Nanomaterials for DNA Diagnostics

Led by MIPT's Maxim Nikitin, the team published a paper in ACS Nano, presenting a smart material with unique properties, which holds promise for express DNA analysis and next-generation drugs against cancer and other serious diseases. [16]

IBS scientists have reported a novel targeting strategy that allows deep tumor penetration of drug-loaded nanoparticles. [15]

In the journal PNAS this week, researchers at Boston Children's Hospital and MIT show that these mini-antibodies, shrunk further to create so-called nanobodies, may help solve a problem in the cancer field: making CAR T-cell therapies work in solid tumors. [14]

What if the brain could detect its own disease? Researchers have been trying to create a material that "thinks" like the brain does, which would be more sensitive to early signs of neurological diseases such as Parkinson's. [13]

University Professor of Applied Physics Stephen Arnold and his team at the New York University Tandon School of Engineering have made a discovery that could lead to Star Trek-like biosensor devices capable of flagging the barest presence in blood of a specific virus or antibody, or protein marker for a specific cancer; or sniffing out airborne chemical warfare agents while they are still far below toxic levels. [12]

Lead researcher Dr Jonathan Breeze, from Imperial's Department of Materials, said: "This breakthrough paves the way for the widespread adoption of masers and opens the door for a wide array of applications that we are keen to explore. We hope the maser will now enjoy as much success as the laser." [11]

Japanese researchers have optimized the design of laboratory-grown, synthetic diamonds. [10]

Nearly 75 years ago, Nobel Prize-winning physicist Erwin Schrödinger wondered if the mysterious world of quantum mechanics played a role in biology. A recent finding by Northwestern University's Prem Kumar adds further evidence that the answer might be yes. [9]

A UNSW Australia-led team of researchers has discovered how algae that survive in very low levels of light are able to switch on and off a weird quantum phenomenon that occurs during photosynthesis. [8]

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This paper contains the review of quantum entanglement investigations in living systems, and in the quantum mechanically modeled photoactive prebiotic kernel systems. [7]

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems.

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 understand the Quantum Biology.

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Author: George Rajna

Preface

We define our modeled self-assembled supramolecular photoactive centers, composed of one or more sensitizer molecules, precursors of fatty acids and a number of water molecules, as a photoactive prebiotic kernel system. [7]

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems. [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.

Scientists create supersensitive nanomaterials for DNA diagnostics and targeted drug delivery

In 1900, German physician Paul Ehrlich came up with the notion of a "magic bullet." The basic idea is to inject a patient with smart particles capable of finding, recognizing, and treating a disease. Medicine has pursued the magic bullet ever since.

Russian researchers from the Moscow Institute of Physics and Technology and Prokhorov General Physics Institute, RAS, have made headway toward that goal. Led by MIPT's Maxim Nikitin, the team published a paper in *ACS Nano*, presenting a smart material with unique properties, which holds promise for express DNA analysis and next-generation drugs against cancer and other serious diseases.

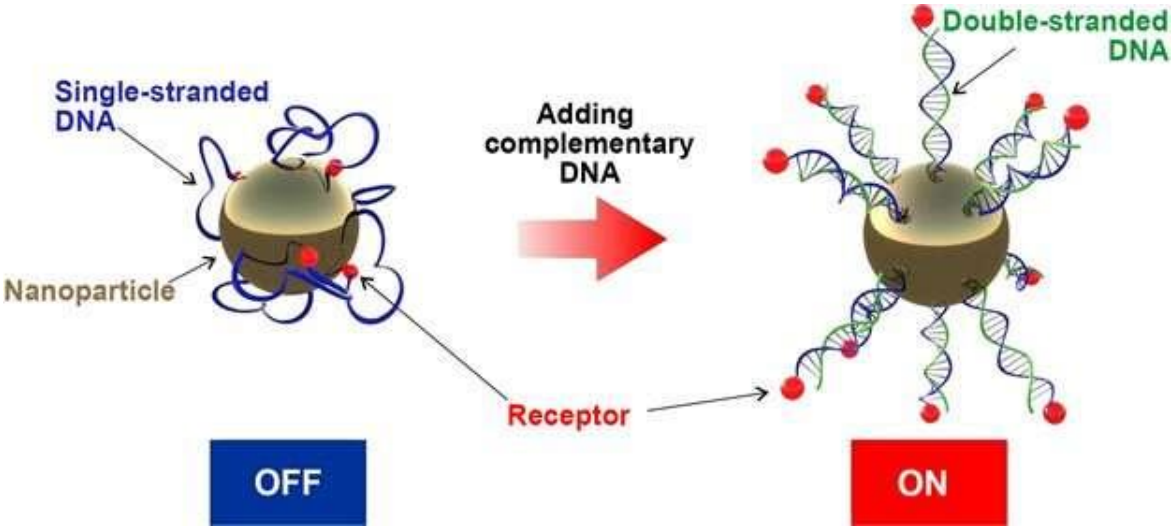
Delivering medications to the cells affected by a disease is a major bottleneck in diagnostics and therapy. The drugs should ideally reach the pathogenic cells only, without doing any harm to the healthy ones. There are a range of marker compounds that give away cancer cells. Among these

telltale molecules, found on the surface of the affected cells or in their microenvironment, are waste products and those sent to other cells as signals.

Modern drugs rely on one such marker to identify sick cells. However, it is usually the case that healthy cells carry the same markers, albeit in smaller quantities. This means the existing targeted drug delivery systems are not perfect. To make drug delivery more specific, smart materials are required that are capable of analyzing multiple environment parameters at once, seeking out the target with a greater precision.

"The conventionally used methods for drug delivery are like sending a letter with the city and street written on the envelope, but without the house and apartment numbers," principal investigator and the head of MIPT's Nanobiotechnology Lab Maxim Nikitin commented. "We need to be able to analyze more parameters to ensure effective delivery."

Previously, Nikitin and co-authors developed nano- and microparticles capable of conducting complex logic computations via biochemical reactions. In their 2014 paper in *Nature Nanotechnology*, the researchers reported that their autonomous nanocomputers could analyze many parameters of a target and were therefore much better at its identification.



Adding a complementary DNA strand activates the receptors on the nanoparticle surface. Credit: Vladimir Cherkasov et al.

The past few years have seen many advances in biocomputing materials. By 2018, hundreds upon hundreds of papers had been published on the subject. *Chemical Reviews*, the field's most reputable journal, published a review of contemporary nanorobotics and biocomputing. The paper, with the subtitle "Dawn of Theranostic Nanorobots," was authored by researchers from MIPT's Nanobiotechnology Lab and the Biophotonics Lab of Prokhorov General Physics Institute of the Russian Academy of Sciences (RAS).

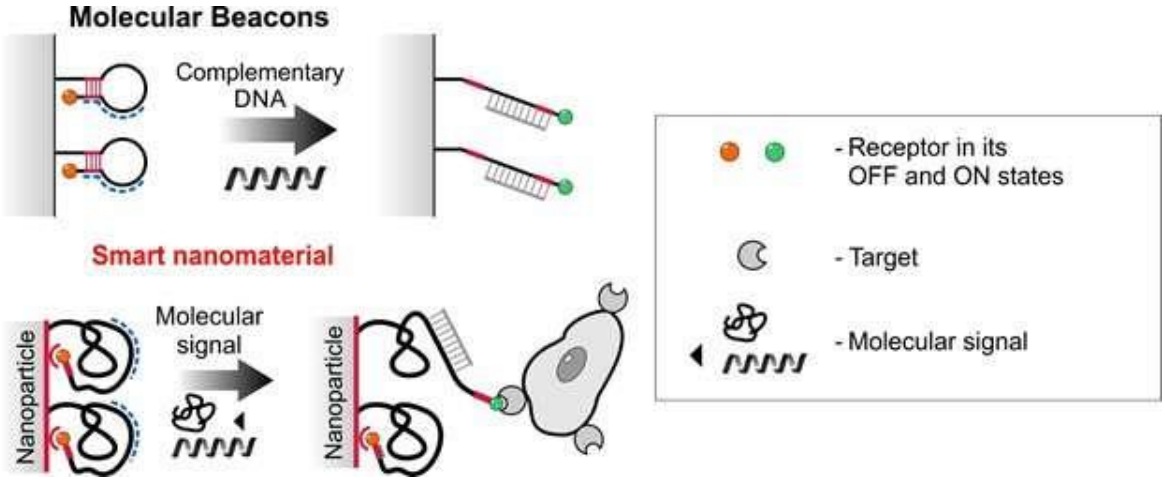
Despite the efforts of numerous research teams around the world trying to expand the functionality of biocomputing materials, they are still not sensitive enough to disease markers, rendering practical applications impossible.

The recent paper of the team in *ACS Nano* marks a breakthrough in this field. They have developed a unique smart material characterized by supersensitivity to DNA signals. It is several orders of magnitude more sensitive than the closest competitor. Moreover, the new material exhibits a higher sensitivity than that of the vast majority of currently available express DNA assays.

The researchers achieved that remarkable result after they discovered that DNA molecules exhibit unusual behavior on the surface of nanoparticles.

In the study, one end of a single-stranded DNA molecule was pinned to a nanoparticle. Importantly, the molecule had no hairpins—that is, double-stranded segments where part of the chain sticks to itself. The team outfitted the other end of the DNA chain with a small molecular receptor. Contrary to expectations, the receptor did not bind its target. After ruling out a mistake, the scientists hypothesized that single-stranded DNA might stick to the nanoparticle and coil up, hiding the receptor beneath it, on the particle's surface.

The hypothesis proved right when the team added complementary single strands of DNA to their particle. The receptor instantly became active, binding its target. This happened because the bonds between the complementary nucleotides caused the two DNA strands to form a rigid double helix, or duplex. Like a chameleon's tongue, the strand uncoiled, exposing the receptor for target binding.



A comparison between molecular beacons and the smart material developed by the authors of the study. Credit: Vladimir Cherkasov et al.

Such uncoiling of the DNA strand resembles that of a molecular beacon. This refers to a single-stranded DNA whose one end forms a duplex with the opposite end, folding up the structure. A complementary strand of DNA can unfold the beacon. However, there is a significant and useful distinction. "Unlike molecular beacons, the discovered phenomenon enables tuning the force of DNA curling on the nanoparticle separately from the straightening force of input DNA. This leads to dramatically better sensitivity to the input," noted the study's first author Vladimir Cherkasov, a leading researcher at the Nanobiotechnology Lab, MIPT.

In their paper, the researchers demonstrate agents capable of detecting DNA concentrations as low as 30 femtomoles (30 billionths of a millionth of a mole) per liter, without DNA and/or signal amplification. The study's co-author Elizaveta Mochalova, a doctoral student at MIPT's Nanobiotechnology Lab, added: "We showed the sensitivity to be so high with a quite simple lateral

flow assay, which is widely used in pregnancy tests. Unlike the existing DNA assays, such tests can be performed outside a clean laboratory setting and require no advanced equipment. This makes the technology well-suited to rapid infectious disease screening, food testing kits for home use, and similar things."

The authors of the paper have also showed the technology to be applicable to the design of smart nanoagents that would recognize cancer cells based on the concentration of small DNA in their microenvironment. Not long ago, small nucleic acids were thought to be just meaningless debris resulting from the recycling of larger functional molecules. However, small RNAs turned out to be key regulators of many processes in living cells. Biologists are currently identifying disease markers among these RNAs.

"Interestingly, the smaller the length of the nucleic acid to be detected, the more competitive our technology becomes," Nikitin commented. "We can fabricate ultrasensitive agents controlled by well-studied small RNAs that are 17 to 25 bases long. However, if we take sequences that are less than 10 nucleotides long, there are simply no technologies with comparable sensitivity."

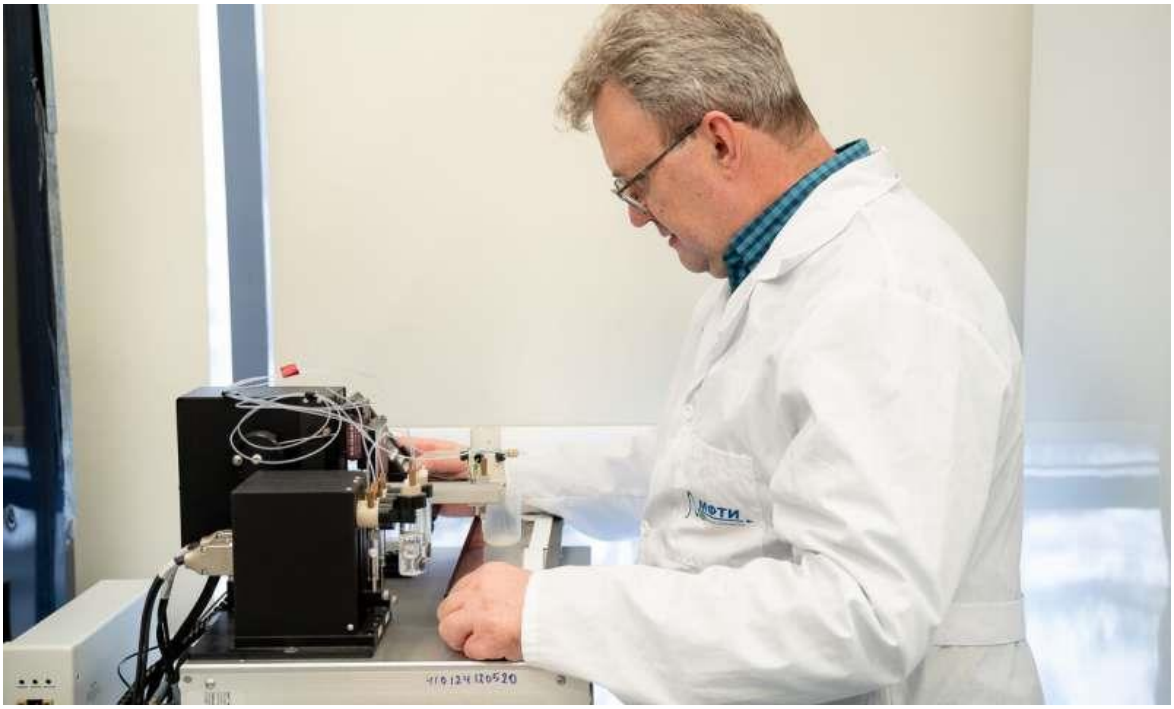


Photo. Vladimir Cherkasov, a leading researcher at the Nanobiotechnology Lab, MIPT, prepares test strips for an express DNA assay. Credit: Evgeniy Pelevin/MIPT

"What's even more exciting is that our method enables probing the microenvironment of cells to determine whether shorter small RNAs are useful disease markers rather than the meaningless compounds they are commonly held to be due to the difficulties in their detection," the scientist added.

The newly developed technology offers prospects for genomics, both in terms of express point-of-care DNA assays and for developing next-generation therapeutic nanomaterials. The recent years have seen immense breakthroughs in genome research and editing, but the new technology could

solve the problem that remains relevant: delivering drugs only to the cells with a particular microenvironment genetic profile.

The researchers plan to continue developing their technology. This includes future work at MIPT's recently established Center for Genomic Technologies and Bioinformatics. [16]

Nanoparticles 'click' immune cells to make a deeper penetration into tumors

IBS scientists have reported a novel targeting strategy that allows deep tumor penetration of drug-loaded nanoparticles. They induced the linking of immune cell-targeting antibodies to drug-loaded nanoparticles on the cells, instead of taking them up in the cells or using antibody-nanoparticle conjugates.

Tiny nanobots flowing through the body to repair damaged cells. Once supposed to be considered as science fiction, these microrobots are becoming a reality with a slew of experimental trials. It is generally thought that nanoparticles are so tiny that they can roam freely all over the body after administration. However, this is only partly true. In a tumor, nanoparticles can make inroads into tumors only as deep as 100 µm from the vessels. The diffusion of the nanoparticles can be also hindered by several barriers, such as dense tumor tissue, high interstitial pressure, and inhomogeneous vascular distribution. Thus, cancer cells located deep in the tissue may survive, resulting in recurrence.

Interestingly, it is reported that immune cells tend to accumulate at deep tumors. As tumors outgrow blood supply, immune cells are preferentially recruited to a tumor microenvironment to support the blood supply to tumors and tissue remodeling. There have been several attempts to use immune cells to deliver anti-cancer drugsto the regions inaccessible by conventional targeting approaches. Since most of them require time-consuming manipulations to extract, grow, and inject cells, this ex vivo process lowers efficacy of the treatment. Others explored ways to have antibody carrying nanoparticles target immune cells. Again, this approach proves ineffective as nanoparticles bulk up with the chemotherapy drug carried and cannot reach the designations efficiently.

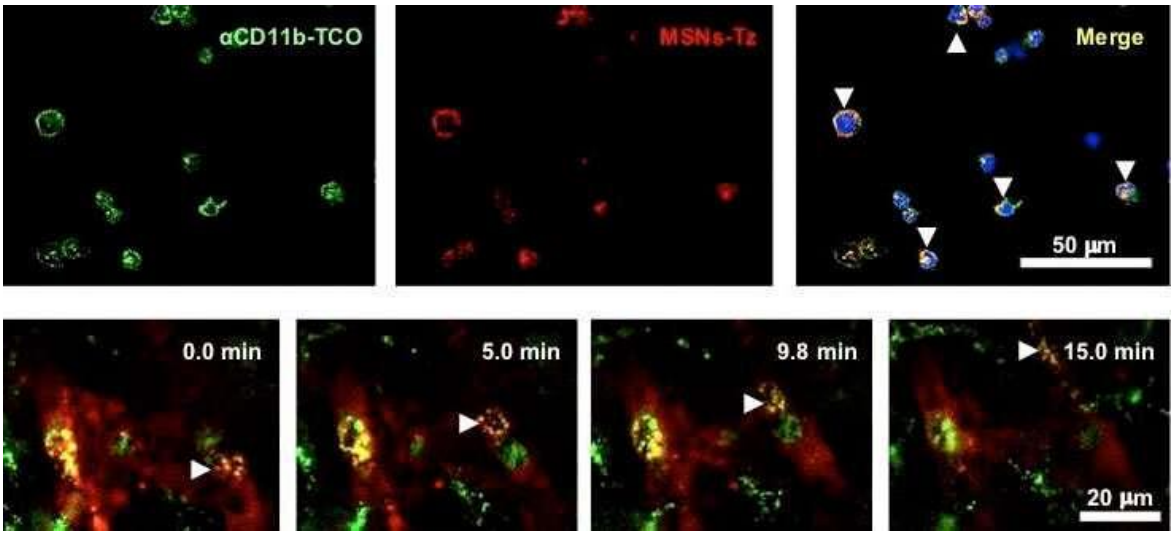


Figure 2: (top) In vitro evaluation of click reaction between antibodies (green) and nanoparticles (red) on immune cells. (bottom) Immune cells transporting nanoparticles migrate in the blood vessels. White arrows indicate yellow immune cells as they are tagged with both antibodies (green) and nanoparticles (red). Credit: IBS

In a paper published in *Journal of the American Chemical Society*, the joint research team led by Director Taeghwan Hyeon at the Center for Nanoparticles within the Institute for Basic Science (IBS) in Daejeon, Dr. Seung-Hae Kwon at Korea Basic Science Institute in Seoul, and Prof. Nohyun Lee at Kookmin University in Seoul, South Korea reported a novel targeting strategy that allows deep tumor penetration of drug-loaded nanoparticles. They used a "click reaction," a chemical reaction that easily joins molecular building blocks just as two pieces of a seat belt "click" to buckle. "Our idea was to induce the linking of immune cell-targeting antibodies to drug-loaded nanoparticles on the cells, instead of taking them up in the cells or using antibody-nanoparticle conjugates. Most other studies did so and failed to produce satisfactory results," notes Professor Nohyun Lee, the corresponding author of the study.

In a click reaction, chemical reagents enable an easy link of unnatural chemical groups to any site of a target protein with high site-selectivity. In the study, researchers used the click reaction between trans-cyclooctene and tetrazine. Trans-cyclooctene-functionalized antibodies are injected into mice to label tumor-infiltrating immune cells. After a certain time, tetrazine-functionalized mesoporous silica nanoparticles are administered so that they "click" to link up to immune cells. "This click reaction-assisted immune cell targeting (CRAIT) strategy successfully "invaded" the intended areas: Real-time fluorescence imaging of the tumor tissue shows that motile immune cells transport the nanoparticles as seen in Figure 2. Compared to passive targeting, the CRAIT method brought a twofold reduction in the tumorburden in aggressive breast cancer models," explains Dr. Soo Hong Lee, the first author of the study. The nanoparticles loaded with an anticancer drug, doxorubicin, did not affect the viability and migration of the cells.

Director Taeghwan Hyeon, the corresponding author of the study says, "The intratumoral distribution of nanoparticles delivered by the CRAIT method was the key to overcoming limitations of conventional delivery methods. This study will broaden the application of nanomedicines."

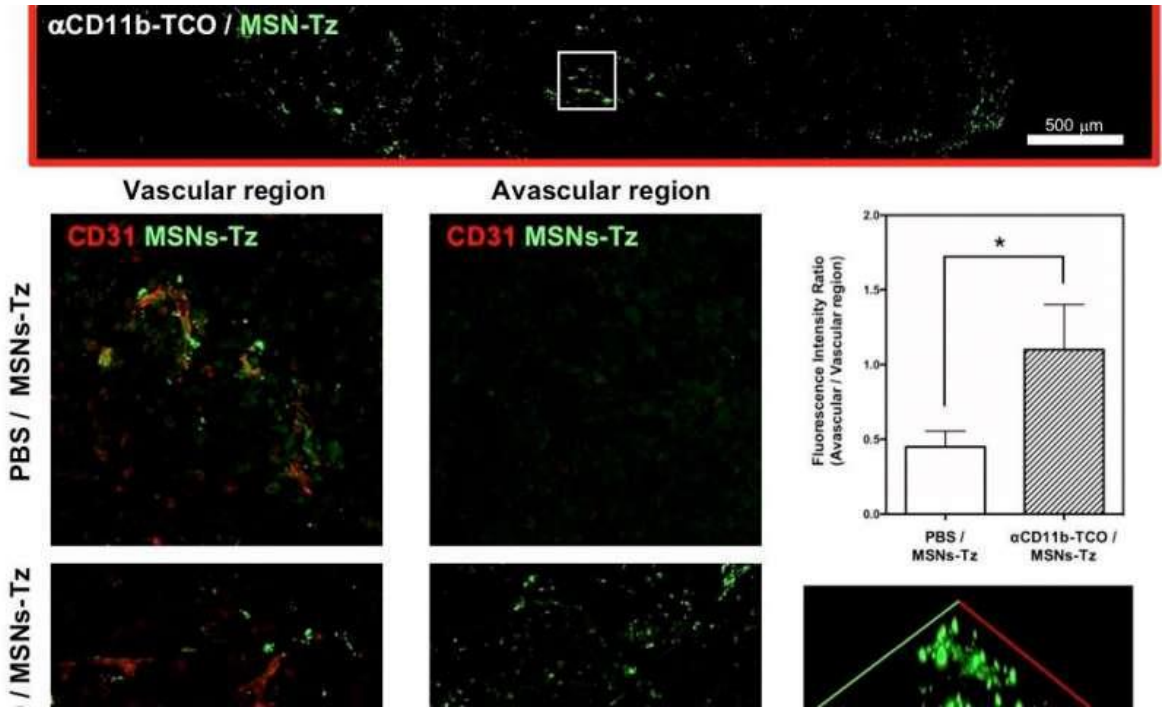


Figure 3: (top) Representative tumors sections selected to show the distribution of nanoparticles in the non-targeted group (orange box) and the CRAIT group (red box). (middle and bottom, left and middle) Intratumoral distribution of the non-targeted group (middle) and the CRAIT group (bottom) in the vascular region (left) and the avascular region (middle). (right, middle) Ratio between vascular and region of non-targeted group and CRAIT group. (right, bottom) Three-dimensional microscopy image of the tumor section. Credit: IBS

Since the CRAIT method relies on the click reaction, it can be applied to various delivery vehicles including micelles, liposomes, and other nanoparticles. Additionally, if adequate antibodies are available, various circulating cells can be used as delivery vehicles. Because the circulating cells are involved in various inflammatory diseases, the coverage of the CRAIT method is not limited to cancer. The versatile CRAIT method is simple, which requires modification of antibodies and nanoparticles using well-developed bio-conjugation reaction. [15]

'Nanobodies' from alpacas could help bring CAR T-cell therapy to solid tumors

In 1989, two undergraduate students at the Free University of Brussels were asked to test frozen blood serum from camels, and stumbled on a previously unknown kind of antibody. It was a miniaturized version of a human antibody, made up only of two heavy protein chains, rather than two light and two heavy chains. As they eventually reported, the antibodies' presence was confirmed not only in camels, but also in llamas and alpacas.

Fast forward 30 years. In the journal *PNAS* this week, researchers at Boston Children's Hospital and MIT show that these mini-antibodies, shrunk further to create so-called nanobodies, may help solve a problem in the cancer field: making CAR T-cell therapies work in solid tumors.

Highly promising for blood cancers, chimeric antigen receptor (CAR) T-cell therapy genetically engineers a patient's own T cells to make them better at attacking cancer cells. The Dana-Farber/Boston Children's Cancer and Blood Disorders Center is currently using CAR T-cell therapy for relapsed acute lymphocytic leukemia (ALL), for example.

But CAR T cells haven't been good at eliminating solid tumors. It's been hard to find cancer-specific proteins on solid tumors that could serve as safe targets. Solid tumors are also protected by an extracellular matrix, a supportive web of proteins that acts as a barrier, as well as immunosuppressive molecules that weaken the T-cell attack.

Rethinking CAR T cells

That's where nanobodies come in. For two decades, they largely remained in the hands of the Belgian team. But that changed after the patent expired in 2013.

"A lot of people got into the game and began to appreciate nanobodies' unique properties," says Hidde Ploegh, Ph.D., an immunologist in the Program in Cellular and Molecular Medicine at Boston Children's and senior investigator on the *PNAS* study.

One useful attribute is their enhanced targeting abilities. Ploegh and his team at Boston Children's, in collaboration with Noo Jalikhani, Ph.D., and Richard Hynes, Ph.D. at MIT's Koch Institute for Integrative Cancer Research, have harnessed nanobodies to carry imaging agents, allowing precise visualization of metastatic cancers.

The Hynes team targeted the nanobodies to the tumors' extracellular matrix, or ECM—aiming imaging agents not at the cancer cells themselves, but at the environment that surrounds them. Such markers are common to many tumors, but don't typically appear on normal cells.

"Our lab and the Hynes lab are among the few actively pursuing this approach of targeting the tumor micro-environment," says Ploegh. "Most labs are looking for tumor-specific antigens."

Targeting tumor protectors

Ploegh's lab took this idea to CAR T-cell therapy. His team, including members of the Hynes lab, took aim at the very factors that make solid tumors difficult to treat.

The CAR T cells they created were studded with nanobodies that recognize specific proteins in the tumor environment, bearing signals directing them to kill any cell they bound to. One protein, EIIIB, a variant of fibronectin, is found only on newly formed blood vessels that supply tumors with nutrients. Another, PD-L1, is an immunosuppressive protein that most cancers use to silence approaching T cells.

Biochemist Jessica Ingram, Ph.D. of the Dana-Farber Cancer Institute, Ploegh's partner and a coauthor on the paper, led the manufacturing pipeline. She would drive to Amherst, Mass., to gather T cells

from two alpacas, Bryson and Sanchez, inject them with the antigen of interest and harvest their blood for further processing back in Boston to generate mini-antibodies.

Taking down melanoma and colon cancer

Tested in two separate melanoma mouse models, as well as a colon adenocarcinoma model in mice, the nanobody-based CAR T cells killed tumor cells, significantly slowed tumor growth and improved the animals' survival, with no readily apparent side effects.

Ploegh thinks that the engineered T cells work through a combination of factors. They caused damage to tumor tissue, which tends to stimulate inflammatory immune responses. Targeting EIIIB may damage blood vessels in a way that decreases blood supply to tumors, while making them more permeable to cancer drugs.

"If you destroy the local blood supply and cause vascular leakage, you could perhaps improve the delivery of other things that might have a harder time getting in," says Ploegh. "I think we should look at this as part of a combination therapy."

Future directions

Ploegh thinks his team's approach could be useful in many solid tumors. He's particularly interested in testing nanobody-based CAR T cells in models of pancreatic cancer and cholangiocarcinoma, a bile duct cancer from which Ingram passed away in 2018.

The technology itself can be pushed even further, says Ploegh.

"Nanobodies could potentially carry a cytokine to boost the immune response to the tumor, toxic molecules that kill tumor and radioisotopes to irradiate the tumor at close range," he says. "CAR T cells are the battering ram that would come in to open the door; the other elements would finish the job. In theory, you could equip a single T cell with multiple chimeric antigen receptors and achieve even more precision. That's something we would like to pursue."

Yushu Joy Xie, a graduate student in Boston Children's Program in Cellular and Molecular Medicine and MIT's Koch Institute, was first author on the paper. Supporters include the Lustgarten Foundation, the National Science Foundation, the National Institutes of Health, the American Gastroenterological Association, the Howard Hughes Medical Institute Department of Defense and the National Cancer Institute. See the paper for details on authors and funders. [14]

New quantum material could warn of neurological disease

What if the brain could detect its own disease? Researchers have been trying to create a material that "thinks" like the brain does, which would be more sensitive to early signs of neurological diseases such as Parkinson's.

Thinking is a long way off, but Purdue University and Argonne National Laboratory researchers have engineered a new material that can at least "listen."

The lingua franca is ionic currents, which help the brain perform a particular reaction, needed for something as basic as sending a signal to breathe. Detecting ions means also detecting the concentration of a molecule, which serves as an indicator of the brain's health.

In a study published in *Nature Communications*, researchers demonstrate the ability of a quantum material to automatically receive hydrogen when placed beneath an animal model's brain slice. Quantum means that the material has electronic properties that both can't be explained by classical physics, and that give it a unique edge over other materials used in electronics, such as silicon.

The edge, in this case, is strong, "correlated" electrons that make the material extra sensitive and extra tunable.

"The goal is to bridge the gap between how electronics think, which is via electrons, and how the brain thinks, which is via ions. This material helped us find a potential bridge," said Hai-Tian Zhang, a Gilbreth postdoctoral fellow in Purdue's College of Engineering and first author on the paper.

In the long run, this material might even bring the ability to "download" your brain, the researchers say.

"Imagine putting an electronic device in the brain, so that when natural brain functions start deteriorating, a person could still retrieve memories from that device," said Shriram Ramanathan, a Purdue professor of materials engineering whose lab specializes in developing brain-inspired technology.

"We can confidently say that this material is a potential pathway to building a computing device that would store and transfer memories," he said.

The researchers tested this material on two molecules: Glucose, a sugar essential for energy production, and dopamine, a chemical messenger that regulates movement, emotional responses and memory.

Because dopamine amounts are typically low in the brain, and even lower for people with Parkinson's disease, detecting this chemical has been notoriously difficult. But detecting dopamine levels early would mean sooner treatment of the disease.

"This quantum material is about nine times more sensitive to dopamine than methods that we use currently in animal models," said Alexander Chubykin, an assistant professor of biological sciences in the Purdue Institute for Integrative Neuroscience, based in Discovery Park.

The quantum material owes its sensitivity to strong interactions between so-called "correlated electrons." The researchers first found that when they placed the material in contact with glucose molecules, the oxides would spontaneously grab hydrogen from the glucose via an enzyme. The same happened with dopamine released from a mouse brain slice.

The strong affinity to hydrogen, as shown when researchers at Argonne National Laboratory created simulations of the experiments, allowed the material to extract atoms on its own—without a power source.

"The fact that we didn't provide power to the material for it to take in hydrogen means that it could bring very low-power electronics with high sensitivity," Ramanathan said. "This could be helpful for probing unexplored environments, as well."

The researchers also say that this material could sense the atoms of a range of molecules, beyond just glucose and dopamine. The next step is creating a way for the material to "talk back" to the brain. [13]

Breakthrough in photonic biosensors could lead to super-accurate diagnostic and detectors

University Professor of Applied Physics Stephen Arnold and his team at the New York University Tandon School of Engineering have made a discovery that could lead to Star Trek-like biosensor devices capable of flagging the barest presence in blood of a specific virus or antibody, or protein marker for a specific cancer; or sniffing out airborne chemical warfare agents while they are still far below toxic levels.

The discovery follows years of groundbreaking work by Arnold, who in 1995 discovered that an optical fiber could excite what he termed Whispering Gallery Mode (WGM) in silicon micro-beads less than one-third the diameter of a human hair. Further discoveries and patents led to WGM biosensors capable of gauging the mass of viruses, proteins and other nanoparticles by sending them into spacecraft-like orbit around the micro-bead, thanks to a photonic "tractor beam" caused by the resonating light. Arnold and collaborators then devised a way to make these WGM biosensors sensitive enough to identify even the smallest individual bio-particles from the RNA virus MS2 to single molecules down to 6 zepto-grams (10?21 grams), below the mass of all known cancer markers. Many companies, including Genalyte, employ WGM biosensors in diagnostic products that can perform dozens of bioassays in minutes.

Now, Arnold and his team at NYU Tandon's MicroParticle PhotoPhysics Laboratory for BioPhotonics (MP3L) are the first to find a way to determine the density of charges on an area of a WGM micro-bead's surface, as well as the charge of an ensnared nanoparticle or virus, by measuring how light frequency fluctuates as the tiny particle follows its wobbly course around the sphere. This discovery could allow researchers and manufacturers not just to identify nanoparticles, but to manipulate them.

Arnold, who also is a member of the Othmer-Jacobs Department of Chemical and Biomolecular Engineering at NYU, and his fellow researchers, including Jehovani Lopez, Eshan Treasurer, Kaitlynn Snyder, and David Keng, recently published their findings in *Applied Physics Letters*.

The WGM biosensor, which Arnold named for the famous Whispering Gallery in the dome of St. Paul's Cathedral in London, is a device the size of a small smartphone comprising a tunable laser guided down a specially treated fiber optic filament with a detector at the far end of the filament measuring

the light's intensity and resonance. A tiny silica bead next to the filament diverts a portion of the light beam, which begins to resonate within the bead the way sound resonates under the dome of the church gallery for which the phenomenon is named.

While the WGM biosensor's ability to identify individual nanoparticles led to highly sensitive measuring capabilities, Arnold's latest discovery could make possible biosensors tailored to very specific applications, from wearable sensors for soldiers and rescuers designed to detect extremely low concentrations of a suspected airborne nerve agent, to ways of increasing the efficiency of nanoparticle drug uptake and redistribution.

"Charge controls the ability to transport particles that are interacting with cells and other objects that possess electric fields," he said. "By determining the charge of a virus, for example, you can understand how it can be transported to the cell surface. You need to understand this mechanism in order to engineer a WGM micro-bead that has a specific antigen at a specific region of its surface so that the biosensor can attract specific pathogens or other biomolecules."

Arnold and the MP3L team were able to extract the electrostatic force between the orbiting nanoparticle and the surface of the glass bead through experiments based on the observation that the nano-orbital phenomenon requires a near balance between the electrostatic force and the known optical tractor beam force, just as a weighing scale balances the force of a spring against your body's weight.

"The difference in the strength of the force being measured is extraordinarily small," said Arnold, who explained that the measured electrostatic force involved in keeping a nanoparticle in orbit was only 0.00000000000003 ($3x10^{-14}$) pounds. "With this force in hand both the charge on the nanoparticle and the microcavity charge density could be calculated through a series of experiments."

The team next plans to use the discovery to develop technology for "photonic printing," the ability to quickly create numerous task-specific WGM biosensors, with specific molecules attached to specific areas of the micro-bead. [12]

Scientists use diamond in world's first continuous room-temperature solid-state maser

The maser (microwave amplification by stimulated emission of radiation), the older microwave frequency sibling of the laser, was invented in 1954. However unlike lasers, which have become widespread, masers are much less widely used because in order to function they must be cooled to temperatures close to absolute zero (-273°C).

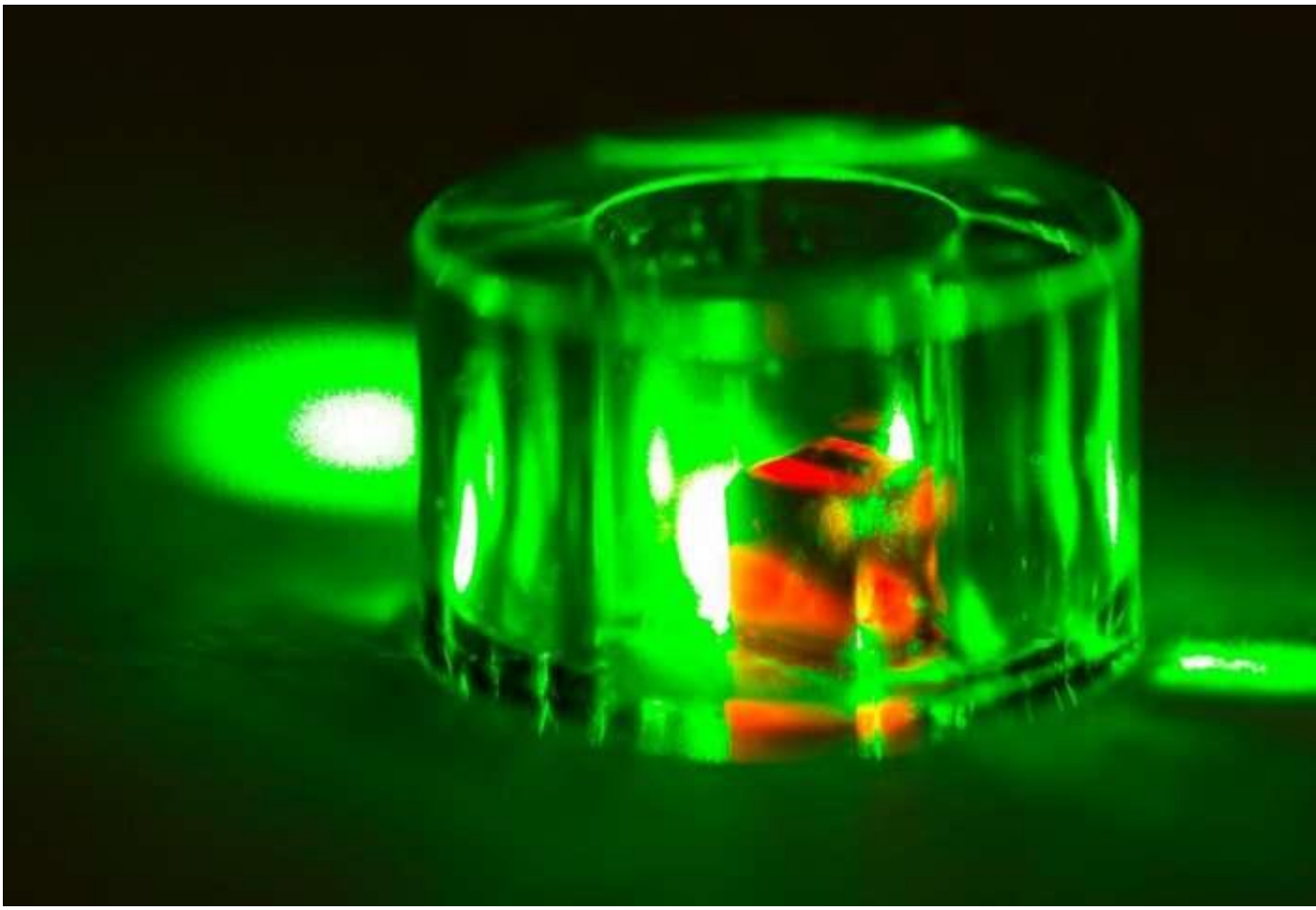
However, this new study from Imperial College London and UCL, and published in *Nature*, reports for the first time a maser that can act continuously at room temperature.

Lead researcher Dr Jonathan Breeze, from Imperial's Department of Materials, said: "This breakthrough paves the way for the widespread adoption of masers and opens the door for a wide array of applications that we are keen to explore. We hope the maser will now enjoy as much success as the laser."

In 2012, scientists demonstrated that a maser could operate at room temperature using the organic molecule pentacene. However, it only produced short bursts of maser radiation that lasted less than one thousandth of a second. In any case, had the maser operated continuously, the crystal would likely have melted.

Now, Dr Breeze and colleagues have used a synthetic diamond grown in a nitrogen-rich atmosphere to create a new maser that operates continuously.

Carbon atoms were 'knocked out' from the diamond using a high energy electron beam, creating spaces known as 'vacancies'. The diamond was then heated, which allowed nitrogen atoms and carbon vacancies to pair up, forming a type of defect known as a nitrogen-vacancy (NV) defect centre. The diamond was provided by Element Six.



The diamond is held inside a sapphire ring and illuminated by 532-nm green laser. The red light is fluorescence from the NV centres. Credit: Thomas Angus, Imperial College London

When placed inside a ring of sapphire to concentrate the microwave energy, and illuminated by green laser light, the researchers found that the maser worked at room temperature and importantly, continuously.

Co-author Professor Neil Alford, also from Imperial's Department of Materials, said: "This technology has a way to go, but I can see it being used where sensitive detection of microwave radiation is essential".

The team who made the discovery say masers could be used in a range of applications such as medical imaging and airport security scanning. They have more traditionally been used in deep space communication and radio astronomy.

As well as medical imaging and airport security scanning, masers could play a pivotal role in improving sensors to remotely detect bombs, new technology for quantum computers, and might even improve space communication methods to potentially find life on other planets. [11]

Designing diamonds for medical imaging technologies

Japanese researchers have optimized the design of laboratory-grown, synthetic diamonds. This brings the new technology one step closer to enhancing biosensing applications, such as magnetic brain imaging. The advantages of this layered, sandwichlike, diamond structure are described in a recent issue of *Applied Physics Letters*.

Chemical processes are used to create large sheets of diamonds for industrial applications. Artificial diamonds can be grown on various surfaces to increase the hardness and reduce the wear of tools, or to take advantage of diamond's high thermal conductivity as a heat sink for electronics. Scientists can manipulate the properties of artificial diamonds by altering their chemical composition. This chemical manipulation is called doping. These "doped" diamonds are proving to be a cheap alternative material for a range of technologies—from quantum information to biosensing—that would otherwise have been prohibitively expensive to develop.

Diamonds designed with nitrogen-vacancy (NV) centers that can detect changes in magnetic fields are a powerful tool for biosensing technologies and used in the medical detection and diagnosis of disease. For instance, magnetoencephalography (MEG) is a neuroimaging technique used to map brain activity and trace pathological abnormalities, such as epileptic tissue.

"MEG is commercially available and used in some hospitals but is very expensive so not many MEGs are used," said Norikazu Mizuochi, an author on the paper. Mizuochi explained that using diamonds with NV centers would reduce the equipment costs of MEG diagnoses.

However, these biosensing technologies require light activation, which induces charge switching in NV centers. Neutral NV centers are not able to accurately detect magnetic fields, so the introduction of switching remains a challenge for diamond utilization. "Only the minus [negative] charge can be used for such sensing applications, therefore stabilizing [NV] centers is important for operation," Mizuochi said.

The researchers had previously doped a simple diamond structure with phosphorus to stabilize the NV centers. Phosphorus doping pushed over 90 percent of NV centers to the negative charge state, enabling magnetic field detection. However, the phosphorus introduced noise to the readout, negating the positive result.

In this study, the team adapted the diamond design to preserve the stabilization of negative NV centers, but removed the phosphorus-induced noise. They used a layered structure, like a sandwich, with phosphorus doped diamond as the bread, and enclosed a 10µm thick NV-center diamond filling. This stabilized 70-80 percent of NV centers in the negative charge state, while reducing the noise previously seen in the system.

"At the moment, we have just demonstrated stabilization, but we expect it to also improve sensitivity," Mizuochi said. His team is currently testing the sensitivity of the new design to changes in magnetic fields, and hoping that this structure could be used for biosensing applications such as MEG. [10]

Experiment demonstrates quantum mechanical effects from biological systems

Nearly 75 years ago, Nobel Prize-winning physicist Erwin Schrödinger wondered if the mysterious world of quantum mechanics played a role in biology. A recent finding by Northwestern University's Prem Kumar adds further evidence that the answer might be yes.
Kumar and his team have, for the first time, created quantum entanglement from a biological system. This finding could advance scientists' fundamental understanding of biology and potentially open doors to exploit biological tools to enable new functions by harnessing quantum mechanics.

"Can we apply quantum tools to learn about biology?" said Kumar, professor of electrical engineering and computer science in Northwestern's McCormick School of Engineering and of physics and astronomy in the Weinberg College of Arts and Sciences. "People have asked this question for many, many years—dating back to the dawn of quantum mechanics. The reason we are interested in these new quantum states is because they allow applications that are otherwise impossible."

Partially supported by the Defense Advanced Research Projects Agency, the research was published Dec. 5 in *Nature Communications*.

Quantum entanglement is one of quantum mechanics' most mystifying phenomena. When two particles—such as atoms, photons, or electrons—are entangled, they experience an inexplicable link that is maintained even if the particles are on opposite sides of the universe. While entangled, the particles' behavior is tied one another. If one particle is found spinning in one direction, for example, then the other particle instantaneously changes its spin in a corresponding manner dictated by the entanglement. Researchers, including Kumar, have been interested in harnessing quantum entanglement for several applications, including quantum communications. Because the

particles can communicate without wires or cables, they could be used to send secure messages or help build an extremely fast "quantum Internet."

"Researchers have been trying to entangle a larger and larger set of atoms or photons to develop substrates on which to design and build a quantum machine," Kumar said. "My laboratory is asking if we can build these machines on a biological substrate."

In the study, Kumar's team used green fluorescent proteins, which are responsible for bioluminescence and commonly used in biomedical research. The team attempted to entangle the photons generated from the fluorescing molecules within the algae's barrel-shaped protein structure by exposing them to spontaneous four-wave mixing, a process in which multiple wavelengths interact with one another to produce new wavelengths.

Through a series of these experiments, Kumar and his team successfully demonstrated a type of entanglement, called polarization entanglement, between photon pairs. The same feature used to make glasses for viewing 3D movies, polarization is the orientation of oscillations in light waves. A wave can oscillate vertically, horizontally, or at different angles. In Kumar's entangled pairs, the photons' polarizations are entangled, meaning that the oscillation directions of light waves are linked. Kumar also noticed that the barrel-shaped structure surrounding the fluorescing molecules protected the entanglement from being disrupted.

"When I measured the vertical polarization of one particle, we knew it would be the same in the other," he said. "If we measured the horizontal polarization of one particle, we could predict the horizontal polarization in the other particle. We created an entangled state that correlated in all possibilities simultaneously."

Now that they have demonstrated that it's possible to create quantum entanglement from biological particles, next Kumar and his team plan to make a biological substrate of entangled particles, which could be used to build a quantum machine. Then, they will seek to understand if a biological substrate works more efficiently than a synthetic one. [9]

Quantum biology: Algae evolved to switch quantum coherence on and off

A UNSW Australia-led team of researchers has discovered how algae that survive in very low levels of light are able to switch on and off a weird quantum phenomenon that occurs during photosynthesis.

The function in the algae of this quantum effect, known as coherence, remains a mystery, but it is thought it could help them harvest energy from the sun much more efficiently. Working out its role in a living organism could lead to technological advances, such as better organic solar cells and quantum-based electronic devices.

The research is published in the journal Proceedings of the National Academy of Sciences.

It is part of an emerging field called quantum biology, in which evidence is growing that quantum phenomena are operating in nature, not just the laboratory, and may even account for how birds can navigate using the earth's magnetic field.

"We studied tiny single-celled algae called cryptophytes that thrive in the bottom of pools of water, or under thick ice, where very little light reaches them," says senior author, Professor Paul Curmi, of the UNSW School of Physics.

"Most cryptophytes have a light-harvesting system where quantum coherence is present. But we have found a class of cryptophytes where it is switched off because of a genetic mutation that alters the shape of a light-harvesting protein.

"This is a very exciting find. It means we will be able to uncover the role of quantum coherence in photosynthesis by comparing organisms with the two different types of proteins."

In the weird world of quantum physics, a system that is coherent – with all quantum waves in step with each other – can exist in many different states simultaneously, an effect known as superposition. This phenomenon is usually only observed under tightly controlled laboratory conditions.

So the team, which includes Professor Gregory Scholes from the University of Toronto in Canada, was surprised to discover in 2010 that the transfer of energy between molecules in the light harvesting systems from two different cryptophyte species was coherent.

The same effect has been found in green sulphur bacteria that also survive in very low light levels.

"The assumption is that this could increase the efficiency of photosynthesis, allowing the algae and bacteria to exist on almost no light," says Professor Curmi.

"Once a light-harvesting protein has captured sunlight, it needs to get that trapped energy to the reaction centre in the cell as quickly as possible, where the energy is converted into chemical energy for the organism.

"It was assumed the energy gets to the reaction centre in a random fashion, like a drunk staggering home. But quantum coherence would allow the energy to test every possible pathway simultaneously before travelling via the quickest route."

In the new study, the team used x-ray crystallography to work out the crystal structure of the lightharvesting complexes from three different species of cryptophytes.

They found that in two species a genetic mutation has led to the insertion of an extra amino acid that changes the structure of the protein complex, disrupting coherence.

"This shows cryptophytes have evolved an elegant but powerful genetic switch to control coherence and change the mechanisms used for light harvesting," says Professor Curmi.

The next step will be to compare the biology of different cryptophytes, such as whether they inhabit different environmental niches, to work out whether the quantum coherence effect is assisting their survival. [8]

Photoactive Prebiotic Systems

We propose that life first emerged in the form of such minimal photoactive prebiotic kernel systems and later in the process of evolution these photoactive prebiotic kernel systems would have produced fatty acids and covered themselves with fatty acid envelopes to become the minimal cells of the Fatty Acid World. Specifically, we model self-assembling of photoactive prebiotic systems with observed quantum entanglement phenomena. We address the idea that quantum entanglement was important in the first stages of origins of life and evolution of the biospheres because simultaneously excite two prebiotic kernels in the system by appearance of two additional quantum entangled excited states, leading to faster growth and self-replication of minimal living cells. The quantum mechanically modeled possibility of synthesizing artificial selfreproducing quantum entangled prebiotic kernel systems and minimal cells also impacts the possibility of the most probable path of emergence of photocells on the Earth or elsewhere. We also examine the quantum entangled logic gates discovered in the modeled systems composed of two prebiotic kernels. Such logic gates may have application in the destruction of cancer cells or becoming building blocks of new forms of artificial cells including magnetically active ones.

Significance Statement

Our investigated self-assembly of molecules towards supramolecular bioorganic and minimal cellular systems depends on the quantum mechanics laws which induce hydrogen and Van der Waals bindings (Tamulis A, Grigalavicius, M, Orig Life Evol Biosph 41:51-71, 2011).

In the work presented here, quantum entanglement takes the form of a quantum superposition of the active components in synthesized self-assembling and self-replicating living systems. When a quantum calculation of an entangled system is made that causes one photoactive biomolecule of such a pair to take on a definite value (e.g., electron density transfer or electron spin density transfer), the other member of this entangled pair will be found to have taken the appropriately correlated value (e.g., electron density transfer or electron spin density transfer). In our simulations, the separation distance of supramolecular bio systems changes took place during geometry optimization procedures, which mimic real-world intermolecular interaction processes.

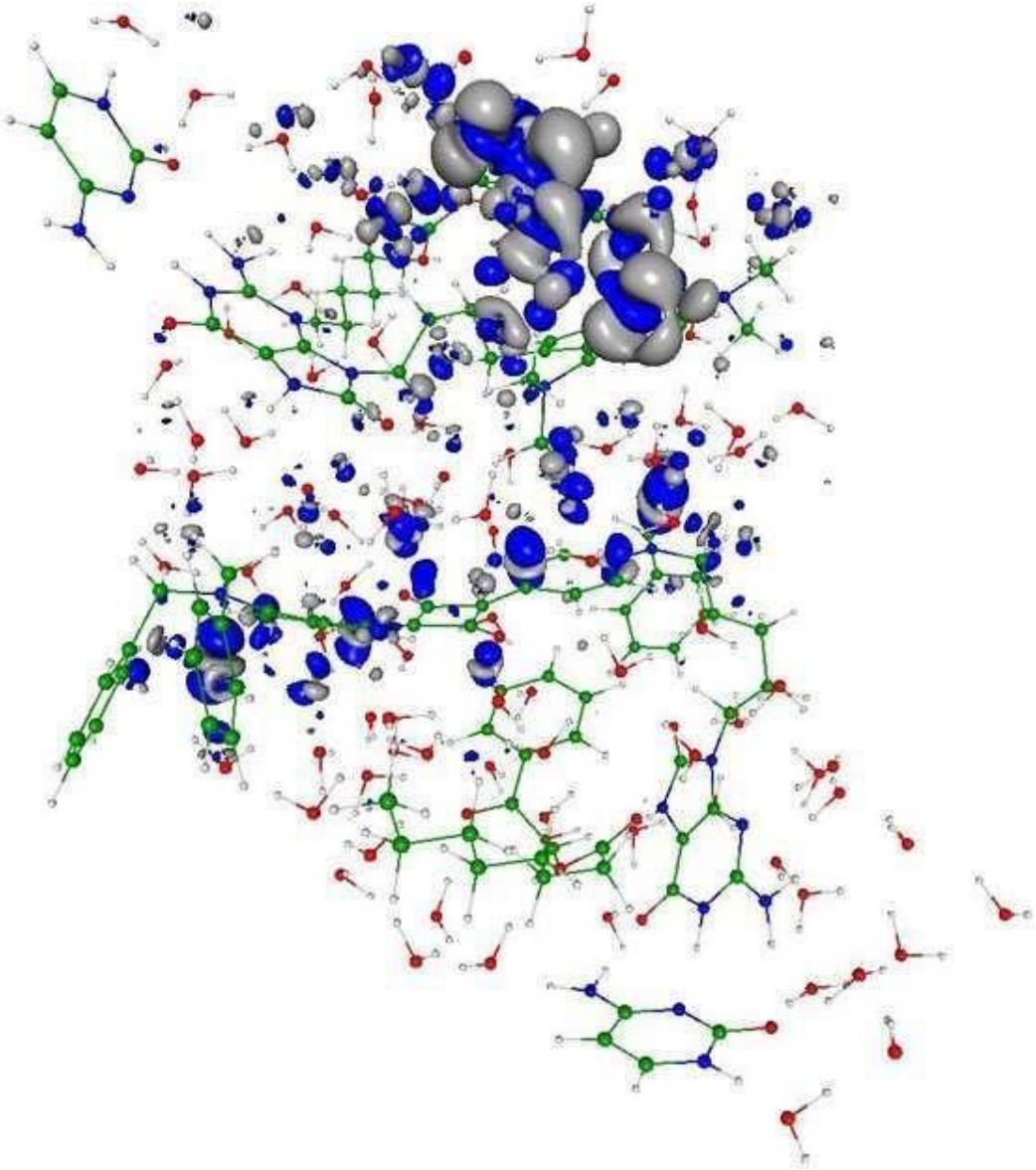
Our discovered phenomenon of the quantum entanglement in the prebiotic systems enhance the photosynthesis in the proposed systems because simultaneously excite two prebiotic kernels in the system by appearance of two additional quantum entangled excited states (Tamulis A, Grigalavicius M, Baltrusaitis J, Orig Life Evol Biosph 43:49-66, 2013; Tamulis A, Grigalavicius M, Krisciukaitis S (2014) , J Comput Theor Nanos, 11, 1597-1608, 2014; Tamulis A, Grigalavicius M, 8:117-140, 2014.). We can propose that quantum entanglement enhanced the emergence of photosynthetic prebiotic kernels and accelerated the evolution of photosynthetic life because of additional absorbed light energy, leading to faster growth and self-replication of minimal living cells.

We can state that: Livings are self-assembled and self-replicating wet and warm stochastically moving supramolecular systems where quantum entanglement can be continuously generated and destroyed by non-equilibrium effects in an environment where no static entanglement exists; quantum entanglement involve the biomolecule inside one living or between other neighboring livings.

This warm quantum coherence is basic for the explanation of DNA stability and for the understanding of brain magnetic orientation during migration in more than 50 species of birds, fishes and insects. Exists experimental evidence for quantum-coherent is used for more efficient light-harvesting in plant photosynthesis. Quantum entanglement exists in supramolecules determining the sense of smell and in the brain neurons microtubules due to quantum vibrations.

In the work presented here, we started to design and quantum mechanical investigations of the molecular logical devices which are useful for construction of nano medicine biorobots against the molecular diseases such a cancer tumors, and against the new kinds of synthesized microorganisms and nano guns.

Figure legend



You can see in the enclosed figure the quantum entanglement phenomenon in the closely selfassembled two synthesized protocell system due to the photo excited electron charge transfer from one protocell to another that leads to closer self-assembly and exchange of energy and information.

Visualization of the electron charge tunneling associated with the 6th (467.3 nm) excited state. The transition is mainly from squarine molecule of the first protocell situated in the bottom of this bi cellular system to precursor of fatty acid (pFA) molecule of the second subsystem (in the top) and little from the 1,4-bis(N,N-dimethylamino)naphthalene molecule (in the top-right) to the same pFA molecule of the second subsystem (in the top). The electron cloud hole is indicated by the dark blue color while the transferred electron cloud location is designated by the gray color.

As a result, these nonlinear quantum interactions compressed the overall molecular system resulting in a smaller gap between the HOMO and LUMO electron energy levels which allows

enhanced tunneling of photo excited electrons from the sensitizer squarine and (1,4bis(N,Ndimethylamino)naphthalene) to the pFA molecule resulting in its cleavage. The new fatty acid joins the existing minimal cell thus increasing it in size. After reaching some critical size, the minimal cell should divide (i.e. self-replicate) into two separate smaller minimal cells. [7]

Quantum Biology

Researchers have long suspected that something unusual is afoot in photosynthesis. Particles of light called photons, streaming down from the Sun; arrive randomly at the chlorophyll molecules and other light-absorbing 'antenna' pigments that cluster inside the cells of every leaf, and within every photosynthetic bacterium. But once the photons' energy is deposited, it doesn't stay random. Somehow, it gets channeled into a steady flow towards the cell's photosynthetic reaction centre, which can then use it at maximum efficiency to convert carbon dioxide into sugars. Quantum coherence in photosynthesis seems to be beneficial to the organisms using it. But did their ability to exploit quantum effects evolve through natural selection? Or is quantum coherence just an accidental side effect of the way certain molecules are structured? [6]

Quantum Consciousness

Extensive scientific investigation has found that a form of quantum coherence operates within living biological systems through what is known as biological excitations and biophoton emission. What this means is that metabolic energy is stored as a form of electromechanical and electromagnetic excitations. These coherent excitations are considered responsible for generating and maintaining long-range order via the transformation of energy and very weak electromagnetic signals. After nearly twenty years of experimental research, Fritz-Albert Popp put forward the hypothesis that biophotons are emitted from a coherent electrodynamics field within the living system.

What this means is that each living cell is giving off, or resonating, a biophoton field of coherent energy. If each cell is emitting this field, then the whole living system is, in effect, a resonating field-a ubiquitous nonlocal field. And since biophotons are the entities through which the living system communicates, there is near-instantaneous intercommunication throughout. And this, claims Popp, is the basis for coherent biological organization -- referred to as quantum coherence. This discovery led Popp to state that the capacity for evolution rests not on aggressive struggle and rivalry but on the capacity for communication and cooperation. In this sense the built-in capacity for species evolution is not based on the individual but rather living systems that are interlinked within a coherent whole: Living systems are thus neither the subjects alone, nor objects isolated, but both subjects and objects in a mutually communicating universe of meaning. . . . Just as the cells in an organism take on different tasks for the whole, different populations enfold information not only for themselves, but for all other organisms, expanding the consciousness of the whole, while at the same time becoming more and more aware of this collective consciousness.

Biophysicist Mae-Wan Ho describes how the living organism, including the human body, is coordinated throughout and is "coherent beyond our wildest dreams." It appears that every part of our body is "in communication with every other part through a dynamic, tunable, responsive, liquid crystalline medium that pervades the whole body, from organs and tissues to the interior of every cell."

What this tells us is that the medium of our bodies is a form of liquid crystal, an ideal transmitter of communication, resonance, and coherence. These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [5]

Creating quantum technology

Another area of potential application is in quantum computing. The long-standing goal of the physicists and engineers working in this area is to manipulate data encoded in quantum bits (qubits) of information, such as the spin-up and spin-down states of an electron or of an atomic nucleus. Qubits can exist in both states at once, thus permitting the simultaneous exploration of all possible answers to the computation that they encode. In principle, this would give quantum computers the power to find the best solution far more quickly than today’s computers can — but only if the qubits can maintain their coherence, without the noise of the surrounding environment, such as the jostling of neighboring atoms, destroying the synchrony of the waves. [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 $E = h\nu$ and $E = mc^2$, $m = h\nu / c^2$ that is the m depends only on the ν 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

Exists experimental evidence for quantum-coherent is used for more efficient light-harvesting in plant photosynthesis. Quantum entanglement exists in supramolecules determining the sense of smell and in the brain neurons microtubules due to quantum vibrations.

In the work presented here, we started to design and quantum mechanical investigations of the molecular logical devices which are useful for construction of nano medicine biorobots against the molecular diseases such a cancer tumors, and against the new kinds of synthesized microorganisms and nano guns. [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]
These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [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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