot of water. Now suppose your fitness function is linear, so a little water gives you a little fitness, medium water gives you medium fitness, and lots of water gives you lots of fitness- in that case, the organism that sees the truth about the water in the world can win, but only because the fitness function happens to align with the true structure in reality. Generically, in the real world, that will never be the case. Something much more natural is a bell curve: too little water you die of thirst, but too much water you drown, and only somewhere in between is good for survival. The fitness function doesn't match the structure in the real world; that's enough to send truth to extinction.

Evolution has shaped us with perceptions that allow us to survive. They guide adaptive behaviors. But part of that involves hiding from us the stuff we don't need to know; that's pretty much all of reality, whatever reality might be. We've been shaped to have perceptions that keep us alive, so we must take them seriously. If I see something that I think of as a snake, I don't pick it up. I've evolved these symbols to keep me alive, so I must take them seriously. But it's a logical flaw to think that if we must take it seriously, we also must take it literally.

Snakes, like the particles of physics, have no objective, observer-independent features. The snake I see is a description created by my sensory system to inform me of the fitness consequences of my actions. Evolution shapes acceptable solutions, not optimal ones.

There are conscious experiences. We have pains, tastes, smells, all the sensory experiences, moods and emotions. One part of this consciousness structure is a set of all possible experiences. Donald Hoffman says: "*When I'm having an experience, based on that experience I may want to change what I'm doing. So, I need to have a collection of possible actions I can take and a decision strategy that, given my experiences, allows me to change how I'm acting. That's the basic idea of the whole thing. I have a space X of experiences, a space G of actions, and an algorithm D that lets* *me choose a new action given my experiences. Then I posited a W for a world, which is also a probability space. Somehow the world affects my perceptions, so there's a perception map P from the world to my experiences, and when I act, I change the world, so there's a map A from the space of actions to the world. That's the entire structure. Six elements. The claim is: This is the structure of consciousness. I put that out there so people have something to shoot at. If there's a W, an external world, I can pull the W out of the model and stick a conscious agent in its place and get a circuit of conscious agents. In fact, you can have whole networks of arbitrary complexity. And that's the world."* He calls it conscious realism: objective reality is just conscious agents, just points of view. Interestingly, we can take two conscious agents and have them interact, and the mathematical structure of that interaction also satisfies the definition of a conscious agent. The idea that what we're doing is measuring publicly accessible objects, the idea that objectivity results from the fact that we can measure the same object in the exact same situation and get the same results- it's very clear from quantum mechanics that that idea must go. Physics tells us that there are no public physical objects.

It doesn't seem like many people in neuroscience or philosophy of mind are thinking about fundamental physics. Not only are they ignoring the progress in fundamental physics, they are often explicit about it. They'll say openly that quantum physics is not relevant to the aspects of brain function that are causally involved in consciousness. They are certain that it's got to be classical properties of neural activity, which exist independent of any observers- spiking rates, connection strengths at synapses, perhaps dynamical properties as well. These are all very classical notions under Newtonian physics, where time is absolute, and objects exist absolutely. And then neuroscientists don't avail themselves of the incredible insights and breakthroughs that physics has made. They might be reacting to things like Roger Penrose and Stuart Hameroff's model, where you still have a physical brain, it's still sitting in space, but supposedly it's performing some quantum feat.

The neuroscientists are saying: *"We don't need to invoke those kind of quantum processes; we don't need quantum wave functions collapsing inside neurons; we can just use classical physics to describe processes in the brain."* But neurons, brains, space … these are just symbols we use; they're not real. It's not that there's a classical brain that does some quantum magic. It's that there's no brain! Quantum mechanics says that classical objects -including brains- don't exist. So, this is a far more radical claim about the nature of reality and does not involve the brain pulling off some tricky quantum computation.

In *Quartz* Magazine of June 5th, 2016, Olivia Goldhill reported on that week's Recode Code's Conference where Elon Musk –of Tesla, Solar City, SpaceX, and Hyperloop- put forward a provocative argument: *"The odds are overwhelming that we're characters in an advanced civilization's computer simulation. Our own video games have advanced at a rapid pace, from Pong in the 1970s to immersive virtual reality today. So, given that we're clearly on a trajectory to have games that are indistinguishable from reality, and those games could be played on any set-top box or on a PC or whatever, and there would probably be billions of such computers or set-top boxes, it would seem to follow that the odds that we're in base reality is one in billions".* It seems absurd at first reading, but Musk's theory comes from a well-regarded philosopher. Nick Bostrom, a professor at Oxford University, published his computer simulation argument in 2003. He argues that one of the following three propositions is true:

- Virtually all civilizations at our pace of development will go extinct before they reach the technological capability of creating ultra-realistic video games.
- Civilizations with such technological capabilities are uninterested in running such computer simulations.
- We are almost certainly characters living in a computer simulation.

His view is that we don't have strong enough evidence to rule out any of these three possibilities. Bostrom believes it's entirely possible that conscious characters could be created inside a computer simulation. Even if it takes hundreds of thousands of years before such a feat is achieved, his argument still holds. Bostrom doesn't see an obvious implication for the question of free will. In other words, the same questions about agency hold whether we were created by God, the Big Bang, or an extremely sophisticated teenager on a futuristic Xbox. For Robert Rupert, philosophy of mind professor at the University of Colorado, it might be that, in some sense, all the world that we think of as 'the real world' is itself information. And that's what computers are running as well. It might turn out that metaphysically speaking, deep down, a simulation and reality are the same sorts of things.

Bostrom says: *"You might initially think that, well in the far future, you could make up any story and we can't know anything about it. But it turns out it's not that easy to think of even one coherent picture that fits all the things we know about the world together. From that point of view, it's important intellectually for those who do want to try to think through these big picture questions."*

In other words, don't laugh away Musk's comments. There's currently no way of proving that you aren't a simulated character in an advanced civilization's computer. But most of us were born realists. We're born physicalists. This is a really, really hard one to let go of. The experiences of everyday life -our real feeling of a headache, the real taste of chocolate- that really is the ultimate nature of reality.

The Western concepts of Berkeley *et al.*, the recent integration of quantum physics/equations of Donald Hoffman, Stuart Hameroff and others, and many other sub-threshold currents may seem –for many- a vain attempt in sodomizing flies (as the French say). Time will tell. The mind, the complexity of the brain, the reciprocal influences of the individual on the familial, social, geographical, evolutionary environment(s) are and will remain an active field of research. Do not expect a solution anytime soon –if ever.

Tiantai Buddhism

In Asia –i.e. mostly China- philosophical ideas have emerged that attempted to deal with these human preoccupations. Laozi, with the *Daodejing*, is the best known. But other philosophical currents flowed at the same time (~6th century CE), just as Socrates in Athens was ambulating with Plato and the *Academics*. One of these schools of thinking was Tiantai Buddhism. Tiantai is the name of a mountain and surrounding geographical location in China, literally meaning "*platform of the sky*", but the term is traditionally used to denote a particular school of Mahāyāna Buddhism with historical connections to that locale. The term "*Tiantai*" is also used to refer to the philosophical ideas developed from the sixth to eleventh centuries by this school, as expounded in the writings of its three most representative figures: Tiantai Zhiyi (538–597), Jingxi Zhanran (711–782) and Siming Zhili (960–1028).

Courtesy Chinese Buddhist Encyclopedia

To translate Tiantai's rather technical scholastic terminology and its typically Buddhist soteriological orientation into something approaching traditional philosophical categories, most academics start by identifying a few hashtag themes that are characteristic of Tiantai thinking.

Tiantai is *a radical contextualism*, *a radical holism, a radical monism*, and *a theory of radical immanence.* It asserts a radical impermanence, radical anti-substantialism, and radical ambiguity of identity for all finite and conditional entities. Epistemologically this entails radical skepticism about all unconditional claims, and radical anti-realism. Ethically it implies a radical renunciation of all finite aims, as well as radical repudiation of all determinate moral rules, moral consequences, and moral virtues.

But our understanding of each of these points must be thoroughly modified by the most characteristic premise of Tiantai thought of all, which determines the meaning we intend for the term "*radical*" here: the idea of "*self-recontextualization*", whereby the full expression of any quiddity intrinsically entails its self-overcoming. It has roots in 1) indigenous Chinese interest in the "reversals" observed in the cycles of nature, conceptualized according to the naïve ancient generalization that when *anything is pushed its own extreme it will "reverse"*, that an *increase in a thing's extension or intensity leads to its self-undermining* (e.g. it keeps getting colder until it gets coldest, and then it starts getting warmer), and in 2) the sophisticated ruminations on the *nature of conditionality* developed in *the Emptiness and Two Truths doctrines* as expressed in Indian Buddhist logic. What this means is that "*radical contextualism*" will in Tiantai *reverse* into a radical assertion of the self-validation of every entity, that "radical holism" will in Tiantai self-reverse also into radical individualism, "*radical monism*" also into radical pluralism, "*radical immanentism*" also into radical transcendentalism, along with a claim that these two extremes are, when fully thought through, *actually synonyms for one another*.

When the dust from these turnarounds settles, Tiantai ends up with a unique view of the structure of reality: *every event, function or characteristic occurring in any experience anywhere is the action of all sentient and insentient beings working together.* Every instant of experience is the whole of reality manifesting in this particular form, *as* this particular entity or experience. Each such instant is however no mere accidental, dispensable form; rather, it is itself unconditional and ineradicable, is eternal and omnipresent.

Moreover, this "*whole of reality*" is irreducibly multiple and irreducibly unified at once, in the following way: all possible conflicting, contrasted and axiologically varied aspects are irrevocably present -in the sense of "*findable*"- in and as each of these individual determinate totality-effects. Good and evil, delusion and enlightenment, Buddhahood and deviltry, are all *"inherently entailed*" in each-and-every event. Each part is the whole, each quality subsumes all other qualities, and yet none are ever eradicable. A Buddha in the world makes the world all Buddha, saturated in every locus with the quality "*Buddhahood*"; a devil in the world makes the world all devil, permeated with "deviltry". Both Buddha and devil are always in the world. So, every event in the world is always both *entirely* Buddhahood and *entirely* deviltry. Every moment of experience is always completely delusion, evil and pain, through and through, and also completely enlightenment, goodness and joy, through and through.

Traditional Buddhism gives a rather commonsensical account of sentient experience: every moment of sentient experience is a sensory apparatus encountering an object, giving rise thereby to a particular moment of contentful awareness. But in the Tiantai view, each of these three -sense organ, object, this moment of consciousness- is itself the Absolute, the entirety of reality, expressed without remainder in the peculiar temporary form of sense organ, of object, of this consciousness. Hence each moment of every being's experience is redescribed, to paraphrase a canonical early Tiantai work, as follows:

The absolute totality encounters the absolute totality, and the result is the arising of the absolute totality. (法界對法界起法界)

The Absolute, the whole of reality, is one and eternal, always the same and omnipresent, but it is also the kind of whole that divides from itself, encounters itself, arises anew each moment, engenders itself ***as*** the transient flux of each unique and individual moment of experience of every sentient being.

The term "nirvana" in the soteriological sense of *"blown out, extinguished"* state of liberation does not appear in the Vedas nor in the Upanishads. The Buddhists seem to have been the first to call it nirvana. However, the ideas of spiritual liberation using different terminology, with the concept of soul and Brahman, appears in Vedic texts and Upanishads, such as in verse 4.4.6 of the Brihadaranyaka Upanishad. Nirvāṇa is a term found in the texts of all major Indian religions–Buddhism, Hinduism, Jainism and Sikhism. It refers to the profound peace of mind that is acquired with moksha, liberation from samsara, or release from a state of suffering, after respective spiritual practice or sādhanā.

Khmer traditional mural painting depicts Gautama Buddha entering nirvana - Dharma assembly pavilion, Wat Botum Wattey Reacheveraram, Phnom Penh, Cambodia.

Nirvana (*nibbana*) literally means "*blowing out*" or "*quenching*". It is the most used as well as the earliest term to describe the soteriological goal in Buddhism: release from the cycle of rebirth (*saṃsāra*). Nirvana is part of the Third Truth on "*cessation of dukkha*" in the Four Noble Truths doctrine of Buddhism. It is the goal of the Noble Eightfold Path. The Buddha is believed in the Buddhist scholastic tradition to have realized two types of nirvana, one at enlightenment, and another at his death. The first is called *sopadhishesa-nirvana* (nirvana with a remainder), the second *parinirvana* or *anupadhishesa-nirvana* (nirvana without remainder, or final nirvana). In the Buddhist tradition, nirvana is described as the extinguishing of the *fires* that cause rebirths and associated suffering. The Buddhist texts identify these three "*three fires*" or "*three poisons*" as *raga* (greed, sensuality), *dvesha* (aversion, hate) and *avidyā* or *moha* (ignorance, delusion).

The concept of nirvana occupies a unique place in Buddhist thought –not just because it represents the culmination of the Buddhist path, and not just because it represents the nicest imaginable place to be, but also because of the way it straddles the two sides of Buddhism. There is, on the one hand, the naturalistic side of Buddhism, featuring ideas that would fit easily into a college psychology or philosophy course: ideas about the nature of the mind, about the causes of human suffering, and about how we should live our lives considering these realities. These are the ideas that form the core of the '*secular Buddhism'* that is practiced by many in the West. Indeed, so naturalistic, so '*secular*', is this set of ideas that some people see Buddhist meditation as more of a therapeutic than a spiritual undertaking, as basically palliative and not too profound. That's a particularly common view of the kind of Buddhist meditation known as mindfulness meditation –which is sometimes packaged in the frankly therapeutic form of '*mindfulness-based stress reduction*'. And then there is the more exotic side of Buddhism, which features supernatural, or at least mind-bendingly metaphysical, ideas. These ideas include various cosmic realms and deities, but the most famous such idea is reincarnation –or, as Buddhists more commonly call it, rebirth.

Nirvana certainly has its exotic aspects. Attaining it, according to traditional Buddhist belief, means being liberated from an otherwise endless cycle of rebirth. But this story about nirvana –the story about how exactly you find the escape hatch from recurring life cycles– leads seamlessly to a more naturalistic story about nirvana, a claim about the mechanics of suffering and of contentment. And in the process of following one story to the other, you can see mindfulness meditation in a new light, a light that emphasizes how much more than casually therapeutic it can be; a light that shows it to be one of the most radical undertakings imaginable, a rebellion against the very laws that govern human existence. In ancient texts, nirvana is often described with a word that is commonly translated as '*the unconditioned*'. For years, I heard this strange-sounding term and wondered what it meant, but I figured that understanding it without actually reaching nirvana was probably hopeless and, for my purposes, not all that important. It turns out that I was wrong on both counts. The question '*What is the unconditioned?*' has a pretty clear answer and a very important one, an answer that forms a kind of intersection between the exotically metaphysical and the naturalistic. One obvious approach to deciphering *'the unconditioned'* is to drop the *un* and ask what *conditioned* means. *'The conditioned'*, in Buddhist terminology, can be thought of as roughly synonymous with '*the caused*'. Which makes sense. After all, when we talk about the conditions that give rise to something –the conditions that lead water to boil or rain to fall or the crime rate to rise– we're basically saying that these conditions are involved in the causal chain that led to that something. Things that are '*conditioned*' in the Buddhist sense are subject to causes. So, if nirvana is '*the unconditioned'*, then you might think that it would involve some kind of escape from '*the caused'*. And you would be right! But what does *that* mean? The answer to that question involves one of the most important terms in Buddhism: *paticca-samuppada*. It is a term that has numerous applications and numerous translations. For present purposes –when we're using it to illuminate the logic of nirvana– a good translation is '*conditioned arising'*. In its most generic sense, conditioned arising refers to the basic idea of causality: out of certain conditions some things arise; out of other conditions other things arise. But the term is also used to refer to a specific sequence of causal links –a series of 12 conditions, one giving rise to the next – that are said to enslave human beings in the cycle of endless rebirth. It is this chain of causal links that nirvana is said to break.

I won't run through the exact sequence of 12 conditions, partly because some of them are a little murky. But the part of the sequence that concerns us, the part that puts a finer point on nirvana in both the exotic and the naturalistic senses of the term, is reasonably clear. That part starts after a person's sensory faculties –eyes, ears, tongue, etc.– have taken shape. It is through these faculties that the person's consciousness contacts the material world. Or, as it is put more formally in ancient texts that spell out the 12-causal links: through the condition of the sensory faculties, contact arises. And here is the next link: through the condition of contact, feelings arise– which makes sense, because, in the Buddhist view (and in the view of many modern psychologists), the things we perceive through our sense organs tend to come with feelings attached, however subtle the feelings. Then, in the next causal link, feelings give rise to *tanha*, to '*craving*': we crave the pleasant feelings and crave to escape the unpleasant feelings. It is here in this space between feeling and craving that the battle will be fought which will determine whether bondage will continue indefinitely into the future or whether it will be replaced by enlightenment and liberation. For if instead of yielding to craving, to the driving thirst for pleasure, if a person contemplates with mindfulness and awareness the nature of feelings and understands these feelings as they are, then that person can prevent craving from crystallizing and solidifying.

This is where we start to segue from the exotic to the naturalistic. The liberation that Bhikkhu Bodhi is talking about is, in the first instance, a liberation from perpetual rebirth, a liberation that will fully kick in at the end of this life cycle. But it is also liberation in the here and now, liberation from the suffering that *tanha* brings– liberation from the craving to capture pleasant feelings and to escape unpleasant feelings, liberation from the persistent desire for things to be different than they are. (The Buddha famously said that human life as ordinarily lived involves persistent suffering, but '*suffering*' is a translation of the ancient word *dukkha*, whose connotations also include '*unsatisfactoriness*' –a connotation that well captures the Buddhist view of suffering's nature and roots.) These two senses of liberation – liberation from rebirth, and liberation from suffering– are reflected in the Buddhist idea that there are two kinds of nirvana. As soon as you are liberated in the here and now, you enter a nirvana you can enjoy for the rest of your life. Then, after death – which will be your final death, now that you're liberated from the cycle of rebirth– a second kind of nirvana will apply.

I'm sorry to say I can't describe the first kind of nirvana from personal experience, and I'm ambivalent about not being able to describe the second kind. But the main point is that whichever kind of nirvana you're focused on, mindfulness meditation directly addresses the challenge of getting there. Mindfulness involves, among other things, cultivating an awareness of your feelings that fundamentally changes your relationship to them. It can, if practiced rigorously, let you experience feelings with a kind of dispassion or 'non-attachment' –neither struggling uncomfortably to escape the 'bad' feelings nor trying, desperately and futilely, to hang on to the 'good' feelings. So, regardless of how exotic or how practical your aspirations – whether you believe in a cycle of rebirth and want to escape it, or just want to attain complete liberation in the here and now, or for that matter just hope to find *partial* liberation in the here and now –a key tool in the quest for liberation, mindfulness, remains the same. And, accordingly, some of the basic terminology remains the same. Even if you're not trying to escape an eternal repetition of 12 successive conditions, even if you would just like your one and only life to be better, you are still seeking liberation from *conditions* –from chains of causation that otherwise shackle you. The things in your environment –the sights, the sounds, the smells, the people, the news, the videos– are pushing your buttons, activating feelings that, however subtly, set in motion trains of thought and reaction that govern your behavior, sometimes in ways that are unfortunate. And they will keep doing that unless you become more mindful –unless you start paying attention to what's going on, and thus respond to it reflectively, not reactively.

All this points to the sense in which the ancient Buddhist appraisal of the human condition is very modern in spirit. The human brain is a machine designed by natural selection to respond in reflexive fashion to the sensory input impinging on it. It is designed, in a certain sense, to be controlled by that input. And a key cog in the machinery of control are the feelings that arise in response to the input. A donut smells good, so we approach it; a restless hunger feels bad, so we try to escape it – by, say, eating a donut; social status feels good and ridicule feels bad, so we pursue and avoid, respectively. If you interact with such feelings via *tanha* –via the natural, reflexive thirst for the pleasant feelings and the natural, reflexive aversion to the unpleasant feelings– you will continue to be controlled by the world around you. But if you observe those feelings mindfully rather than just reacting to them, you can in some measure escape the control; the causes that ordinarily shape your behavior can be defied, and you can get closer to the unconditioned.

There are debates within Buddhism about how dramatically to conceive of nirvana and the unconditioned. Is there something like a transcendent metaphysical 'space' that you in some sense occupy once fully liberated? Or is it a bit more mundane, just freedom from the mindless reactivity to causes, to conditions, that would otherwise control you? People who embrace a naturalistic Buddhism, and don't believe in rebirth, tend to go with the less dramatic interpretation. Indeed, some of them don't like the term *the unconditioned* because it *sounds* so dramatic. Stephen Batchelor, a longtime proponent of 'secular Buddhism' and the author of the book *Buddhism Without Beliefs* (1997), has written: '*There is no such thing as the unconditioned, only the possibility of not being conditioned by something*.' Underlying this whole endeavor is a highly mechanistic conception of how the mind works. The idea is to finely sense the workings of the machine and use that understanding to rewire it, to subvert its programming, to radically alter its response to the causes, the conditions, impinging on it. Doing this doesn't let you enter 'the unconditioned' in the strict sense; it doesn't let you literally escape the realm of cause and effect. Then again, airplanes don't literally defy the law of gravity. But they still fly.

Tantric Buddhism, the Liberation

Detail from a Nepalese Kama Sutra manuscript.
Photo courtesy the Wellcome Collection

Not spitefully binding or beating someone,
Not cruelly stabbing someone with a spear;
Passion is offered to a passionate human.
It may not be a virtue, but how could it be a sin?

From *A Treatise on Passion* (1967) by Gendun Chopel

Buddhist monks follow a lot of rules –253 in one tradition, 200 in another. As the story goes, these rules were made by the Buddha himself. However, he did not announce them all at once, like Moses descending from Mount Sinai with the Ten Commandments. Instead, they're said to have evolved organically, with the Buddha making a rule only after he judged a deed to be a misdeed. The first of the rules to be established was not against murder; it was against ***sex.*** The inciting incident was when a man named Sudinna left his wife and parents to become a monk. Sometime later, he came home and made love to his wife –not for love or lust, but at the urging of his mother. She worried that if she and her husband died without an heir, the king would seize their property. Although there was no rule against monks having sex at the time, Sudinna felt guilty and told some other monks what had happened. Those monks tattled to the Buddha, who summoned Sudinna for perhaps the worst scolding in Buddhist literature:

> *Worthless man, it would be better that your penis be stuck into the mouth of a poisonous snake than into a woman's vagina. It would be better that your penis be stuck into the mouth of a black viper than into a woman's vagina. It would be better that your penis be stuck into a pit of burning embers, blazing and glowing, than into a woman's vagina. Why is that? For that reason, you would undergo death or death-like suffering, but you would not on that account, at the breakup of the body, after death, fall into deprivation, the bad destination, the abyss, hell.*

Over the long history of Buddhism, most of its vast literature has been composed by celibate monks. Sexual intercourse –defined as the penetration of an orifice even to the depth of a sesame seed– was the first transgression to entail permanent expulsion from the monastic order. Monks have written works of particular misogyny, such as the '*Blood Bowl Sutra'* where the blood is menstrual blood. They've also sought to control the sex lives of Buddhist lay people by imposing a wide range of restrictions, such as prohibiting sex during the day or the penetration of any orifice other than the vagina. These rules have remained in place, cited in modern discussions of Buddhist attitudes toward gay and lesbian sex. Buddhist texts across Asia have presented monks as models of chastity. However, their depiction in the plays and novels of various Buddhist lands can be quite different –like in medieval Europe, monks were often portrayed as lechers.

An important counter-narrative about sex came with the rise of what is called *tantra*, a movement that began in India about a millennium after the Buddha's death. While sex had long been seen as pollution, here it was transformed into a path to purity. Tantric texts made elaborate arguments about the sublime states of bliss available through orgasm and set forth secret techniques that resulted in deep states of bodily bliss. Some would claim that sex was not only permissible but necessary –that all buddhas of the past had attained enlightenment and buddhahood through tantric sex. Still, it wasn't until the 20th century that we find a sustained critique of monastic norms and advocacy of sexual pleasure in Buddhist literature outside the tantric milieu. In 1939, the Tibetan writer (and former monk) Gendun Chopel composed a work that he called simply *A Treatise on Passion*. Written entirely in verse, it is one of only two works of erotica in the vast literature of Tibetan Buddhism.

Gendun Chopel is the most famous, and infamous, Tibetan intellectual of the 20th century. Ordained as a monk at the age of 12, he went on to excel at the highest levels of the Buddhist academy before leaving Tibet in 1934. He spent the next 12 years in India, in the state of Sikkim, and Sri Lanka, studying the classics of Sanskrit literature; at some point, he gave up his monastic vows. He wrote and painted extensively during this period, producing learned essays and translations, a travel guide and a newspaper article explaining to Tibetans that the world is round.

One of the Sanskrit classics that he studied was the *Kama Sutra*. Knowing that erotica was a genre of Indian literature unknown in Tibet, Gendun Chopel decided to compose his own treatise on passion –one that drew on Sanskrit sex manuals as well as from his own experience, much of it apparently drawn from the days and nights he spent in the brothels of Calcutta and with several lovers, whom he names, and thanks. Having renounced the vow of celibacy just a few years before, his poetry shimmers with the wonder of someone discovering the joys of sex, all the more memorable because they were forbidden to him for so long. His verse is tinged with shades of irony, self-deprecating wit, and a love of women, not merely as sources of male pleasure, but as full partners in the play of passion.

In the *Treatise*, Gendun Chopel seeks to understand the true nature of tantric bliss and how it relates to the pleasures of lovemaking:

The hills and valleys of a place add to its beauty.
The thorns of thought are the root of illness.
To stop thought without meditation,

For the common person, comes only in the bliss of sex.

Gendun Chopel arrived in India during the height of the independence movement, as Hindu and Muslim patriots sought to throw off the chains of British bondage. He was deeply sympathetic to their cause, taking many of its principles back to Tibet with him. Yet Gendun Chopel was also an apostle of another kind of freedom: sexual freedom. He condemned the hypocrisy of church and state, portraying sexual pleasure as a force of nature and a universal human right. The *Kama Sutra* was intended for the social elite; the tantric literature was intended for the spiritually advanced. And whether intended for the cultured gentleman or the tantric yogi, the instructions were provided for men. By contrast, in his *Treatise*, Gendun Chopel tried to wrest the erotic from the ruling class and give it to the workers of the world:

May all humble people who live on this broad earth
Be delivered from the pit of merciless laws
And be able to indulge, with freedom,
In common enjoyments, so needed and right.

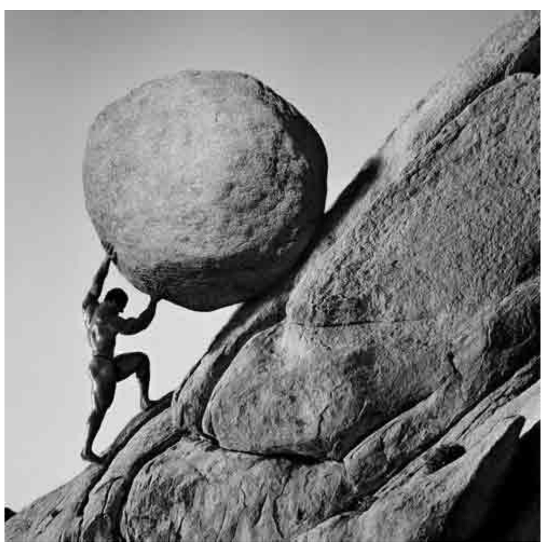
Sexual liberation has since been championed in other lands and in other languages, often with dire consequences for the revolutionaries. And so, it was for Gendun Chopel in Tibet, the site of another revolution. He had returned to Lhasa in 1945 after 12 years abroad. At first, he was the toast of the town, dining each night at the home of a different aristocrat. But soon he came under suspicion, likely instigated by the British delegation. In 1946, Gendun Chopel was arrested on trumped-up charges of distributing counterfeit currency. He was jailed for three years at the prison at the foot of the Dalai Lama's palace, released as part of a general amnesty when the young (and current) Dalai Lama reached his majority. On 9 September 1951, when troops of the People's Liberation Army marched into Lhasa, bearing banners proclaiming Tibet's return to the motherland of China, Gendun Chopel was a broken man, who had to be lifted from his deathbed to watch the parade. His *Treatise* was not published until 1967, long after his death –and not in Tibet but in India, where so many Tibetans had followed the Dalai Lama into exile. Gendun Chopel's book did not contribute to the sexual revolution that occurred in Europe and the US in the 1960s. Still, reading his instructions for the play of passion, it's clear that much remains to be done, both in the Buddhist world and beyond.

The Tunnel at the End of the Light?

This zigzagging voyage was on a roller coaster. A tough one, and we could be easily thrown out in an especially sharp curve. The meanders were also impasses. I know, and I am dizzy; possibly more than ever (blame my rigid brain arteries).

My essay is obviously a patchwork, a collage, cut-and-paste pillage and vandalism, without much –and then mediocre- original, personal prose. *Traduttore, traditore.* Adapting a text to fit my goals is mean, shabby, shoddy, and misses the target. But '*it's all there!*', waiting to be cherry-picked to satisfy and justify my biases. Accept my apologies, but this time –at least- I avoided to truffle my text with the numbered references; you will find most listed at the very end. This text is also –already- obsolete. Each researcher, thinker, philosopher is pushing every minute the envelope further; these areas are replenished every day by publications, presentations, roundtables, lectures, acerbic discussions, clashes of entrenched opinions. Worse: obsolescence is built-in! I bet that much –possibly most- of this essay is already passé.

I feel like Sisyphus, forced to roll an immense boulder up a hill, only to watch it roll back down, repeating this action for eternity.



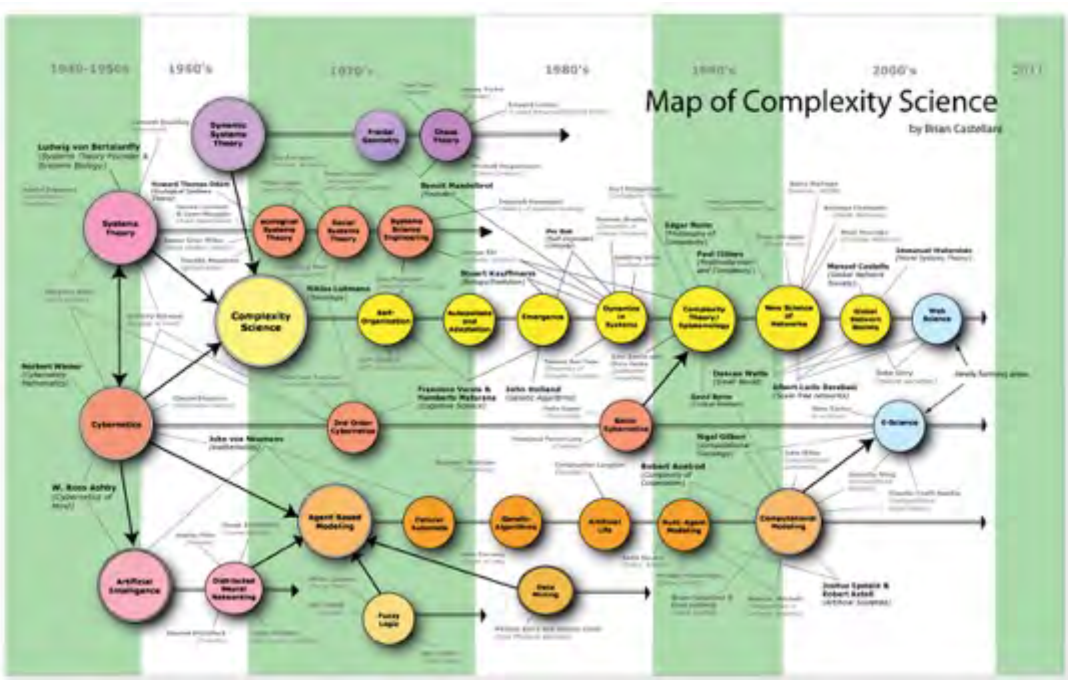
Courtesy of Um-insight.net

Indeed, my education and background did not prepare me to the challenges that pop up daily, and bigger -like mushrooms after a rain. Apprehending the translations from Chinese of Laozi or Mencius required attention and patience, but the exercise was not only rewarding: it was illuminating, opening the gates of sublime horizons.

The experience with quantum physics was (much) more arduous and frustrating. Richard Feynman was clear about the effort, the pain, and the frustration. But it evolves further already: Max Tegmark in his (excellent) book *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality* writes: *"…Our physical world not only is described by mathematics, but that **it is mathematics,** making us self-aware parts of a giant mathematical object."*

Woooohhh!!!

We, the world around us as we know it, everything that hits our senses exist in the world of Newtonian physics; and we are also **all** made of subatomic particles, bosons -forces that only respond to the criteria of quantum physics. We know: modern electronics, ultra-precise clocks, uncrackable codes, super-powerful computers, entanglement-enhanced microscopes, biological compasses in birds, [unfortunately also *Little Boy* (Hiroshima) and *Fat Boy* (Nagasaki)] and many more exist already – with many more to come- in our daily environment. Whole industries and millions of students are devoted to quantum mechanics and biology.



Hence the way to go, the path to walk is the *Complexity* approach, as illustrated by this map.

Can we ever succeed? Maybe. But scratching our heads or arguing endlessly is not an agenda. The *Dao* prefigures quantum mechanics. Symbiosis is always, by its own nature a *complex* endeavor. Time will tell, but time is running short.

I often feel like a dumb dinosaur (but I am getting better!). My attempt to find common ground between modern, current, promising Western science and Chinese philosophies might be vain, useless, and very boring. I may be the *"scaphandrier*" (deep-sea diver) of Léo Ferré:

Mets ton habit, scaphandrier
Descends dans les yeux de ma blonde,
Que vois-tu bon scaphandrier ?

Je vois un étrange attirail :
Des fleurs, des oiseaux, du corail,
Et de l'or en fines paillettes.

Mets ton habit, scaphandrier
Descends dans le cœur de ma blonde,
Que vois-tu, bon scaphandrier ?
Je vois une source très pure,
Je vois des rires et des deuils,
Une oasis près d'un écueil...

Mets ton habit scaphandrier,
Et dans le cerveau de ma blonde,
Tu vas descendre ; que vois-tu ?
Il est descendu, descendu ...
Et dans les profondeurs du vide
Le scaphandrier s'est perdu ...

(English translation is provided in the references)

Acknowledgements

With whom should I start? Obviously, the contributors of *Wikipedia* and Google Search; that's a truism! More personally, my wife Emiko: we were discussing Locke and Hume over lunch, and that sparked the search. Jonathan Sim (of Nanyang Technological University), a philosopher, pointed to Tantai Buddhism. Yves P. Huin is the friendly critic, the formatter and the superb webmaster. Thanks to my philosophy teachers at the Lycées Henri IV (René Maublanc, the Marxist) and Michelet (Emmanuel Peillet, the Pataphysicist), and to my students in Hong Kong and many other continents. My gratitude is endless and keeps me speechless.

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English Lyrics:
Put on your coat, diver
Come down into the eyes of my blond.
What do you see good diver?
I see a strange paraphernalia:
Flowers, birds, coral,
And gold in thin flakes.

Put on your coat, diver
Go down to the heart of my blond.
What do you see, good diver?
I see a very pure source,
I see laughter and mourning,
An oasis near a reef ...

Put your dress diver,
And in the brain of my blond,
You're going down, what do you see?
He went down, down ...
And in the depths of emptiness
The diver got lost ...