Diamonds are Forever

They say diamonds are forever, but diamonds in fact are a metastable form of carbon that will slowly but eventually transform into graphite, another form of carbon. [12]

Scientists at Lehigh University, in collaboration with Lawrence Berkeley National Laboratory, have demonstrated the fabrication of what they call a new class of crystalline solid by using a laser heating technique that induces atoms to organize into a rotating lattice without affecting the macroscopic shape of the solid. [11]

The geometry and topology of electronic states in solids plays a central role in a wide range of modern condensed-matter systems including graphene or topological insulators. However, experimentally accessing this information has proven to be challenging, especially when the bands are not well-isolated from one another. As reported in last week's issue of Science, an international team of researchers has devised a straightforward method to probe the band geometry using ultracold atoms in an optical lattice. [10]

Researchers at the University of Chicago's Institute for Molecular Engineering and the University of Konstanz have demonstrated the ability to generate a quantum logic operation, or rotation of the qubit, that - surprisingly—is intrinsically resilient to noise as well as to variations in the strength or duration of the control. Their achievement is based on a geometric concept known as the Berry phase and is implemented through entirely optical means within a single electronic spin in diamond. [9]

New research demonstrates that particles at the quantum level can in fact be seen as behaving something like billiard balls rolling along a table, and not merely as the probabilistic smears that the standard interpretation of quantum mechanics suggests. But there's a catch - the tracks the particles follow do not always behave as one would expect from "realistic" trajectories, but often in a fashion that has been termed "surrealistic." [8]

Quantum entanglement—which occurs when two or more particles are correlated in such a way that they can influence each other even across large distances—is not an all-or-nothing phenomenon, but occurs in various degrees. The more a quantum state is entangled with its partner, the better the states will perform in quantum information applications. Unfortunately, quantifying entanglement is a difficult process involving complex optimization problems that give even physicists headaches. [7]

A trio of physicists in Europe has come up with an idea that they believe would allow a person to actually witness entanglement. Valentina Caprara Vivoli, with the University of Geneva, Pavel Sekatski, with the University of Innsbruck and Nicolas Sangouard, with the University of Basel, have together written a paper describing a scenario where a human subject would be able to witness an instance of entanglement—they have uploaded it to the arXiv server for review by others. [6]

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.

Contents

Author: George Rajna

Preface

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. In a new proposed experiment in this area, two toaster-sized "nanosatellites" carrying entangled condensates orbit around the Earth, until one of them moves to a different orbit with different gravitational field strength. As a result of the change in gravity, the entanglement between the condensates is predicted to degrade by up to 20%. Experimentally testing the proposal may be possible in the near future. [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.

New understanding of metastability clears path for next-generation materials

They say diamonds are forever, but diamonds in fact are a metastable form of carbon that will slowly but eventually transform into graphite, another form of carbon. Being able to design and synthesize other long-lived, thermodynamically metastable materials could be a potential gold mine for materials designers, but until now, scientists lacked a rational understanding of them.

Now researchers at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) have published a new study that, for the first time, explicitly quantifies the thermodynamic scale of metastability for almost 30,000 known materials. This paves the way for designing and making promising next-generation materials for use in everything from semiconductors to pharmaceuticals to steels.

"There's a great amount of possibility in the space of metastable materials, but when experimentalists go to the lab to make them, the process is very heuristic—it's trial and error," said Berkeley Lab researcher Wenhao Sun. "What we've done in this research is to understand the metastable phases that have been made, so that we can better understand which metastable phases can be made."

The research was published last week in the journal Science Advances in a paper titled, "The Thermodynamic Scale of Inorganic Crystalline Metastability." Sun, a postdoctoral fellow working with Gerbrand Ceder in Berkeley Lab's Materials Sciences Division, was the lead author, and Ceder was the corresponding author.

The study involved large-scale data mining of the Materials Project, which is a Google-like database of materials that uses supercomputers to calculate properties based on first-principles quantum-mechanical frameworks. The Materials Project, directed by Berkeley Lab researcher Kristin Persson, who was also a co-author of the new paper, has calculated properties of more than 67,000 known and predicted materials with the goal of accelerating materials discovery and innovation.

"Materials design and development is truly a slow process but is now being greatly accelerated by the fact that we can compute properties of compounds before they are made," Ceder said. "Although we still don't fully understand which materials can be made and how, mapping the underlying thermodynamics is an important first step."

Bridging a gap in the fundamental paradigm of materials science

Metastable materials, or materials that transform to another state over a long period of time, are ubiquitous in both nature and technology and often have superior properties. Chocolate, for example, is metastable, with a lower melting point and better texture than stable chocolate. There are also metastable steels that have both toughness and strength, properties not normally found simultaneously in most stable steels.

Scientists would love to develop new materials with certain properties for various applications—an ultra-strong yet lightweight metal for vehicles, for example—but to make any new material with desired properties, materials scientists must understand how synthesizing the material influences its structure, and then how the structure in turn affects its properties and performance. This, Sun explains, is the fundamental paradigm of materials science.

"The Materials Project has helped us link a material's structure to its properties," Ceder said. "What we've done here is the first quantitative step in understanding synthesis-structure relationships."

Sun offers an analogy to food: "If the Materials Project were a cookbook, it'd be like a database of ingredients and delicious dishes but no recipes. Designing recipes is difficult because scientists have a poor understanding of why metastable phases appear during 'cooking.' There are some applications where a metastable material is better, and others where the stable phases are better. This study sets a foundation to investigate how to use computers to predict recipes."

Proposing a new principle of metastability

Previously, scientists had thermodynamic numbers for less than 1,000 metastable compounds. "It's very hard to survey metastability over known materials because there's not much data out there in terms of calorimetry, which is measuring thermodynamic numbers," Sun said.

What's more, metastable materials come in many forms, spanning metal alloys and minerals to ceramics, salts, and more, making a comprehensive survey difficult. "What we've done is large-scale data mining on nearly 30,000 observed materials to explicitly measure the thermodynamic scale of metastability, as a function of a wide variety of parameters, like chemistry and composition, which inorganic chemists and materials scientists can use to build intuition," Sun said.

Based on their observations, the researchers went a step further, to propose a new principle they term "remnant metastability" to explain which metastable materials can be synthesized and which cannot. "We're essentially proposing search criteria¬?we're identifying which crystalline materials can be made, and possibly under what conditions they can be made," Sun said. "We hope this can be a more refined way to think about which crystal structure nature chooses when a material forms." [12]

Scientists fabricate a new class of crystalline solid

Scientists at Lehigh University, in collaboration with Lawrence Berkeley National Laboratory, have demonstrated the fabrication of what they call a new class of crystalline solid by using a laser heating technique that induces atoms to organize into a rotating lattice without affecting the macroscopic shape of the solid.

By controlling the rotation of the crystalline lattice, the researchers say they will be able to make a new type of synthetic single crystals and "bio-inspired" materials that mimic the structure of special biominerals and their superior electronic and optical properties as well.

The group reported its findings today (Nov. 3) in Scientific Reports, a Nature journal, in an article titled "Rotating lattice single crystal architecture on the surface of glass." The paper's lead author is Dmytro Savytskii, a research scientist in the department of materials science and engineering at Lehigh.

The other authors are Volkmar Dierolf, distinguished professor and chair of the department of physics at Lehigh; Himanshu Jain, the T.L. Diamond Distinguished Chair in Engineering and Applied Science and professor of materials science and engineering at Lehigh; and Nobumichi Tamura of the Lawrence Berkeley National Lab in Berkeley, California.

The development of the rotating lattice single (RLS) crystals follows a discovery reported in March in Scientific Reports in which the Lehigh group demonstrated for the first time that a single crystal could be grown from glass without melting the glass.

In a typical crystalline solid, atoms are arranged in a lattice, a regularly repeating, or periodic three-dimensional structure. When viewed from any angle—left to right, up and down, front to back—a crystal-specific periodicity becomes evident. Glass, by contrast, is an amorphous material with a disordered atomic structure.

Because they have no grain boundaries between interconnecting crystals, single-crystal materials often possess exceptional mechanical, optical and electrical properties. Single crystals give diamonds their brilliance and jet turbine blades their resistance to mechanical forces. And the single crystal of silicon of which a silicon chip is made gives it superior conducting properties that form the basis for microelectronics.

The periodicity, or repeating pattern, in a rotating lattice single crystal, said Jain and Dierolf, differs from the periodicity in a typical single crystal.

"We have found that when we grow a crystal out of glass," said Jain, "the periodicity does not result the some way. In one direction, it looks perfect, but if you turn the lattice and look at it from a different angle, you see that the whole structure is rotating."

"In a typical single-crystal material," said Dierolf, "once I figure out how the pattern repeats, then, if I know the precise location of one atom, I can predict the precise location of every atom. This is possible only because single crystals possess a long-range order.

"When we grow an RLS crystal out of glass, however, we have found that the periodicity does not result the some way. To predict the location of every atom, I have to know not just the precise location of a particular atom but the rotation angle of the lattice as well.

"Thus, we have to slightly modify the textbook definition of single crystals."

The rotation, said Jain, occurs at the atomic scale and does not affect the shape of the glass material. "Only the string of atoms bends, not the entire material. We can see the bending of the crystal lattice with x-ray diffraction."

To achieve this rotation, the researchers heat a very small portion of the surface of a solid glass material with a laser, which causes the atoms to become more flexible.

"The atoms want to arrange in a straight line but the surrounding glass does not allow this," said Jain. "Instead, the glass, being completely solid, forces the configuration of the atoms to bend. The atoms move and try to organize in a crystalline lattice, ideally in a perfect single crystal, but they cannot because the glass prevents the perfect crystal from forming and forces the atoms to arrange in a rotational lattice. The beauty is that the rotation occurs smoothly on the micrometer scale.

"Our laser imposes a degree of asymmetry on the growth of the crystal. We control the asymmetry of the heating source to impose this rotational pattern on the atoms."

The group's ability to control the amount of heating is critical to the formation of the rotating lattice, said Jain.

"The key to the creation of the rotating atomic lattice is that it occurs without melting the glass. Melting allows too much freedom of atomic movement, which makes it impossible to control the organization of the lattice.

"Our subtle way of heating the glass overcomes this. We heat only the surface of the glass, not inside. This is very precise, very localized heating. It causes only a limited movement of the atoms, and it allows us to control how the atomic lattice will bend."

Rotating lattices have been observed in certain biominerals in the ocean, said Jain and Dierolf, and it may also occur on a very small scale in some natural minerals as spherulites.

"But no one had previously made this on a larger scale in a controlled way, which we have accomplished with the asymmetrical imposition of a laser to cause the rotating lattice," said Jain.

"Scientists were not able to understand this phenomenon before because they could not observe it on a large enough scale. We are the first group to induce this to happen on an effectively unlimited dimension with a laser."

Jain and Dierolf and their group are planning further studies to improve their ability to manipulate the ordering of the atoms.

The researchers performed the laser heating of the glass at Lehigh and characterized the glass with micro x-ray diffraction on a synchrotron at the Lawrence Berkeley National Lab. They plan to perform further characterization at Berkeley and with electron microscopy at Lehigh.

The project has been funded for six years by the U.S. Department of Energy.

"This is a novel way of making single crystals," said Dierolf. "It opens a new field by creating a material with unique, novel properties." [11]

Collapsing energy bands to explore their geometric structure

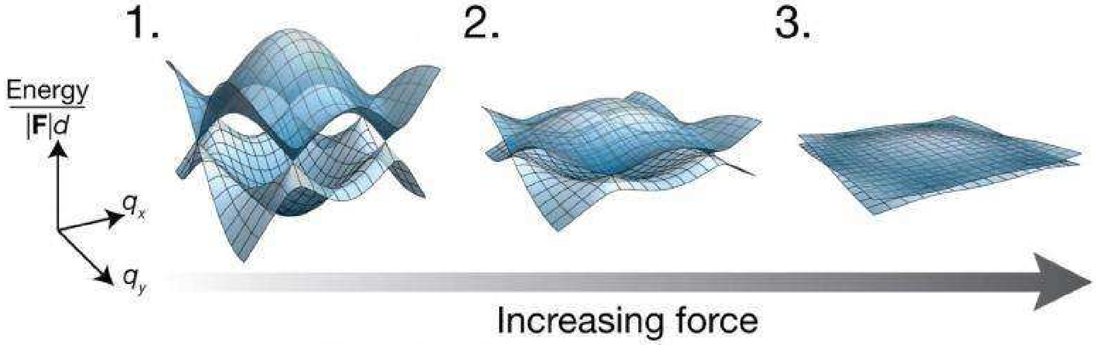


Fig. 1: The researchers accelerated the entire lattice, which results in an inertial force in the frame of the lattice, similar to pulling on a carpet. The larger the force (2,3), the faster the atoms move in crystal momentum space, and the less important the effect of the band energies become. The effect of the band energy is negligible for the strongest forces (3). (F: force, d: distance between neighbouring lattice sites). Credit: T. Li, LMU & MPQ Munich

The geometry and topology of electronic states in solids plays a central role in a wide range of modern condensed-matter systems including graphene or topological insulators. However, experimentally accessing this information has proven to be challenging, especially when the bands are not well-isolated from one another. As reported in last week's issue of Science, an international team of researchers has devised a straightforward method to probe the band geometry using ultracold atoms in an optical lattice. Their method, which combines the controlled steering of atoms through the energy bands with atom interferometry, is an important step in the endeavor to investigate geometric and topological phenomena in synthetic band structures.

A wide array of fundamental phenomena in condensed matter physics, such as why some materials are insulators while others are metals, can be understood simply by examining the energies of the material's constituent electrons. Indeed, band theory, which describes these electron energies, was one of the earliest triumphs of quantum mechanics and has driven much of the technological advances of our time, from the computer chips in our laptops to the liquid-crystal displays on our smartphones. We now know, however, that traditional band theory is incomplete.

Among the most surprising and fruitful developments in modern condensed matter physics was the realization that there is more than the energies—rather, the geometric structure of the bands also plays an important role. This geometric information is responsible for much of the exotic physics in newly discovered materials such as graphene or topological insulators and underlies an array of exciting technological possibilities from spintronics to topological quantum computing. It is, however, notoriously challenging to experimentally access.

Now, an international team of researchers, with experiments performed at the Ludwig-Maximilians-Universität Munich and the Max Planck Institute of Quantum Optics, has devised a straightforward method to probe the band geometry using ultracold atoms in an optical lattice, a synthetic crystal formed from standing waves of light. Their method relies on creating a system that can be described by a quantity known as the Wilson line.

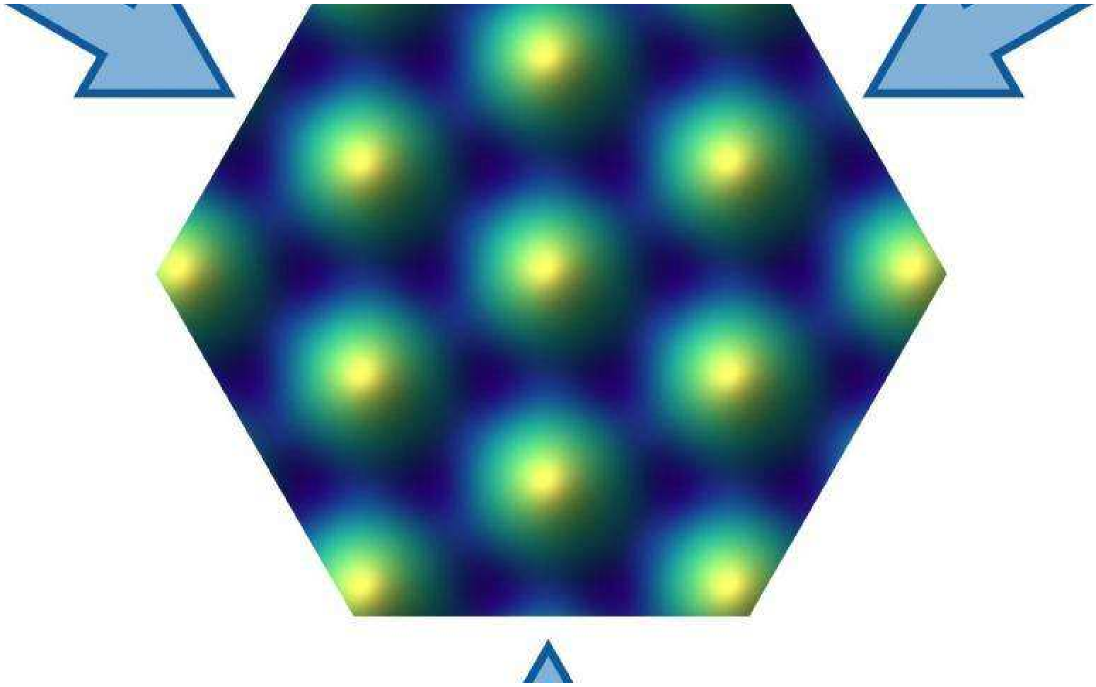


Fig. 2: The researchers interfered three laser beams at 120-degree angles to form a graphene-like honeycomb lattice. The atoms are trapped in the honeycomb structure formed from by the valleys (dark blue) of the potential. Credit: T. Li, LMU & MPQ Munich

Although originally formulated in the context of quantum chromodynamics, Wilson lines surprisingly also describe the evolution of degenerate quantum states, i.e., quantum states with the same energy. Applied to condensed matter systems, the elements of the Wilson line directly encode the geometric structure of the bands.

Therefore, to access the band geometry, the researchers need only to access the Wilson line elements.

The problem, however, is that the bands of a solid are generally not degenerate. The researchers realized that there was a work-around: when moved fast enough in momentum space, the atoms no longer feel the effect of the energy bands and probe only the essential geometric information. In this regime, two bands with two different energies behave like two bands with the same energy (see Figure 1).

In their work, the researchers first cooled atoms to quantum degeneracy. The atoms were then placed into an optical lattice formed by laser beams (Figure 2) to realize a system that mimics the behavior of electrons in a solid, but without the added complexities of real materials. In addition to being exceptionally clean, optical lattices are highly tunable—different types of lattice structures can be created by changing the intensity or the polarization of the light. In their experiment, the researchers interfered three laser beams to form a graphene-like honeycomb lattice.

Although spread out over all lattice sites, the quantum degenerate atoms carry a well-defined momentum in the light crystal. The researchers then rapidly accelerated the atoms to a different momentum and measured the amount of excitations they created. When the acceleration is fast enough, such that the system is described by the Wilson line, this straightforward measurement reveals how the electronic wavefunction at the second momentum differs from the wavefunction at the first momentum. Repeating the same experiment at many different crystal momenta would yield a complete map of how the wavefunctions change over the entire momentum space of the artificial solid.

The researchers not only confirmed that it was possible to move the atoms such that the dynamics were described by two-band Wilson lines; they also revealed both the local, geometric properties and the global, topological structure of the bands. While the lowest two bands of the honeycomb lattice are known not to be topological, the results demonstrate that Wilson lines can indeed be experimentally used to probe and reveal the band geometry and topology in these novel synthetic settings. [10]

Moving electrons around loops with light: A quantum device based on geometry

Researchers at the University of Chicago's Institute for Molecular Engineering and the University of Konstanz have demonstrated the ability to generate a quantum logic operation, or rotation of the qubit, that - surprisingly—is intrinsically resilient to noise as well as to variations in the strength or duration of the control. Their achievement is based on a geometric concept known as the Berry phase and is implemented through entirely optical means within a single electronic spin in diamond.

Their findings were published online Feb. 15, 2016, in Nature Photonics and will appear in the March print issue. "We tend to view quantum operations as very fragile and susceptible to noise, especially when compared to conventional electronics," remarked David Awschalom, the Liew Family Professor of Molecular Engineering and senior scientist at Argonne National Laboratory, who led the research. "In contrast, our approach shows incredible resilience to external influences and fulfills a key requirement for any practical quantum technology."

Quantum geometry

When a quantum mechanical object, such as an electron, is cycled along some loop, it retains a memory of the path that it travelled, the Berry phase. To better understand this concept, the Foucault pendulum, a common staple of science museums helps to give some intuition. A pendulum, like those in a grandfather clock, typically oscillates back and forth within a fixed plane. However, a Foucault pendulum oscillates along a plane that gradually rotates over the course of a day due to Earth's rotation, and in turn knocks over a series of pins encircling the pendulum.

The number of knocked-over pins is a direct measure of the total angular shift of the pendulum's oscillation plane, its acquired geometric phase. Essentially, this shift is directly related to the location of the pendulum on Earth's surface as the rotation of Earth transports the pendulum along a specific closed path, its circle of latitude. While this angular shift depends on the particular path traveled, Awschalom said, it remarkably does not depend on the rotational speed of Earth or the oscillation frequency of the pendulum.

"Likewise, the Berry phase is a similar path-dependent rotation of the internal state of a quantum system, and it shows promise in quantum information processing as a robust means to manipulate qubit states," he said.

A light touch

In this experiment, the researchers manipulated the Berry phase of a quantum state within a nitrogen-vacancy (NV) center, an atomic-scale defect in diamond. Over the past decade and a half, its electronic spin state has garnered great interest as a potential qubit. In their experiments, the team members developed a method with which to draw paths for this defect's spin by varying the applied laser light. To demonstrate Berry phase, they traced loops similar to that of a tangerine slice within the quantum space of all of the potential combinations of spin states.

"Essentially, the area of the tangerine slice's peel that we drew dictated the amount of Berry phase that we were able to accumulate," said Christopher Yale, a postdoctoral scholar in Awschalom's laboratory, and one of the co-lead authors of the project.

This approach using laser light to fully control the path of the electronic spin is in contrast to more common techniques that control the NV center spin, through the application of microwave fields. Such an approach may one day be useful in developing photonic networks of these defects, linked and controlled entirely by light, as a way to both process and transmit quantum information.

A noisy path

A key feature of Berry phase that makes it a robust quantum logic operation is its resilience to noise sources. To test the robustness of their Berry phase operations, the researchers intentionally added noise to the laser light controlling the path. As a result, the spin state would travel along its intended path in an erratic fashion.

However, as long as the total area of the path remained the same, so did the Berry phase that they measured.

"In particular, we found the Berry phase to be insensitive to fluctuations in the intensity of the laser. Noise like this is normally a bane for quantum control," said Brian Zhou, a postdoctoral scholar in the group, and co-lead author.

"Imagine you're hiking along the shore of a lake, and even though you continually leave the path to go take pictures, you eventually finish hiking around the lake," said F. Joseph Heremans, co-lead author, and now a staff scientist at Argonne National Laboratory. "You've still hiked the entire loop regardless of the bizarre path you took, and so the area enclosed remains virtually the same."

These optically controlled Berry phases within diamond suggest a route toward robust and fault-tolerant quantum information processing, noted Guido Burkard, professor of physics at the University of Konstanz and theory collaborator on the project.

"Though its technological applications are still nascent, Berry phases have a rich underlying mathematical framework that makes them a fascinating area of study," Burkard said. [9]

Researchers demonstrate 'quantum surrealism'

In a new version of an old experiment, CIFAR Senior Fellow Aephraim Steinberg (University of Toronto) and colleagues tracked the trajectories of photons as the particles traced a path through one of two slits and onto a screen. But the researchers went further, and observed the "nonlocal" influence of another photon that the first photon had been entangled with.

The results counter a long-standing criticism of an interpretation of quantum mechanics called the De Broglie-Bohm theory. Detractors of this interpretation had faulted it for failing to explain the behaviour of entangled photons realistically. For Steinberg, the results are important because they give us a way of visualizing quantum mechanics that's just as valid as the standard interpretation, and perhaps more intuitive.

"I'm less interested in focusing on the philosophical question of what's 'really' out there. I think the fruitful question is more down to earth. Rather than thinking about different metaphysical interpretations, I would phrase it in terms of having different pictures. Different pictures can be useful. They can help shape better intuitions."

At stake is what is "really" happening at the quantum level. The uncertainty principle tells us that we can never know both a particle's position and momentum with complete certainty. And when we do interact with a quantum system, for instance by measuring it, we disturb the system. So if we fire a photon at a screen and want to know where it will hit, we'll never know for sure exactly where it will hit or what path it will take to get there.

The standard interpretation of quantum mechanics holds that this uncertainty means that there is no "real" trajectory between the light source and the screen. The best we can do is to calculate a "wave function" that shows the odds of the photon being in any one place at any time, but won't tell us where it is until we make a measurement.

Yet another interpretation, called the De Broglie-Bohm theory, says that the photons do have real trajectories that are guided by a "pilot wave" that accompanies the particle. The wave is still probabilistic, but the particle takes a real trajectory from source to target. It doesn't simply "collapse" into a particular location once it's measured.

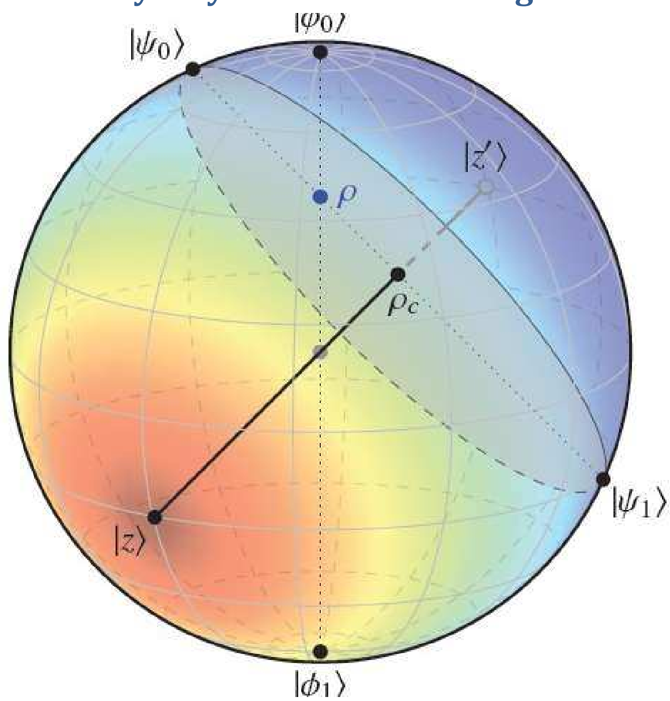
In 2011 Steinberg and his colleagues showed that they could follow trajectories for photons by subjecting many identical particles to measurements so weak that the particles were barely disturbed, and then averaging out the information. This method showed trajectories that looked similar to classical ones - say, those of balls flying through the air.

But critics had pointed out a problem with this viewpoint. Quantum mechanics also tells us that two particles can be entangled, so that a measurement of one particle affects the other. The critics complained that in some cases, a measurement of one particle would lead to an incorrect prediction of the trajectory of the entangled particle. They coined the term "surreal trajectories" to describe them.

In the most recent experiment, Steinberg and colleagues showed that the surrealism was a consequence of non-locality - the fact that the particles were able to influence one another instantaneously at a distance. In fact, the "incorrect" predictions of trajectories by the entangled photon were actually a consequence of where in their course the entangled particles were measured. Considering both particles together, the measurements made sense and were consistent with real trajectories.

Steinberg points out that both the standard interpretation of quantum mechanics and the De Broglie-Bohm interpretation are consistent with experimental evidence, and are mathematically equivalent. But it is helpful in some circumstances to visualize real trajectories, rather than wave function collapses, he says. [8]

Physicists discover easy way to measure entanglement—on a sphere



Entanglement on a sphere: This Bloch sphere shows entanglement for the one-root state ρ and its radial state ρc. The color on the sphere corresponds to the value of the entanglement, which is determined by the distance from the root state z, the point at which there is no entanglement. The closer to z, the less the entanglement (red); the further from z, the greater the entanglement (blue). Credit: Regula and Adesso. ©2016 American Physical Society

Now in a new paper to be published in Physical Review Letters, mathematical physicists Bartosz Regula and Gerardo Adesso at The University of Nottingham have greatly simplified the problem of measuring entanglement.

To do this, the scientists turned the difficult analytical problem into an easy geometrical one. They showed that, in many cases, the amount of entanglement between states corresponds to the distance between two points on a Bloch sphere, which is basically a normal 3D sphere that physicists use to model quantum states.

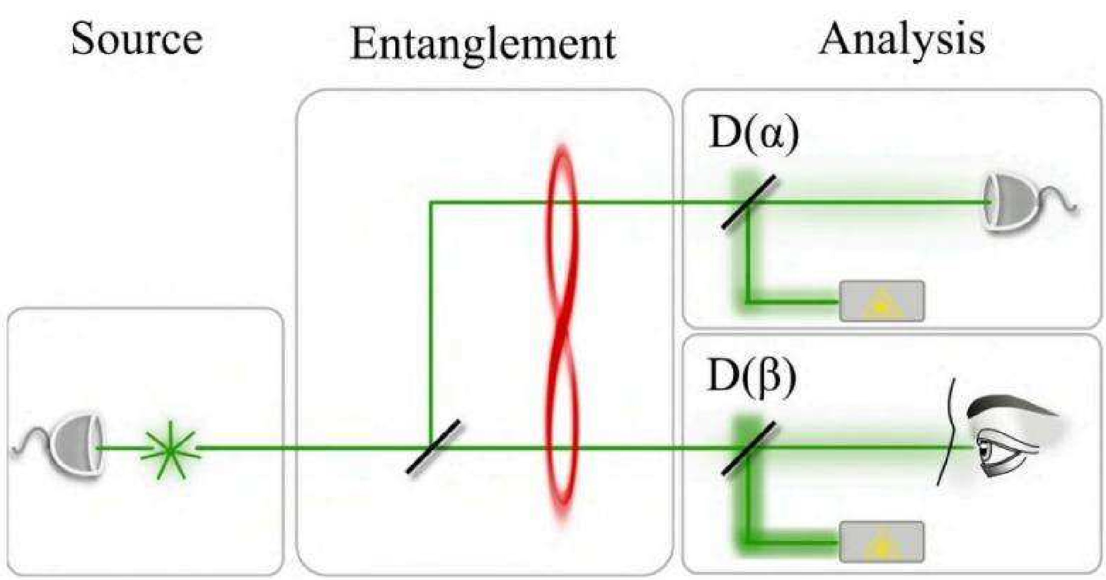
As the scientists explain, the traditionally difficult part of the math problem is that it requires finding the optimal decomposition of mixed states into pure states. The geometrical approach completely eliminates this requirement by reducing the many possible ways that states could decompose down to a single point on the sphere at which there is zero entanglement. The approach requires that there be only one such point, or "root," of zero entanglement, prompting the physicists to describe the method as "one root to rule them all."

The scientists explain that the "one root" property is common among quantum states and can be easily verified, transforming a formidable math problem into one that is trivially easy. They demonstrated that the new approach works for many types of two-, three- and four-qubit entangled states.

"This method reveals an intriguing and previously unexplored connection between the quantum features of a state and classical geometry, allowing all one-root states to enjoy a convenient visual representation which considerably simplifies the study and understanding of their properties," the researchers explained.

The simple way of measuring a state's entanglement could have applications in many technological areas, such as quantum cryptography, computation, and communication. It could also provide insight into understanding the foundations of thermodynamics, condensed matter physics, and biology. [7]

An idea for allowing the human eye to observe an instance of entanglement



Scheme of the proposal for detecting entanglement with the human eye. Credit: arXiv:1602.01907

Entanglement, is of course, where two quantum particles are intrinsically linked to the extent that they actually share the same existence, even though they can be separated and moved apart. The idea was first proposed nearly a century ago, and it has not only been proven, but researchers routinely cause it to occur, but, to date, not one single person has every actually seen it happen—they only know it happens by conducting a series of experiments. It is not clear if anyone has ever actually tried to see it happen, but in this new effort, the research trio claim to have found a way to make it happen—if only someone else will carry out the experiment on a willing volunteer.

The idea involves using a beam splitter and two beans of light—an initial beam of coherent photons fired at the beam splitter and a secondary beam of coherent photons that interferes with the photons in the first beam causing a change of phase, forcing the light to be reflected rather than transmitted. In such a scenario, the secondary beam would not need to be as intense as the first, and could in fact be just a single coherent photon—if it were entangled, it could be used to allow a person to see the more powerful beam while still preserving the entanglement of the original photon.

The researchers suggest the technology to carry out such an experiment exists today, but also acknowledge that it would take a special person to volunteer for such an assignment because to prove that they had seen entanglement taking place would involve shooting a large number of photons in series, into a person's eye, whereby the resolute volunteer would announce whether they had seen the light on the order of thousands of times. [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]

The Secret of Quantum Entanglement

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] When one of the entangled particles wave function is collapses by measurement, the intermediate photon also collapses and transforms its state to the second entangled particle giving it the continuity of this entanglement. Since the accelerated charges are self-maintaining their potential locally causing their acceleration, it seems that they entanglement is a spooky action at a distance.

Conclusions

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

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.

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 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. 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.

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