# Trapped Ions and Superconductors

*The race to build larger and larger quantum computers is heating up, with several technologies competing for a role in future devices. Each potential platform has strengths and weaknesses, but little has been done to directly compare the performance of early prototypes. Now, researchers at the JQI have performed a first-of-its-kind benchmark test of two small quantum computers built from different technologies. [18]*

*To find out whether quantum computers will work properly, scientists must simulate them on a classical computer. Now a record-breaking experiment has simulated the largest quantum computer yet. [17]*

*How fast will a quantum computer be able to calculate? While fully functional versions of these long-sought technological marvels have yet to be built, one theorist at the National Institute of Standards and Technology (NIST) has shown that, if they can be realized, there may be fewer limits to their speed than previously put forth. [16]*

*Unlike experimental neuroscientists who deal with real-life neurons, computational neuroscientists use model simulations to investigate how the brain functions. [15]*

*A pair of physicists with ETH Zurich has developed a way to use an artificial neural network to characterize the wave function of a quantum many-body system. [14]*

*A team of researchers at Google's DeepMind Technologies has been working on a means to increase the capabilities of computers by combining aspects of data processing and artificial intelligence and have come up with what they are calling a differentiable neural computer (DNC.) In their paper published in the journal Nature, they describe the work they are doing and where they believe it is headed. To make the work more accessible to the public team members, Alexander Graves and Greg Wayne have posted an explanatory page on the DeepMind website. [13]*

*Nobody understands why deep neural networks are so good at solving complex problems. Now physicists say the secret is buried in the laws of physics. [12]*

*A team of researchers working at the University of California (and one from Stony Brook University) has for the first time created a neural-network chip that was built using just memristors. In their paper published in the journal Nature, the team describes how they built their chip and what capabilities it has. [11]*

*A team of researchers used a promising new material to build more functional memristors, bringing us closer to brain-like computing. Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons. [10]*

*Cambridge Quantum Computing Limited (CQCL) has built a new Fastest Operating System aimed at running the futuristic superfast quantum computers. [9]*

*IBM scientists today unveiled two critical advances towards the realization of a practical quantum computer. For the first time, they showed the ability to detect and measure both kinds of quantum errors simultaneously, as well as demonstrated a new, square quantum bit circuit design that is the only physical architecture that could successfully scale to larger dimensions. [8]*

*Physicists at the Universities of Bonn and Cambridge have succeeded in linking two completely different quantum systems to one another. In doing so, they have taken an important step forward on the way to a quantum computer. To accomplish their feat the researchers used a method that seems to function as well in the quantum world as it does for us people: teamwork. The results have now been published in the "Physical Review Letters". [7]*

*While physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena, computer scientists are searching for technologies to build the quantum computer.*

*The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.*

*The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.*

*The diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the Relativistic Quantum Theory and making possible to build the Quantum Computer.*

# Contents

Author: George Rajna

## Preface

While physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena, computer scientists are searching for technologies to build the quantum computer.

Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons. [10]

So far, we just have heard about Quantum computing that could make even complex calculations trivial, but there are no practical Quantum computers exist. However, the dream of Quantum computers could become a reality in coming future. [9]

Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems. [8]

Australian engineers detect in real-time the quantum spin properties of a pair of atoms inside a silicon chip, and disclose new method to perform quantum logic operations between two atoms. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

## Trapped ions and superconductors face off in quantum benchmark

The race to build larger and larger quantum computers is heating up, with several technologies competing for a role in future devices. Each potential platform has strengths and weaknesses, but little has been done to directly compare the performance of early prototypes. Now, researchers at the JQI have performed a first-of-its-kind benchmark test of two small quantum computers built from different technologies.

The team, working with JQI Fellow Christopher Monroe and led by postdoctoral researcher Norbert Linke, sized up their own small-scale quantum computer against a device built by IBM. Both machines use five qubits—the fundamental units of information in a quantum computer—and both machines have similar error rates. But while the JQI device relies on chains of trapped atomic ions, IBM Q (link is external) uses coupled regions of superconducting material.

To make their comparison, the JQI team ran several quantum programs on the devices, each of which solved a simple problem using a series of logic gates to manipulate one or two qubits at a time. Researchers accessed the IBM device using an online interface, which allows anyone to try their hand at programming IBM Q.

Both computers have strengths and weaknesses. For example, the superconducting platform has quicker gates and may be easier to mass produce, but its man-made qubits are all slightly different and have shorter lifetimes. Monroe says that the slower gates of ions might not be a major hurdle, though. "Because there is time," Monroe says. "Trapped ion qubit lifetimes are way longer than any other type of qubit. Moreover, the ion qubits are identical, and they can be better replicated without error."

When put to the test, researchers found that the trapped-ion module was more accurate for programs that involved many pairs of qubits. Linke and Monroe attribute this to the simple fact that every qubit in their device is connected to every other—meaning that a logic gate can connect any pair of qubits. IBM Q has fewer than half the connections of its JQI counterpart, and in order to run some programs it had to shuffle information between qubits—a step that introduced errors into the calculation. When this shuffling wasn't necessary, the two computers had similar performance. "As we build larger systems, connectivity between qubits will become even more important," Monroe says.

The new study, which was recently published in Proceedings of the National Academy of Sciences (link is external), provides an important benchmark for researchers studying quantum computing. And such head-to-head comparisons will become increasingly important in the future. "If you want to buy a quantum computer, you'll need to know which one is best for your application," Linke says. "You'll need to test them in some way, and this is the first of this kind of comparison." [18]

## Supercomputer Simulation Offers Peek at the Future of Quantum Computers

An example of the kind of task that can be simulated on a 45-qubit compuer

Computer scientists have a name for the point at which quantum computers become more powerful than ordinary computers. They call it “quantum supremacy,” and, by all accounts, that time is rapidly approaching.

The current thinking is that a quantum computer capable of handling 49 qubits will match the capability of the most powerful supercomputer on the planet. And anything bigger than that will be beyond the ken of ordinary computing machines.

That isn’t quite possible yet. But it raises important questions about how we can know whether these quantum computers will work as expected. To find out, computer scientists have begun using powerful classical computers to simulate the behavior of quantum computers.

The idea is to calibrate and benchmark their behavior as accurately as possible, while we still can. After that, we’ll just have to trust the quantum world.

Of course, nobody has yet simulated a 49-qubit quantum computer. But today, Thomas Haner and Damian Steiger from ETH Zurich in Switzerland announce the most ambitious attempt to date.

These guys have used the fifth most powerful supercomputer in the world to simulate the behavior of a 45-qubit quantum computer. “To our knowledge, this constitutes a new record in the maximal number of simulated qubits,” say Haner and Steiger. And they show how more powerful simulations ought to be possible.

These simulations are difficult because of the sheer magnitude of the calculations that quantum computers make possible. This great power comes from the quantum phenomenon of superposition, which allows quantum particles, such as photons, to exist in more than one state at the same time.

For example, a horizontally polarized photon can represent a 0 and a vertically polarized photon can represent a 1. But when a photon exists as a superposition of both horizontal and vertical polarizations at the same time, it can represent both a 0 and 1 in a calculation.

In this way, two photons can represent four numbers, three photons can represent eight numbers, and so on. This is where quantum computers get their computational horsepower, and it is why classical computers pale in comparison.

For example, just 50 photons can represent 10,000,000,000,000,000 numbers. A classical computer would require a petabyte-scale memory to store that many.

Processing these numbers on a classical computer is an even bigger task. That’s because most supercomputers are made up of many processing units connected in a giant computing network. As a result, managing the dataflow to and from these nodes is a significant communications overhead.

This challenge has limited the size of simulations to well below the quantum-supremacy limit. The current world record is a simulation of 42 qubits, work that was done on the Julich supercomputer in 2010. Little progress has been made since then because of the problems with computational overheads.

That has now changed thanks to the work of Haner and Steiger. Their breakthrough is to find ways of reducing the overhead so that the simulation can run more than an order of magnitude faster than before.

The researchers have applied these improvements to a set of simulations on the Cori II supercomputer at the Lawrence Berkeley National Laboratory in California. This device consists of 9,304 nodes, each containing a 68-core Intel Xeon Phi processor 7250 running at 1.4 gigahertz. This leads to a peak performance of 29.1 petaflops with one petabyte of memory.

Named after Gerty Cori, the first woman to win a Nobel Prize for medicine, the Cori II is the fifth most powerful supercomputer on the planet. So it is not short of computational horsepower.

Haner and Steiger used this device to simulate the way a quantum computer would perform calculations using 30, 36, 42, and 45 qubits. For the biggest simulation, they used 0.5 petabytes of memory and 8,192 nodes, achieving a performance of 0.428 petaflops.

That's significantly less than the machine is capable of, even with the speedups the team has designed. The team put down this loss of performance to the communication overhead, which still takes up 75 percent of the computational time.

Haner and Steiger compared the results with simulations of 30- and 36-qubit computers run on a less powerful supercomputer called Edison, also at the Lawrence Berkeley Lab. They found that their approach also sped up these calculations. "This indicates that the obtained speedups were not merely a consequence of a new generation of hardware [for Cori II]," say Haner and Steiger.

They say this improvement suggests that simulation of a 49-qubit computer ought to be possible in the near future.

That's interesting work that paves the way for future quantum computers. The data from this work will play an important role in ensuring that physicists have confidence in quantum calculations when quantum supremacy is finally achieved. And that day is surely not too far in the future. [17]

## Quantum computers may have higher 'speed limits' than thought

How fast will a quantum computer be able to calculate? While fully functional versions of these long-sought technological marvels have yet to be built, one theorist at the National Institute of Standards and Technology (NIST) has shown that, if they can be realized, there may be fewer limits to their speed than previously put forth.

The findings—described as a "thought experiment" by NIST's Stephen Jordan—are about a different aspect of quantum computing speed than another group of NIST researchers explored about two years ago. While the previous findings were concerned with how fast information can travel between two switches in a computer's processor, Jordan's new paper deals with how quickly those switches can flip from one state to another.

The rate of flipping is equivalent to the "clock speed" of conventional processors. To make computations, the processor sends out mathematical instructions known as logic operations that change the configurations of the switches. Present day CPUs have clock speeds measured in gigahertz, which means that they are capable of performing a few billion elementary logic operations per second.

Because they harness the power of quantum mechanics to make their calculations, quantum computers will necessarily have vastly different architectures than today's machines. Their switches, called quantum bits or "qubits," will be able to represent more than just a 1 or 0, as conventional processors do; they will be able to represent multiple values simultaneously, giving them powers conventional computers do not possess.

Jordan's paper disputes longstanding conclusions about what quantum states imply about clock speed. According to quantum mechanics, the rate at which a quantum state can change—and therefore the rate at which a qubit can flip—is limited by how much energy it has. While Jordan believes these findings to be valid, several subsequent papers over the years have argued that they also imply a limit to how fast a quantum computer can calculate in general.

"At first glance this seems quite plausible," Jordan said. "If you're performing more logic operations, it makes sense that your switches would need to go through more changes. In both conventional and quantum computing designs, each time a logic operation occurs"—making its switches flip—"the computer hops to a new state."

Using the mathematics of quantum systems, Jordan shows is that it is possible to engineer a quantum computer that does not have this limitation. In fact, with the right design, he said, the computer "could perform an arbitrarily large number of logic operations while only hopping through a constant number of distinct states."

Counterintuitively, in such a quantum computer, the number of logic operations carried out per second could be vastly larger than the rate at which any qubit can be flipped. This would allow quantum computers that embrace this design to break previously suggested speed limits.

What advantages might this faster clock speed grant? One of the primary applications envisioned for quantum computers is the simulation of other physical systems. The theoretical speed limit on clock speed was thought to place an upper bound on the difficulty of this task. Any physical system, the argument went, could be thought of as a sort of computer—one with a clock speed limited by the system's energy. The number of clock cycles needed to simulate the system on a quantum computer should be comparable to the number of clock cycles the original system carried out.

However, these newly discovered loopholes to the computational speed limit are a "double-edged sword." If energy does not limit the speed of a quantum computer, then quantum computers could simulate physical systems of greater complexity than previously thought. But energy doesn't limit the computational complexity of naturally occurring systems either, and this could make them harder to simulate on quantum computers.

Jordan said his findings do not imply that there are no limits to how fast a quantum computer could conceivably calculate, but that these limits derive from other aspects of physics than merely the availability of energy.

"For example, if you take into account geometrical constraints, like how densely you can pack information, and a limit to how fast you can transmit information (namely, the speed of light), then I think you can make more solid arguments," he said. "That will tell you where the real limits to computational speed lie." [16]

## Parallel computation provides deeper insight into brain function

Unlike experimental neuroscientists who deal with real-life neurons, computational neuroscientists use model simulations to investigate how the brain functions. While many computational neuroscientists use simplified mathematical models of neurons, researchers in the Computational Neuroscience Unit at the Okinawa Institute of Science and Technology Graduate University (OIST) develop software that models neurons to the detail of molecular interactions with the goal of eliciting new insights into neuronal function. Applications of the software were limited in scope up until now because of the intense computational power required for such detailed neuronal models, but recently Dr. Weiliang Chen, Dr. Iain Hepburn, and Professor Erik De Schutter published two related papers in which they outline the accuracy and scalability of their new high-speed computational software, "Parallel STEPS". The combined findings suggest that Parallel STEPS could be used to reveal new insights into how individual neurons function and communicate with each other.

The first paper, published in The Journal of Chemical Physics in August 2016, focusses on ensuring that the accuracy of Parallel STEPS is comparable with conventional methods. In conventional approaches, computations associate with neuronal chemical reactions and molecule diffusion are all calculated on one computational processing unit or 'core' sequentially. However, Dr. Iain Hepburn and colleagues introduced a new approach to perform computations of reaction and diffusion in parallel which can then be distributed over multiple computer cores, whilst maintaining simulation accuracy to a high degree. The key was to develop an original algorithm separated into two parts - one that computed chemical reaction events and the other diffusion events.

"We tested a range of model simulations from simple diffusion models to realistic biological models and found that we could achieve improved performance using a parallel approach with minimal loss of accuracy. This demonstrated the potential suitability of the method on a larger scale," says Dr. Hepburn.

In a related paper published in Frontiers in Neuroinformatics this February, Dr. Weiliang Chen presented the implementation details of Parallel STEPS and investigated its performance and potential applications. By breaking a partial model of a Purkinje cell - one of the largest neurons in the brain - into 50 to 1000 sections and simulating reaction and diffusion events for each section in parallel on the Sango supercomputer at OIST, Dr. Chen and colleagues saw dramatically increased computation speeds. They tested this approach on both simple models and more complicated models of calcium bursts in Purkinje cells and demonstrated that parallel simulation could speed up computations by more than several hundred times that of conventional methods.

"Together, our findings show that Parallel STEPS implementation achieves significant improvements in performance, and good scalability," says Dr. Chen. "Similar models that previously required months of simulation can now be completed within hours or minutes, meaning that we can develop and simulate more complex models, and learn more about the brain in a shorter amount of time."

Dr. Hepburn and Dr. Chen from OIST's Computational Neuroscience Unit, led by Professor Erik De Schutter, are actively collaborating with the Human Brain Project, a world-wide initiative based at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, to develop a more robust version of Parallel STEPS that incorporates electric field simulation of cell membranes.

So far STEPS is only realistically capable of modeling parts of neurons but with the support of Parallel STEPS, the Computational Neuroscience Unit hopes to develop a full-scale model of a whole neuron and subsequently the interactions between neurons in a network. By collaborating with the EPFL team and by making use of the IBM 'Blue Gene/Q' supercomputer located there, they aim to achieve these goals in the near future.

"Thanks to modern supercomputers we can study molecular events within neurons in a much more transparent way than before," says Prof. De Schutter. "Our research opens up interesting avenues in computational neuroscience that links biochemistry with electrophysiology for the first time." [15]

## Researchers use artificial neural network to simulate a quantum many-body system

A pair of physicists with ETH Zurich has developed a way to use an artificial neural network to characterize the wave function of a quantum many-body system. In their paper published in the journal Science, Giuseppe Carleo and Matthias Troyer describe how they coaxed a neural network to simulate some aspects of a quantum many-body system. Michael Hush with the University of New South Wales offers a Perspectives piece on the work done by the pair in the same journal issue and also outlines the problems other researchers have faced when attempting to solve the same problem.

One of the difficult challenges facing physicists today is coming up with a way to simulate quantum many-body systems, i.e., showing all the states that exist in a given system, such as a chunk of matter. Such systems grow complicated quickly—a group of just 100 quantum particles, for example, could have as many as 1035 spin states. Even the most powerful modern computers very quickly become overwhelmed trying to depict such systems. In this new effort, the researchers took a different approach—instead of attempting to calculate every possible state, they used a neural network to generalize the entire system.

The pair began by noting that the system used to defeat a Go world champion last year might be modified in a way that could simulate a many-body system. They created a simplified version of the same type of neural network and programed it to simulate the wave function of a multi-body system (by using a set of weights and just one layer of hidden biases). They then followed up by getting the neural network to figure out the ground state of a system. To see how well their system worked, they ran comparisons with problems that have already been solved and report that their system was better than those that rely on a brute-force approach.

The system was a proof-of-concept rather than an actual tool for use by physicists, but it demonstrates what is possible—large efforts, as Hush notes, that involve more hidden biases and weights could result in a tool with groundbreaking applications. [14]

## Google DeepMind project taking neural networks to a new level

A team of researchers at Google's DeepMind Technologies has been working on a means to increase the capabilities of computers by combining aspects of data processing and artificial intelligence and have come up with what they are calling a differentiable neural computer (DNC.) In their paper published in the journal Nature, they describe the work they are doing and where they believe it is headed. To make the work more accessible to the public team members, Alexander Graves and Greg Wayne have posted an explanatory page on the DeepMind website.

DeepMind is a Google-owned company that does research on artificial intelligence, including neural networks, and more recently, deep neural networks, which are computer systems that learn how to do things by seeing many other examples. But, as Graves and Wayne note, such systems are typically limited by their ability to use and manipulate memory in useful ways because they are in essence based on decision trees. The work being done with DNCs is meant to overcome that deficiency, allowing for the creation of computer systems that are not only able to learn, but which will be able to remember what they have learned and then to use that information for decision making when faced with a new task. The researchers highlight an example of how such a system might be of greater use to human operators—a DNC could be taught how to get from one point to another, for example, and then caused to remember what it learned along the way. That would allow for the creation of a system that offers the best route to take on the subway, perhaps, or on a grander scale, advice on adding roads to a city.

By adding memory access to neural networking, the researchers are also looking to take advantage of another ability we humans take for granted—forming relationships between memories, particularly as they relate to time. One example would be when a person walks by a candy store and the aroma immediately takes them back to their childhood—to Christmas, perhaps, and the emotions that surround the holiday season. A computer able to make the same sorts of connections would be able to make similar leaps, jumping back to a sequence of connected learning events that could be useful in providing an answer to a problem about a certain topic—such as what caused the Great Depression or how Google became so successful.

The research team has not yet revealed if there are any plans in place for actually using the systems they are developing, but it would seem likely, and it might be gradual, showing up in better search results when using Google, for example. [13]

## The Extraordinary Link Between Deep Neural Networks and the Nature of the Universe

Nobody understands why deep neural networks are so good at solving complex problems. Now physicists say the secret is buried in the laws of physics.

In the last couple of years, deep learning techniques have transformed the world of artificial intelligence. One by one, the abilities and techniques that humans once imagined were uniquely our own have begun to fall to the onslaught of ever more powerful machines. Deep neural networks are now better than humans at tasks such as face recognition and object recognition. They’ve mastered the ancient game of Go and thrashed the best human players.

But there is a problem. There is no mathematical reason why networks arranged in layers should be so good at these challenges. Mathematicians are flummoxed.

Despite the huge success of deep neural networks, nobody is quite sure how they achieve their success.

Today that changes thanks to the work of Henry Lin at Harvard University and Max Tegmark at MIT. These guys say the reason why mathematicians have been so embarrassed is that the answer depends on the nature of the universe. In other words, the answer lies in the regime of physics rather than mathematics.

First, let's set up the problem using the example of classifying a megabit grayscale image to determine whether it shows a cat or a dog.

Such an image consists of a million pixels that can each take one of 256 grayscale values. So in theory, there can be 2561000000 possible images, and for each one it is necessary to compute whether it shows a cat or dog. And yet neural networks, with merely thousands or millions of parameters, somehow manage this classification task with ease.

In the language of mathematics, neural networks work by approximating complex mathematical functions with simpler ones. When it comes to classifying images of cats and dogs, the neural network must implement a function that takes as an input a million grayscale pixels and outputs the probability distribution of what it might represent.

The problem is that there are orders of magnitude more mathematical functions than possible networks to approximate them. And yet deep neural networks somehow get the right answer.

Now Lin and Tegmark say they've worked out why. The answer is that the universe is governed by a tiny subset of all possible functions. In other words, when the laws of physics are written down mathematically, they can all be described by functions that have a remarkable set of simple properties.

So deep neural networks don't have to approximate any possible mathematical function, only a tiny subset of them.

To put this in perspective, consider the order of a polynomial function, which is the size of its highest exponent. So a quadratic equation like y=x2 has order 2, the equation y=x24 has order 24, and so on.

Obviously, the number of orders is infinite and yet only a tiny subset of polynomials appear in the laws of physics. "For reasons that are still not fully understood, our universe can be accurately described by polynomial Hamiltonians of low order," say Lin and Tegmark. Typically, the polynomials that describe laws of physics have orders ranging from 2 to 4.

The laws of physics have other important properties. For example, they are usually symmetrical when it comes to rotation and translation. Rotate a cat or dog through 360 degrees and it looks the same; translate it by 10 meters or 100 meters or a kilometer and it will look the same. That also simplifies the task of approximating the process of cat or dog recognition.

These properties mean that neural networks do not need to approximate an infinitude of possible mathematical functions but only a tiny subset of the simplest ones.

There is another property of the universe that neural networks exploit. This is the hierarchy of its structure. “Elementary particles form atoms which in turn form molecules, cells, organisms, planets, solar systems, galaxies, etc.,” say Lin and Tegmark. And complex structures are often formed through a sequence of simpler steps.

This is why the structure of neural networks is important too: the layers in these networks can approximate each step in the causal sequence.

Lin and Tegmark give the example of the cosmic microwave background radiation, the echo of the Big Bang that permeates the universe. In recent years, various spacecraft have mapped this radiation in ever higher resolution. And of course, physicists have puzzled over why these maps take the form they do.

Tegmark and Lin point out that whatever the reason, it is undoubtedly the result of a causal hierarchy. “A set of cosmological parameters (the density of dark matter, etc.) determines the power spectrum of density fluctuations in our universe, which in turn determines the pattern of cosmic microwave background radiation reaching us from our early universe, which gets combined with foreground radio noise from our galaxy to produce the frequency-dependent sky maps that are recorded by a satellite-based telescope,” they say.

Each of these causal layers contains progressively more data. There are only a handful of cosmological parameters but the maps and the noise they contain are made up of billions of numbers. The goal of physics is to analyze the big numbers in a way that reveals the smaller ones.

And when phenomena have this hierarchical structure, neural networks make the process of analyzing it significantly easier.

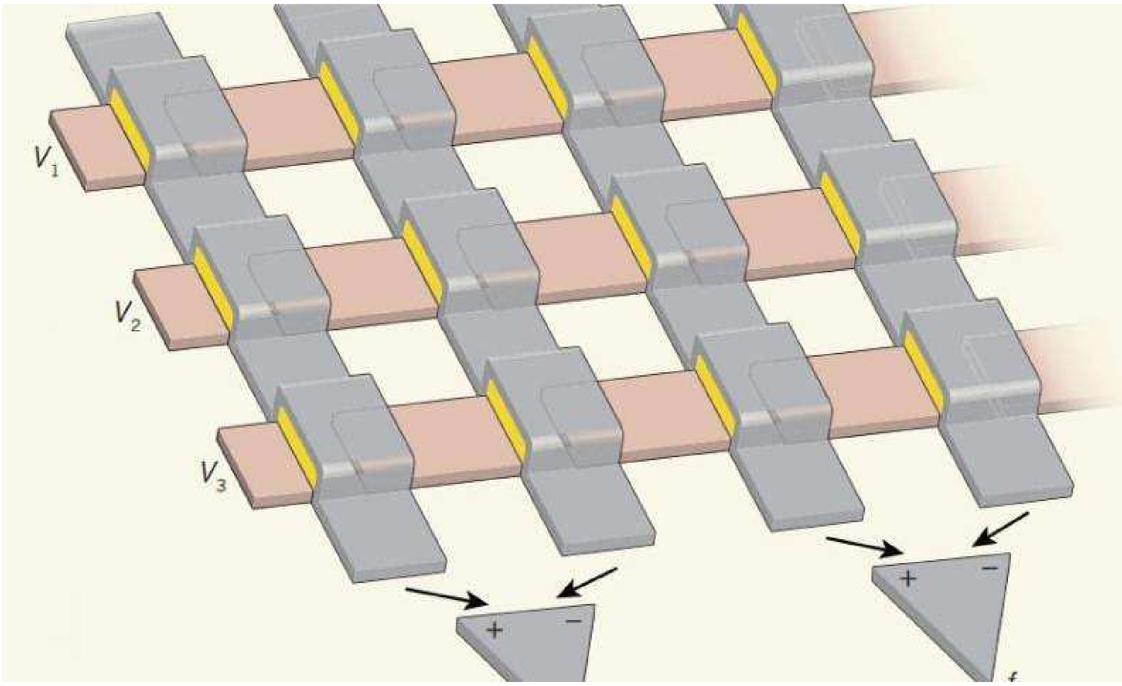
“We have shown that the success of deep and cheap learning depends not only on mathematics but also on physics, which favors certain classes of exceptionally simple probability distributions that deep learning is uniquely suited to model,” conclude Lin and Tegmark.

That’s interesting and important work with significant implications. Artificial neural networks are famously based on biological ones. So not only do Lin and Tegmark’s ideas explain why deep learning machines work so well, they also explain why human brains can make sense of the universe. Evolution has somehow settled on a brain structure that is ideally suited to teasing apart the complexity of the universe.

This work opens the way for significant progress in artificial intelligence. Now that we finally understand why deep neural networks work so well, mathematicians can get to work exploring the specific mathematical properties that allow them to perform so well. “Strengthening the analytic understanding of deep learning may suggest ways of improving it,” say Lin and Tegmark.

Deep learning has taken giant strides in recent years. With this improved understanding, the rate of advancement is bound to accelerate. [12]

# Researchers create first neural-network chip built just with memristors




Memristors may sound like something from a sci-fi movie, but they actually exist—they are electronic analog memory devices that are modeled on human neurons and synapses. Human consciousness, some believe, is in reality, nothing more than an advanced form of memory retention and processing, and it is analog, as opposed to computers, which of course are digital. The idea for memristors was first dreamed up by University of California professor Leon Chua back in 1971, but it was not until a team working at Hewlett-Packard in 2008, first built one. Since then, a lot of research has gone into studying the technology, but until now, no one had ever built a neural-network chip based exclusively on them.

Up till now, most neural networks have been software based, Google, Facebook and IBM, for example, are all working on computer systems running such learning networks, mostly meant to pick faces out of a crowd, or return an answer based on a human phrased question. While the gains in such technology have been obvious, the limiting factor is the hardware—as neural networks grow in size and complexity, they begin to tax the abilities of even the fastest computers. The next step, most in the field believe, is to replace transistors with memristors—each on its own is able to learn, in ways similar to the way neurons in the brain learn when presented with something new. Putting them on a chip would of course reduce the overhead needed to run such a network.

The new chip, the team reports, was created using transistor-free metal-oxide memristor crossbars and represents a basic neural network able to perform just one task—to learn and recognize patterns in very simple 3 × 3-pixel black and white images. The experimental chip, they add, is an important step towards the creation of larger neural networks that tap the real power of memristors.
It also makes possible the idea of building computers in lock-step with advances in research looking into discovering just how exactly our neurons work at their most basic level.

Despite much progress in semiconductor integrated circuit technology, the extreme complexity of the human cerebral cortex, with its approximately 1014 synapses, makes the hardware implementation of neuromorphic networks with a comparable number of devices exceptionally challenging. To provide comparable complexity while operating much faster and with manageable power dissipation, networks based on circuits combining complementary metal-oxide-semiconductors (CMOSs) and adjustable two-terminal resistive devices (memristors) have been developed. In such circuits, the usual CMOS stack is augmented with one or several crossbar layers, with memristors at each crosspoint. There have recently been notable improvements in the fabrication of such memristive crossbars and their integration with CMOS circuits, including first demonstrations of their vertical integration. Separately, discrete memristors have been used as artificial synapses in neuromorphic networks. Very recently, such experiments have been extended to crossbar arrays of phase-change memristive devices. The adjustment of such devices, however, requires an additional transistor at each crosspoint, and hence these devices are much harder to scale than metal-oxide memristors, whose nonlinear current–voltage curves enable transistor-free operation. Here we report the experimental implementation of transistor-free metal-oxide memristor crossbars, with device variability sufficiently low to allow operation of integrated neural networks, in a simple network: a single-layer perceptron (an algorithm for linear classification). The network can be taught in situ using a coarse-grain variety of the delta rule algorithm to perform the perfect classification of 3 × 3-pixel black/white images into three classes (representing letters). This demonstration is an important step towards much larger and more complex memristive neuromorphic networks. [11]

## Computers that mimic the function of the brain

Concept illustration (stock image). A new step forward in memristor technology could bring us closer to brain-like computing.

Researchers are always searching for improved technologies, but the most efficient computer possible already exists. It can learn and adapt without needing to be programmed or updated. It has nearly limitless memory, is difficult to crash, and works at extremely fast speeds. It's not a Mac or a PC; it's the human brain. And scientists around the world want to mimic its abilities.

Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons.

"Computers are very impressive in many ways, but they're not equal to the mind," said Mark Hersam, the Bette and Neison Harris Chair in Teaching Excellence in Northwestern University's McCormick School of Engineering. "Neurons can achieve very complicated computation with very low power consumption compared to a digital computer."

A team of Northwestern researchers, including Hersam, has accomplished a new step forward in electronics that could bring brain-like computing closer to reality. The team's work advances memory resistors, or "memristors," which are resistors in a circuit that "remember" how much current has flowed through them.

The research is described in the April 6 issue of Nature Nanotechnology. Tobin Marks, the Vladimir N. Ipatieff Professor of Catalytic Chemistry, and Lincoln Lauhon, professor of materials science and engineering, are also authors on the paper. Vinod Sangwan, a postdoctoral fellow co-advised by Hersam, Marks, and Lauhon, served as first author. The remaining co-authors--Deep Jariwala, In Soo Kim, and Kan-Sheng Chen--are members of the Hersam, Marks, and/or Lauhon research groups.

"Memristors could be used as a memory element in an integrated circuit or computer," Hersam said. "Unlike other memories that exist today in modern electronics, memristors are stable and remember their state even if you lose power."

Current computers use random access memory (RAM), which moves very quickly as a user works but does not retain unsaved data if power is lost. Flash drives, on the other hand, store information when they are not powered but work much slower. Memristors could provide a memory that is the best of both worlds: fast and reliable. But there's a problem: memristors are two-terminal electronic devices, which can only control one voltage channel. Hersam wanted to transform it into a three-terminal device, allowing it to be used in more complex electronic circuits and systems.

Hersam and his team met this challenge by using single-layer molybdenum disulfide ($MoS_2$), an atomically thin, two-dimensional nanomaterial semiconductor. Much like the way fibers are arranged in wood, atoms are arranged in a certain direction--called "grains"--within a material. The sheet of $MoS_2$ that Hersam used has a well-defined grain boundary, which is the interface where two different grains come together.

"Because the atoms are not in the same orientation, there are unsatisfied chemical bonds at that interface," Hersam explained. "These grain boundaries influence the flow of current, so they can serve as a means of tuning resistance."

When a large electric field is applied, the grain boundary literally moves, causing a change in resistance. By using $MoS_2$ with this grain boundary defect instead of the typical metal-oxide-metal memristor structure, the team presented a novel three-terminal memristive device that is widely tunable with a gate electrode. [10]

## Fastest Operating System for Quantum Computing Developed By Researchers

Researchers have been working on significant activities to develop quantum computing technology that might enable the development of a Superfast quantum computer, though there has been less work done in the development of an Operating System that might control the quantum computers.

However, CQCL researchers have done just that and also believe that "Quantum computing will be a reality much earlier than originally anticipated. It will have profound and far-reaching effects on a vast number of aspects of our daily lives."

### Polishing Quantum Computing:

CQCL's new operating system for the quantum computer comes just days after IBM researchers brought us even closer to a working Superfast quantum computer by discovering a new method for correcting two errors that a quantum computer can make.

One of the biggest issues that prevent us from developing Superfast Quantum Computers is — Quantum computing is incredibly fragile, and even the slightest fault can cause a major error to the computer.

However, IBM researchers have discovered a new way to detect both types of quantum computer errors, and revealed a new, square quantum bit circuit design that, according to them, can be easily scaled up to make high-performance computers, according to the details published in Nature Communications.

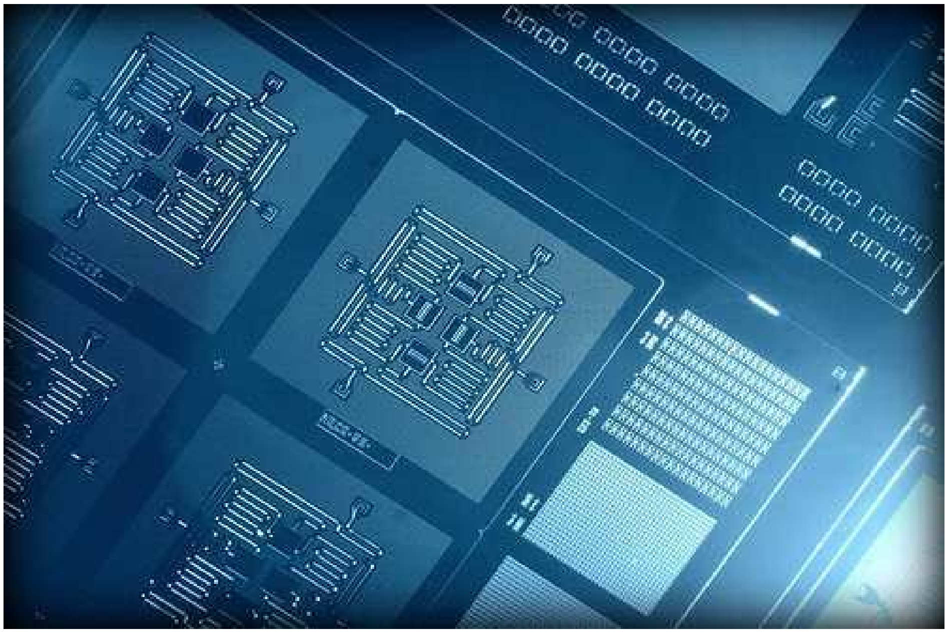
What’s the difference between a Regular computer and a Quantum computer?

Traditional computers use the "bits" to represent information as a 0 or a 1; therefore they are so much slower. On the other hand, Quantum computers use "qubits" (quantum bits) to represent information as a 0, 1, or both at the same time.

But, the major problem with qubits is that they sometimes flip without warning. Qubits can suddenly flip from 0 to 1, which is called a bit flip, or from 0+1 to 0-1, which is called a phase flip. And these flipping are the actual culprits that creates all kinds of errors in a quantum computer.

Until now, scientists could only detect one error at a time. However, IBM's quantum circuit, consisting of four superconducting qubits on a one-quarter inch square chip, allowed researchers to detect bit-flip as well as phase-flip quantum errors simultaneously. [9]

# Scientists achieve critical steps to building first practical quantum computer



Layout of IBM's four superconducting quantum bit device. Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems.

With Moore's Law expected to run out of steam, quantum computing will be among the inventions that could usher in a new era of innovation across industries.
Quantum computers promise to open up new capabilities in the fields of optimization and simulation simply not possible using today's computers. If a quantum computer could be built with just 50 quantum bits (qubits), no combination of today's TOP500 supercomputers could successfully outperform it.

The IBM breakthroughs, described in the April 29 issue of the journal Nature Communications, show for the first time the ability to detect and measure the two types of quantum errors (bit-flip and phase-flip) that will occur in any real quantum computer. Until now, it was only possible to address one type of quantum error or the other, but never both at the same time. This is a necessary step toward quantum error correction, which is a critical requirement for building a practical and reliable large-scale quantum computer.

IBM's novel and complex quantum bit circuit, based on a square lattice of four superconducting qubits on a chip roughly one-quarter-inch square, enables both types of quantum errors to be detected at the same time. By opting for a square-shaped design versus a linear array – which prevents the detection of both kinds of quantum errors simultaneously – IBM's design shows the best potential to scale by adding more qubits to arrive at a working quantum system.

"Quantum computing could be potentially transformative, enabling us to solve problems that are impossible or impractical to solve today," said Arvind Krishna, senior vice president and director of IBM Research. "While quantum computers have traditionally been explored for cryptography, one area we find very compelling is the potential for practical quantum systems to solve problems in physics and quantum chemistry that are unsolvable today. This could have enormous potential in materials or drug design, opening up a new realm of applications."

For instance, in physics and chemistry, quantum computing could allow scientists to design new materials and drug compounds without expensive trial and error experiments in the lab, potentially speeding up the rate and pace of innovation across many industries.

For a world consumed by Big Data, quantum computers could quickly sort and curate ever larger databases as well as massive stores of diverse, unstructured data. This could transform how people make decisions and how researchers across industries make critical discoveries.

One of the great challenges for scientists seeking to harness the power of quantum computing is controlling or removing quantum decoherence – the creation of errors in calculations caused by interference from factors such as heat, electromagnetic radiation, and material defects. The errors are especially acute in quantum machines, since quantum information is so fragile.

"Up until now, researchers have been able to detect bit-flip or phase-flip quantum errors, but never the two together. Previous work in this area, using linear arrangements, only looked at bit-flip errors offering incomplete information on the quantum state of a system and making them inadequate for a quantum computer," said Jay Gambetta, a manager in the IBM Quantum Computing Group. "Our four qubit results take us past this hurdle by detecting both types of quantum errors and can be scalable to larger systems, as the qubits are arranged in a square lattice as opposed to a linear array."

The work at IBM was funded in part by the IARPA (Intelligence Advanced Research Projects Activity) multi-qubit-coherent-operations program.

## Detecting quantum errors

The most basic piece of information that a typical computer understands is a bit. Much like a beam of light that can be switched on or off, a bit can have only one of two values: "1" or "0". However, a quantum bit (qubit) can hold a value of 1 or 0 as well as both values at the same time, described as superposition and simply denoted as "0+1". The sign of this superposition is important because both states 0 and 1 have a phase relationship to each other. This superposition property is what allows quantum computers to choose the correct solution amongst millions of possibilities in a time much faster than a conventional computer.

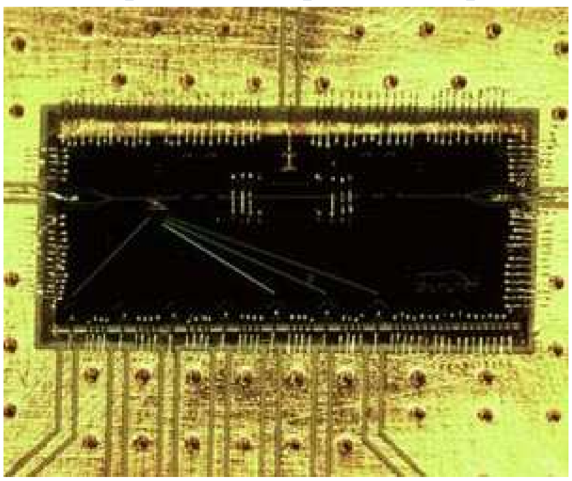
Two types of errors can occur on such a superposition state. One is called a bit-flip error, which simply flips a 0 to a 1 and vice versa. This is similar to classical bit-flip errors and previous work has showed how to detect these errors on qubits. However, this is not sufficient for quantum error correction because phase-flip errors can also be present, which flip the sign of the phase relationship between 0 and 1 in a superposition state. Both types of errors must be detected in order for quantum error correction to function properly.

Quantum information is very fragile because all existing qubit technologies lose their information when interacting with matter and electromagnetic radiation.
Theorists have found ways to preserve the information much longer by spreading information across many physical qubits. "Surface code" is the technical name for a specific error correction scheme

which spreads quantum information across many qubits. It allows for only nearest neighbor interactions to encode one logical qubit, making it sufficiently stable to perform error-free operations.

The IBM Research team used a variety of techniques to measure the states of two independent syndrome (measurement) qubits. Each reveals one aspect of the quantum information stored on two other qubits (called code, or data qubits). Specifically, one syndrome qubit revealed whether a bit-flip error occurred to either of the code qubits, while the other syndrome qubit revealed whether a phase-flip error occurred. Determining the joint quantum information in the code qubits is an essential step for quantum error correction because directly measuring the code qubits destroys the information contained within them. [8]

## Next important step toward quantum computer



When facing big challenges, it is best to work together. In a team, the individual members can contribute their individual strengths - to the benefit of all those involved. One may be an absent-minded scientist who has brilliant ideas, but quickly forgets them. He needs the help of his conscientious colleague, who writes everything down, in order to remind the scatterbrain about it later. It's very similar in the world of quanta.

There the so-called quantum dots (abbreviated: qDots) play the role of the forgetful genius. Quantum dots are unbeatably fast, when it comes to disseminating quantum information. Unfortunately, they forget the result of the calculation just as quickly - too quickly to be of any real use in a quantum computer.

In contrast, charged atoms, called ions, have an excellent memory: They can store quantum information for many minutes. In the quantum world, that is an eternity.

They are less well suited for fast calculations, however, because the internal processes are comparatively slow.

The physicists from Bonn and Cambridge have therefore obliged both of these components, qDots and ions, to work together as a team. Experts speak of a hybrid system, because it combines two completely different quantum systems with one another.

### Absent-minded qDots

qDots are considered the great hopes in the development of quantum computers. In principle, they are extremely miniaturized electron storage units. qDots can be produced using the same techniques as normal computer chips. To do so, it is only necessary to miniaturize the structures on the chips until they hold just one single electron (in a conventional PC it is 10 to 100 electrons).

The electron stored in a qDot can take on states that are predicted by quantum theory. However, they are very short-lived: They decay within a few picoseconds (for illustration: in one picosecond, light travels a distance of just 0.3 millimeters).

This decay produces a small flash of light: a photon. Photons are wave packets that vibrate in a specific plane - the direction of polarization. The state of the qDots determines the direction of polarization of the photon. "We used the photon to excite an ion", explains Prof. Dr. Michael Kohl from the Institute of Physics at the University of Bonn. "Then we stored the direction of polarization of the photon".

### Conscientious ions

To do so, the researchers connected a thin glass fiber to the qDot. They transported the photon via the fiber to the ion many meters away. The fiberoptic networks used in telecommunications operate very similarly. To make the transfer of information as efficient as possible, they had trapped the ion between two mirrors. The mirrors bounced the photon back and forth like a ping pong ball, until it was absorbed by the ion.

"By shooting it with a laser beam, we were able to read out the ion that was excited in this way", explains Prof. Kohl. "In the process, we were able to measure the direction of polarization of the previously absorbed photon". In a sense then, the state of the qDot can be preserved in the ion - theoretically this can be done for many minutes. [7]

## Quantum Computing

A team of electrical engineers at UNSW Australia has observed the unique quantum behavior of a pair of spins in silicon and designed a new method to use them for "2-bit" quantum logic operations.

These milestones bring researchers a step closer to building a quantum computer, which promises dramatic data processing improvements.

Quantum bits, or qubits, are the building blocks of quantum computers. While many ways to create a qubits exist, the Australian team has focused on the use of single atoms of phosphorus, embedded inside a silicon chip similar to those used in normal computers.

The first author on the experimental work, PhD student Juan Pablo Dehollain, recalls the first time he realized what he was looking at.

"We clearly saw these two distinct quantum states, but they behaved very differently from what we were used to with a single atom. We had a real 'Eureka!' moment when we realized what was happening – we were seeing in real time the `entangled' quantum states of a pair of atoms." [5]

Researchers have developed the first silicon quantum computer building blocks that can process data with more than 99 percent accuracy, overcoming a major hurdle in the race to develop reliable quantum computers.

Researchers from the University of New South Wales (UNSW) in Australia have achieved a huge breakthrough in quantum computing - they've created two kinds of silicon quantum bit, or qubits, the building blocks that make up any quantum computer, that are more than 99 percent accurate.

The postdoctoral researcher who was lead author on Morello's paper explained in the press release: "The phosphorus atom contains in fact two qubits: the electron, and the nucleus. With the nucleus in particular, we have achieved accuracy close to 99.99 percent. That means only one error for every 10,000 quantum operations."

Both the breakthroughs were achieved by embedding the atoms in a thin layer of specially purified silicon, which contains only the silicon-28 isotope. Naturally occurring silicon is magnetic and therefore disturbs the quantum bit, messing with the accuracy of its data processing, but silicon-28 is perfectly non-magnetic. [6]

## Quantum Entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

## The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

## Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.
The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

## Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly: ds/dt = at (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate).

# Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

# Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

# Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

## The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

## The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

## The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.
The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.
We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.
There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

## Fermions and Bosons

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

## Van Der Waals force

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

## Electromagnetic inertia and mass

### Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

### Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

### The frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv / c^2$ that is the $m$ depends only on the $v$ frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the $m_o$ inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

### Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [2]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

# Gravity from the point of view of quantum physics

## The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Bing Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate Mp=1840 Me. In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

## The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the $T_{max}$ change and the diffraction patterns change. [2]

## Higgs mechanism and Quantum Gravity

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

### What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

### The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

## Conclusions

"With a memristor that can be tuned with a third electrode, we have the possibility to realize a function you could not previously achieve," Hersam said. "A three-terminal memristor has been proposed as a means of realizing brain-like computing. We are now actively exploring this possibility in the laboratory." [10]

"CQCL is at the forefront of developing an operating system that will allow users to harness the joint power of classical super computers alongside quantum computers," the company said in a press release. [9]

Because these qubits can be designed and manufactured using standard silicon fabrication techniques, IBM anticipates that once a handful of superconducting qubits can be manufactured reliably and repeatedly, and controlled with low error rates, there will be no fundamental obstacle to demonstrating error correction in larger lattices of qubits. [8]

This success is an important step on the still long and rocky road to a quantum computer. In the long term, researchers around the world are hoping for true marvels from this new type of computer: Certain tasks, such as the factoring of large numbers, should be child's play for such a computer. In contrast, conventional computers find this a really tough nut to crack. However, a quantum computer displays its talents only for such special tasks: For normal types of basic computations, it is pitifully slow. [7]

One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .

The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]

The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing.

The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]

The key breakthrough to arrive at this new idea to build qubits was to exploit the ability to control the nuclear spin of each atom. With that insight, the team has now conceived a unique way to use the nuclei as facilitators for the quantum logic operation between the electrons. [5]

Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions also.

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