Runaway Fusion Electrons

When the electrons collide with the high charge in the nuclei of the ions, they encounter resistance and lose speed. [10]

More than seven years later, that collaboration could result in an inexpensive tabletop device to detect elusive neutrinos more efficiently and inexpensively than is currently possible, and could simplify scientists' ability to study the inner workings of the sun. [9]

Scientists in Germany have flipped the switch on a €60 million (US $66 million) device designed to help determine the mass of the universe's lightest particle. [8]

Neutrinos are tricky. Although trillions of these harmless, neutral particles pass through us every second, they interact so rarely with matter that, to study them, scientists send a beam of neutrinos to giant detectors. And to be sure they have enough of them, scientists have to start with a very concentrated beam of neutrinos. To concentrate the beam, an experiment needs a special device called a neutrino horn. [7]

The ultra-low background KamLAND-Zen detector, hosted by research institutes inside and outside Japan demonstrates the best sensitivity in the search for neutrinoless double-beta decay, and sets the best limit on the effective Majorana neutrino mass. [6]

Now, researchers from the University of Tokyo, in collaboration with a Spanish physicist, have used one of the world's most powerful computers to analyse a special decay of calcium-48, whose life, which lasts trillions of years, depends on the unknown mass of neutrinos. This advance will facilitate the detection of this rare decay in underground laboratories. [5]

To measure the mass of neutrinos, scientists study radioactive decays in which they are emitted. An essential ingredient is the decay energy which corresponds to the mass difference between the mother and daughter nuclei. This decay energy must be known with highest precision. A team of scientists now succeeded to resolve a severe discrepancy of the decay energy for the artificial holmium (Ho) isotope with mass number 163. [4]

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 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.*

Author: George Rajna

Deceleration of runaway electrons paves the way for fusion power

Fusion power has the potential to provide clean and safe energy that is free from carbon dioxide emissions. However, imitating the solar energy process is a difficult task to achieve. Two young plasma physicists at Chalmers University of Technology have now taken us one step closer to a functional fusion reactor. Their model could lead to better methods for decelerating the runaway electrons, which could destroy a future reactor without warning.

It takes high pressure and temperatures of about 150 million degrees to get atoms to combine. As if that was not enough, runaway electrons are wreaking havoc in the fusion reactors that are currently being developed. In the promising reactor type tokamak, unwanted electric fields could jeopardise the entire process. Electrons with extremely high energy can suddenly accelerate to speeds so high that they destroy the reactor wall.

It is these runaway electrons that doctoral students Linnea Hesslow and Ola Embréus have successfully identified and decelerated. Together with their advisor, Professor Tünde Fülöp at the Chalmers Department of Physics, they have been able to show that it is possible to effectively decelerate runaway electrons by injecting so-called heavy ions in the form of gas or pellets. For example, neon or argon can be used as "brakes".

When the electrons collide with the high charge in the nuclei of the ions, they encounter resistance and lose speed. The many collisions make the speed controllable and enable the fusion process to continue. Using mathematical descriptions and plasma simulations, it is possible to predict the electrons' energy - and how it changes under different conditions.

"When we can effectively decelerate runaway electrons, we are one step closer to a functional fusion reactor. Considering there are so few options for solving the world's growing energy needs in a sustainable way, fusion energy is incredibly exciting since it takes its fuel from ordinary seawater," says Linnea Hesslow.

She and her colleagues recently had their article published in the reputed journal Physical Review Letters. The results have also attracted a great deal of attention in the field of research. In a short period of time, 24-year-old Linnea Hesslow and 25-year-old Ola Embréus have given lectures at a number of international conferences, including the prestigious and long-standing Sherwood Fusion Theory Conference in Annapolis, Maryland, USA, where they were the only presenters from Europe.

"The interest in this work is enormous. The knowledge is needed for future, large-scale experiments and provides hope when it comes to solving difficult problems. We expect the work to make a big impact going forward," says Professor Tünde Fülöp.

Despite the great progress made in fusion energy research over the past fifty years, there is still no commercial fusion power plant in existence. Right now, all eyes are on the international research collaboration related to the ITER reactor in southern France.

"Many believe it will work, but it's easier to travel to Mars than it is to achieve fusion. You could say that we are trying to harvest stars here on earth, and that can take time. It takes incredibly high temperatures, hotter than the center of the sun, for us to successfully achieve fusion here on earth. That's why I hope research is given the resources needed to solve the energy issue in time," says Linnea Hesslow.

Facts: Fusion energy and runaway electrons

Fusion energy occurs when light atomic nuclei are combined using high pressure and extremely high temperatures of about 150 million degrees Celsius. The energy is created the same way as in the sun, and the process can also be called hydrogen power. Fusion power is a much safer alternative than nuclear power, which is based on the splitting (fission) of heavy atoms. If something goes wrong in a fusion reactor, the entire process stops and it grows cold. Unlike with a nuclear accident, there is no risk of the surrounding environment being affected.

The fuel in a fusion reactor weighs no more than a stamp, and the raw materials come from ordinary seawater.

As yet, fusion reactors have not been able to produce more energy than they are supplied. There is also a problem with so-called runaway electrons. The most common method of preventing this damage is to inject heavy ions, such as argon or neon, which act like brakes due to their large charge. A new model developed by researchers at Chalmers describes how much the electrons are decelerated, paving the way to making these runaway electrons harmless. [10]

Solar physicists unlock easier way to observe peculiar particles that reveal the inner workings of the sun

In 2009, applied physicist Peter Sturrock was visiting the National Solar Observatory in Tucson, Arizona, when the deputy director of the observatory told him he should read a controversial article about radioactive decay. Although the subject was outside Sturrock's field, it inspired a thought so intriguing that the next day he phoned the author of the study, Purdue University physicist Ephraim Fischbach, to suggest a collaboration.

Fischbach replied, "We were about to phone you."

More than seven years later, that collaboration could result in an inexpensive tabletop device to detect elusive neutrinos more efficiently and inexpensively than is currently possible, and could simplify scientists' ability to study the inner workings of the sun. The work was published in the Nov. 7 issue of Solar Physics.

"If we're correct, it means that neutrinos are far easier to detect than people have thought," said Sturrock, professor emeritus of applied physics. "Everyone thought that it would be necessary to have huge experiments, with thousands of tons of water or other material, that may involve huge consortia and huge expense, and you might get a few thousand counts a year. But we may get similar or even better data from an experiment involving only micrograms of radioactive material."

Why, how we study neutrinos

For twenty years, Sturrock and his colleague Jeff Scargle, astrophysicist and data scientist at NASA Ames Research Center, have studied neutrinos, subatomic particles with no electric charge and nearly zero mass, which can be used to learn about the inside of the sun.

Nuclear reactions in the sun's core produce neutrinos. A unique feature of neutrinos is that they rarely interact with other particles and so can escape the sun easily, bringing us information about the deep solar interior. Studying neutrinos is thought to be the best way to obtain direct information about the center of the sun, which is otherwise largely a mystery. Neutrinos can also give us information about supernovas, the creation of the universe and much more.

On Earth, an area the size of a fingernail has 65 billion neutrinos pass through it each second. But only one or two in an entire lifetime will actually stop in our bodies. Studying neutrinos involves massive equipment and expenses to trap enough of the elusive particles for investigation.

At present, the gold standard for neutrino detection is Japan's Super-Kamiokande, a magnificent $100 million observatory. In use since 1996, Super-Kamiokande lies 1,000 meters below ground. It consists of a tank filled with 50,000 tons of ultra-pure water, surrounded by about 13,000 photo-multiplier tubes. If a neutrino enters the water and interacts with electrons or nuclei there, it results in a charged particle that moves faster than the speed of light in water. This leads to an optical shock wave, a cone of light called Cherenkov radiation. This light is projected onto the wall of the tank and recorded by the photomultiplier tubes.

Past challenges in detection

The 2002 Nobel Prize in Physics was awarded to Masatoshi Koshiba of Super-Kamiokande and Raymond Davis Jr. of Homestake Neutrino Observatory for the development of neutrino detectors and "for the detection of cosmic neutrinos." One perplexing detail of this work was that, with their ground-breaking detection methods, they were detecting one-third to one-half as many neutrinos as expected, an issue known as the "solar neutrino problem." This shortfall was first thought to be due to experimental problems. But, once it was confirmed by Super-Kamiokande, the deficit was accepted as real.

The year prior to the Nobel, however, scientists announced a solution to the solar neutrino problem. It turned out that neutrinos oscillate among three forms (electron, muon and tau) and detectors were primarily sensitive to only electron neutrinos. For the discovery of these oscillations, the 2015 Nobel Prize in Physics was awarded to Takaaki Kajita of Super-Kamiokande and Arthur B. MacDonald of the Sudbury Neutrino Observatory.

Even with these Nobel Prize-worthy developments in research and equipment at their disposal, scientists can still detect only a few thousand neutrino events each year.

A new option for research

The research that Sturrock learned about in Tucson concerned fluctuations in the rate of decay of radioactive elements. The fluctuations were highly controversial at the time because it had been thought that the decay rate of any radioactive element was constant. Sturrock decided to study these experimental results using analytical techniques that he and Scargle had developed to study neutrinos.

In examining the radioactive decay fluctuations, the team found evidence that those fluctuations matched patterns they had found in Super-Kamiokande neutrino data, each indicating a one-month oscillation attributable to solar rotation. The likely conclusion is that neutrinos from the sun are directly affecting beta-decays. This connection has been theorized by other researchers dating back 25 years, but the Sturrock-Fischbach-Scargle analysis adds the strongest evidence yet. If this relationship holds, a revolution in neutrino research could be underway.

"It means there's another way to study neutrinos that is much simpler and much less expensive than current methods," Sturrock said. "Some data, some information, you won't get from beta-decays, but only from experiments like Super-Kamiokande. However, the study of beta-decay variability indicates there is another way to detect neutrinos, one that gives you a different view of neutrinos and of the sun."

Sturrock said this could mark the beginning of a new field in neutrino research and solar physics. He and Fischbach see the possibility of bench-top detectors that would cost thousands rather than millions of dollars.

The next steps for now will be to gather more and better data and to work toward a theory that can explain how all these physical processes are connected. [9]

Experiment to weigh 'ghost particles' starts in Germany

Scientists in Germany have flipped the switch on a €60 million (US $66 million) device designed to help determine the mass of the universe's lightest particle. Physicists at the Karlsruhe Institute of Technology hope the 200-metric-tons (220 tons) device will narrow down or even pinpoint the actual mass of neutrinos. Doing so would help scientists to better understand the history of the universe. (Uwe Anspach/dpa via AP)

Scientists in Germany have flipped the switch on a 60 million euro ($66 million) machine designed to help determine the mass of the universe's lightest particle.

The Karlsruhe Tritium Neutrino experiment, or KATRIN, began tests Friday and is expected to begin making actual measurements next year.

Physicists at the Karlsruhe Institute of Technology hope the 200-metric-ton (220-ton) device will narrow down or even pinpoint the actual mass of neutrinos.

Doing so would help scientists to better understand the history of the universe. Neutrinos are sometimes referred to as "ghost particles" because they are so difficult to detect.

The institute says more than 150 scientists and engineers from five countries are participating in the experiment. [8]

Funneling fundamental particles

Neutrinos are tricky. Although trillions of these harmless, neutral particles pass through us every second, they interact so rarely with matter that, to study them, scientists send a beam of neutrinos to giant detectors. And to be sure they have enough of them, scientists have to start with a very concentrated beam of neutrinos.

To concentrate the beam, an experiment needs a special device called a neutrino horn.

An experiment's neutrino beam is born from a shower of short-lived particles, created when protons traveling close to the speed of light slam into a target. But that shower doesn't form a tidy beam itself: That's where the neutrino horn comes in.

Once the accelerated protons smash into the target to create pions and kaons—the short-lived charged particles that decay into neutrinos—the horn has to catch and focus them by using a magnetic field. The pions and kaons have to be focused immediately, before they decay into neutrinos: Unlike the pions and kaons, neutrinos don't interact with magnetic fields, which means we can't focus them directly.

Without the horn, an experiment would lose 95 percent of the neutrinos in its beam. Scientists need to maximize the number of neutrinos in the beam because neutrinos interact so rarely with matter. The more you have, the more opportunities you have to study them.

"You have to have tremendous numbers of neutrinos," said Jim Hylen, a beam physicist at Fermilab. "You're always fighting for more and more."

Also known as magnetic horns, neutrino horns were invented at CERN by the Nobel Prize-winning physicist Simon van der Meer in 1961. A few different labs used neutrino horns over the following years, and Fermilab and J-PARC in Japan are the only major laboratories now hosting experiments with neutrino horns. Fermilab is one of the few places in the world that makes neutrino horns.

"Of the major labs, we currently have the most expertise in horn construction here at Fermilab," Hylen said.

How they work

The proton beam first strikes the target that sits inside or just upstream of the horn. The powerful proton beam would punch through the aluminum horn if it hit it, but the target, which is made of graphite or beryllium segments, is built to withstand the beam's full power. When the target is struck by the beam, its temperature jumps by more than 700 degrees Fahrenheit, making the process of keeping the target-horn system cool a challenge involving a water-cooling system and a wind stream.

Once the beam hits the target, the neutrino horn directs resulting particles that come out at wide angles back toward the detector. To do this, it uses magnetic fields, which are created by pulsing a powerful electrical current—about 200,000 amps—along the horn's surfaces.

"It's essentially a big magnet that acts as a lens for the particles," said physicist Bob Zwaska.

The horns come in slightly different shapes, but they generally look on the outside like a metal cylinder sprouting a complicated network of pipes and other supporting equipment. On the inside, an inner conductor leaves a hollow tunnel for the beam to travel through.

Because the current flows in one direction on the inner conductor and the opposite direction on the outer conductor, a magnetic field forms between them. A particle traveling along the center of the beamline will zip through that tunnel, escaping the magnetic field between the conductors and staying true to its course. Any errant particles that angle off into the field between the conductors are kicked back in toward the center.

The horn's current flows in a way that funnels positively charged particles that decay into neutrinos toward the beam and deflects negatively charged particles that decay into antineutrinos outward. Reversing the current can swap the selection, creating an antimatter beam. Experiments can run either beam and compare the data from the two runs. By studying neutrinos and antineutrinos, scientists try to determine whether neutrinos are responsible for the matter-antimatter asymmetry in the universe. Similarly, experiments can control what range of neutrino energies they target most by tuning the strength of the field or the shape or location of the horn.

Making and running a neutrino horn can be tricky. A horn has to be engineered carefully to keep the current flowing evenly. And the inner conductor has to be as slim as possible to avoid blocking particles. But despite its delicacy, a horn has to handle extreme heat and pressure from the current that threaten to tear it apart.

"It's like hitting it with a hammer 10 million times a year," Hylen said.

Because of the various pressures acting on the horn, its design requires extreme attention to detail, down to the specific shape of the washers used. And as Fermilab is entering a precision era of neutrino experiments running at higher beam powers, the need for the horn engineering to be exact has only grown.

"They are structural and electrical at the same time," Zwaska said. "We go through a huge amount of effort to ensure they are made extremely precisely." [7]

Investigating the neutrino mass scale with the ultra-low background KamLAND-Zen detector

The ultra-low background KamLAND-Zen detector, hosted by the Research Center for Neutrino Science (RCNS) at Tohoku University in collaboration with the Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) at the University of Tokyo and other international institutes, demonstrates the best sensitivity in the search for neutrinoless double-beta decay, and sets the best limit on the effective Majorana neutrino mass.The basic theory of neutrinoless double-beta decay was suggested in the 1930s. The physicist Ettore Majorana hypothesized that the uncharged neutrino particle could be its own antiparticle, and thus could be annihilated by itself. The search for neutrinoless decay is the most practical experimental probe for the neutrino-antineutrino identity.

However, there has been no experimental evidence so far. Recent neutrino measurement results revealed that neutrinos have a tiny mass, and Majorana's hypothesis could be of decisive importance in constructing a theoretical mechanism to realize these tiny masses.

A number of experiments world-wide, using different technologies, are in competition to discover neutrinoless decay. The KamLAND-Zen experiment succeeded in dramatically improving the neutrinoless decay search limit by combing an ultra-low background detector with an unprecedented amount of xenon-136, the isotope where the double-beta decay occurs.

Under the assumption of the neutrino-antineutrino identity, the non-detection constrains the mass scale of neutrinos, close to the so-called inverted hierarchy scale.

This result demonstrates great potential for further investigation of the neutrino mass. [6]

Calcium isotope holds the secret to the mass of neutrinos

Scientists around the world are being kept in suspense by the negligible mass of neutrinos, subatomic particles that could be matter and antimatter at the same time. Now, researchers from the University of Tokyo, in collaboration with a Spanish physicist, have used one of the world's most powerful computers to analyse a special decay of calcium-48, whose life, which lasts trillions of years, depends on the unknown mass of neutrinos. This advance will facilitate the detection of this rare decay in underground laboratories.

Neutrinos were discovered more than 60 years ago; however, scientists are yet to discover some of their fundamental properties, such as their mass (for which only the upper limit is known; this is around 3.6 x 10-36 kg), or whether neutrinos and antineutrinos are in fact the same particle.

An experiment that may offer an answer to the first of these questions is the so-called neutrinoless double beta decay. This occurs when an atom's parent nucleus decays into a daughter nucleus, gaining two protons, losing two neutrons and emitting two electrons. One example of this is the decay of calcium-48 (a very rare isotope of calcium with 20 protons and 28 neutrons) into titanium-48. This is the process that has now been analysed and modelled in unprecedented detail by scientists from the University of Tokyo (Japan). Their study is published in the journal Physical Review Letters.

"The half-life of this decay depends on two factors: the unknown mass of neutrinos (which are part of the process, even though none are emitted) and the characteristics of the parent and daughter nuclei. This implies that, knowing these nuclear characteristics, and once this decay has been measured experimentally in one of the underground laboratories working on it, it will be possible to determine the mass of neutrinos," SINC was told by Javier Menéndez, a Spanish researcher at the Japanese university and one of the study's co-authors.

The researchers used the Japanese K-computer supercomputer, the fourth fastest in the world, to calculate how the calcium-48 nucleus decays.

The team's achievement has been understanding the nuclear part "in a reliable way" through extremely complex quantum mechanics calculations. These included as variables two thirds of the many protons and neutrons involved (to date, scientists had only managed to introduce one third of these particles) using matrices containing 2 trillion pieces of data. These operations were run using the world's fourth fastest supercomputer, the K-computer at Kobe's RIKEN Institute.

"Our findings will make it possible to directly obtain neutrino mass when the half-life of this decay is measured experimentally," says Menéndez. "Moreover, they suggest that the decay of calcium-48 is around half as long as what was previously thought (2 x 1025 years, rather than 4 x 1025 years). This improves our chances of observing it."

In any case, this is an extremely rare and slow decay, as it is mediated by two simultaneous weak decay processes. This means that it takes trillions of years to occur and is very difficult to detect. Laboratories working on this subject hope to observe one (which is due to decay very soon) in deep underground mines, far from any external "noise". Among the experiments trying to achieve this are CANDLES in the Japanese Kamioka Observatory (one of the winners of the Breakthrough Prize for Fundamental Physics for its research on neutrinos) and NEMO III in the Fréjus tunnel (France).

After presenting their findings with calcium-48 (the easiest of the candidate nuclei to analyse), the researchers are now working on similar calculations for the neutrinoless double beta decay of germanium-76, selenium-82 and even xenon-136. The latter is the aim of NEXT, a Spanish project led by the Corpuscular Physics Institute (CSIC-University of Valencia), which is attempting to demonstrate in the Canfranc Underground Laboratory (Huesca) that the neutrino is its own antiparticle.

"The most interesting thing would be to confirm that neutrinos are not emitted during double-beta decay, as that would imply by physical principles that neutrinos and antineutrinos are the same particle; that would be a massive discovery, a Nobel prize for sure," stresses Menéndez. "If that happened, we could say that neutrinos are Majorana particles, because they would be particle and antiparticle at the same time. This property was proposed by the Italian physicist Ettore Majorana in the 30s."

If neutrinos and antineutrinos are discovered to be the same particle, this would be the first known case of matter that is simultaneously antimatter. Additionally, it would generate an asymmetry that would serve to explain why there is no antimatter in the universe. Majorana neutrinos would have allowed for the creation of more matter than antimatter in the first moments after the Big Bang (for example, in neutrinoless double-beta decay, two electrons are emitted - the creation of matter - but no antineutrinos). After that, all antimatter would have been annihilated along with the majority of matter, releasing energy and leaving behind only the "excess" matter which can be observed in the universe today. [5]

Atomic mass difference solution paves way to the neutrino mass

To measure the mass of neutrinos, scientists study radioactive decays in which they are emitted. An essential ingredient is the decay energy which corresponds to the mass difference between the mother and daughter nuclei. This decay energy must be known with highest precision. A team of scientists now succeeded to resolve a severe discrepancy of the decay energy for the artificial holmium (Ho) isotope with mass number 163.

It decays by electron capture to the stable dysprosium-163 (163Dy) and appears well suited to measure the neutrino mass. The team prepared pure samples of 163Ho and 163Dy and directly measured their mass difference with high accuracy using the Penning-trap mass spectrometer SHIPTRAP. The research results have recently been published in Physical Review Letters.

Neutrinos are everywhere. Hundred trillion neutrinos are traversing every human per second, but one of their fundamental properties, i.e., their mass, is still unknown. While the standard model of particle physics predicts neutrinos to be massless, observations prove that neutrinos must have a tiny mass. By studying neutrino masses, scientists thus explore physics beyond this otherwise so successful Standard model. So far, only upper limits of the neutrino mass could be determined, confirming it to be tiny.

This makes a direct mass measurement a challenging task, but spectroscopy of radioactive beta decay or electron capture in suitable nuclei is among the most promising approaches. All radiation emitted in the radioactive decay can be precisely measured, with the exception of the fleeting neutrino, which escapes detection. The neutrino mass is thus deduced from comparing the sum of all detectable radiation to that available for the decay.

An artificial isotope of holmium, with mass number 163, is in the focus of several large collaborations aiming at extracting the neutrino mass from measurements of the energy emitted in the electron capture decay of 163Ho to the stable 163Dy. Currently in the lead is the ECHo Collaboration, centered at the University of Heidelberg. A prior clarification concerning the various values reported for the 163Ho decay energy is mandatory.

Values that span the quite large range from about 2,400 to 2,900 electron Volt (eV) have been published over the past decades from indirect measurements performed using different methods. The value recommended in data tables is on the lower end of this band, but the more recent results are some 100 eV higher than this recommended value casting doubt on its validity. In this situation, an attempt to measure the neutrino mass from the 163Ho decays is questionable.

To solve this puzzle, a team of physicists, chemists, and engineers from Germany, Russia, Switzerland, and France combined their expertise and unique instrumentation: While natural dysprosium contains sufficient amounts of 163Dy, samples of 163Ho, which does not occur in nature, first had to be prepared from natural erbium enriched in 162Er by intense neutron irradiation in the high-flux research reactor at the Institut Laue Langevin inat Grenoble in France. Sample purification and processing was done at the Paul Scherrer Institute Villigen in Switzerland and at Johannes Gutenberg University Mainz.

The atomic mass difference of 163Ho and 163Dy was directly measured using the SHIPTRAP Penning-trap mass spectrometer at the GSI Helmholtz Center for Heavy Ion Research in Darmstadt. Based on the equivalence of mass and energy according to Albert Einstein's famous equation E=mc2, the mass difference translates into the energy available for the decay.

"To determine the masses of holmium and dysprosium, we measured the frequencies of their ion's circular motion in the strong magnetic field of the ion trap, using the novel phase-imaging ion-cyclotron-resonance technique, which allows measurements with highest precision", explained lead scientist Dr. Sergey Eliseev from the Max Planck Institute for Nuclear Physics in Heidelberg. "This circular motion is projected onto a position-sensitive detector in a way that even small mass differences can be determined much faster and more precisely compared to previous methods." 163Ho and 163Dy were measured alternately in intervals of five minutes for several days.

An averaging procedure resulted in a final value of the decay energy of 2,833 eV with an uncertainty of only a few tens of eV. This confirms the recent results, settles the long-standing discrepancy, and thus provides confidence to the approach proposed by the ECHo Collaboration.

"For the statistics expected in the first phase of the ECHo experiment called ECHo-1k, funded by the German Research Foundation (DFG) with a Research Unit, we will reach a sensitivity below 10 eV for the neutrino mass, which is more than a factor of ten below the current upper limit", explained ECHo spokesperson Dr. Loredana Gastaldo from Heidelberg University.

Within the ECHo Collaboration, a research group headed by Professor Christoph E. Dullmann of the Institute of Nuclear Chemistry together with colleagues at the TRIGA research reactor at Mainz University have been responsible for the production and preparation of the needed supply of 163Ho. "Our successful production of 163Ho samples for these studies is an important step towards the preparation of samples suitable for a sensitive measurement of the neutrino mass," said Dullmann.

"For this, we will introduce yet another level of cleaning of the samples. In cooperation with the group of Professor Klaus Wendt at JGU's Institute of Physics, we will exploit the Mainz-based RISIKO mass separator to receive samples of highest purity, as they are necessary for the envisaged experiments." [4]

Asymmetry in the interference occurrences of oscillators

The asymmetrical configurations are stable objects of the real physical world, because they cannot annihilate. One of the most obvious asymmetry is the proton – electron mass rate $M_p = 1840\ M_e$ while they have equal charge. We explain this fact by the strong interaction of the proton, but how remember it his strong interaction ability for example in the H – atom where are only electromagnetic interactions among proton and electron.

This gives us the idea to origin the mass of proton from the electromagnetic interactions by the way interference occurrences of oscillators. The uncertainty relation of Heisenberg makes sure that the particles are oscillating.

The resultant intensity due to n equally spaced oscillators, all of equal amplitude but different from one another in phase, either because they are driven differently in phase or because we are looking at them an angle such that there is a difference in time delay:

(1) $I = I_0 \sin^2 n\ \phi/2\ \mathbf{/}\ \sin^2 \phi/2$

If ϕ is infinitesimal so that $\sin\phi = \phi$, than

(2) $I = n^2 I_0$

This gives us the idea of

(3) $M_p = n^2 M_e$

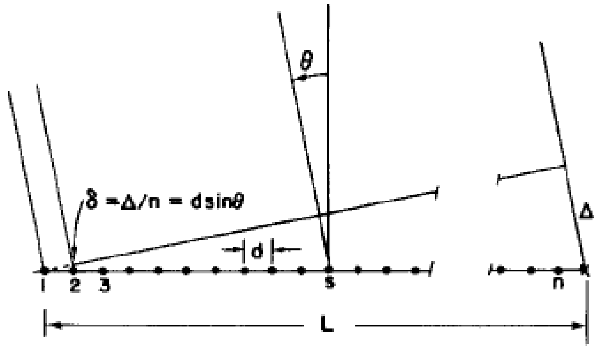

Fig. 30–3. A linear array of *n* equal oscillators, driven with phases $\alpha_s = s\alpha$.

Figure 1.) A linear array of n equal oscillators

There is an important feature about formula (1) which is that if the angle ϕ is increased by the multiple of 2π, it makes no difference to the formula.

So

(4) $d \sin \theta = m \lambda$

and we get m-order beam if λ less than d. [6]

If d less than λ we get only zero-order one centered at $\theta = 0$. Of course, there is also a beam in the opposite direction. The right chooses of d and λ we can ensure the conservation of charge.

For example

(5) $2(m+1) = n$

Where $2(m+1) = N_p$ number of protons and $n = N_e$ number of electrons.

In this way we can see the H_2 molecules so that 2n electrons of n radiate to 4(m+1) protons, because $d_e > \lambda_e$ for electrons, while the two protons of one H_2 molecule radiate to two electrons of them, because of $d_e < \lambda_e$ for this two protons.

To support this idea we can turn to the Planck distribution law, that is equal with the Bose – Einstein statistics.

Spontaneously broken symmetry in the Planck distribution law

The Planck distribution law is temperature dependent and it should be true locally and globally. I think that Einstein's energy-matter equivalence means some kind of existence of electromagnetic oscillations enabled by the temperature, creating the different matter formulas, atoms molecules, crystals, dark matter and energy.

Max Planck found for the black body radiation

As a function of wavelength (λ), Planck's law is written as:

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda k_\mathrm{B}T}} - 1}.$$

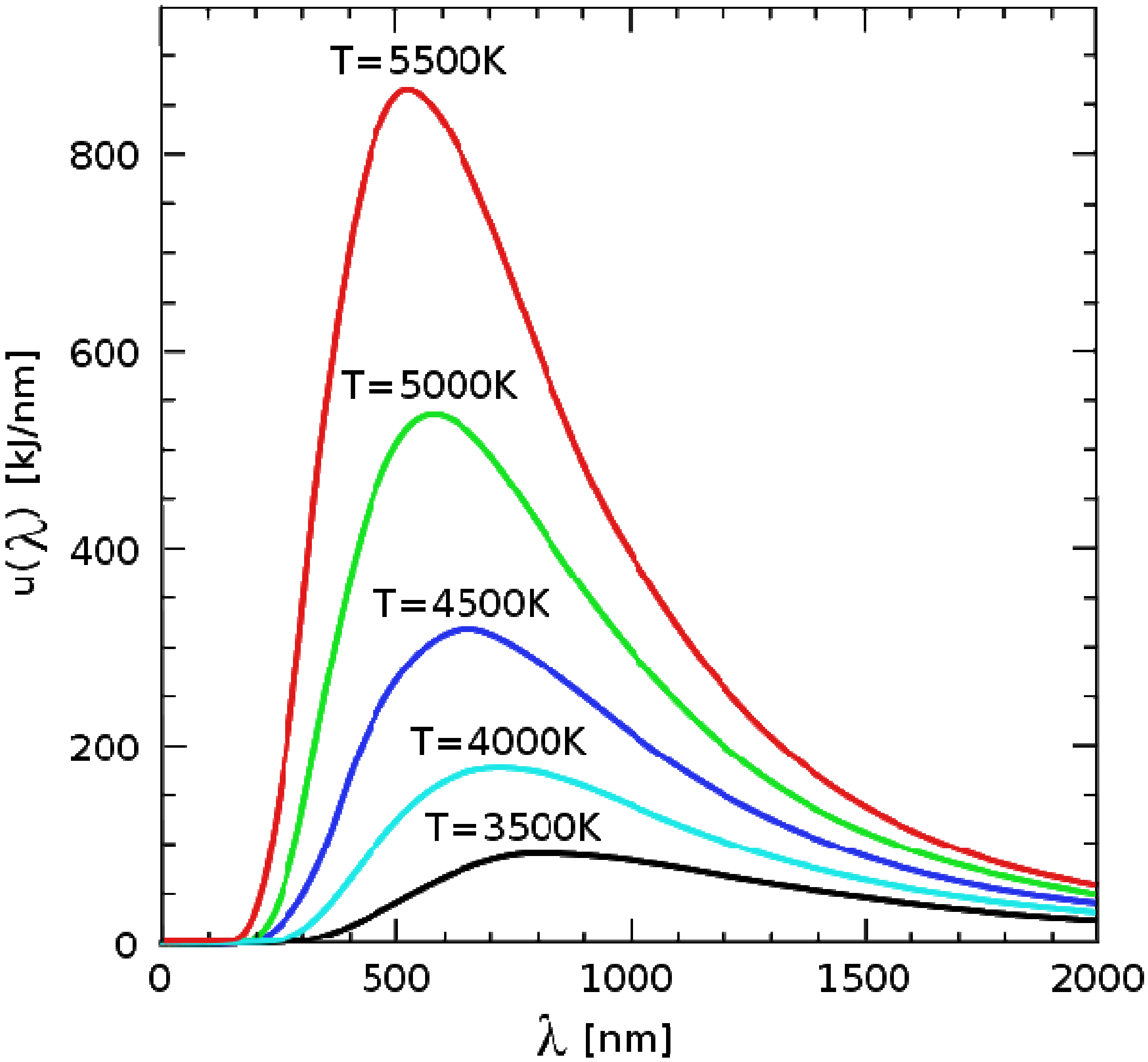

Figure 2. The distribution law for different T temperatures

We see there are two different λ_1 and λ_2 for each T and intensity, so we can find between them a d so that $\lambda_1 < d < \lambda_2$.

We have many possibilities for such asymmetrical reflections, so we have many stable oscillator configurations for any T temperature with equal exchange of intensity by radiation. All of these configurations can exist together. At the λ_{max} is the annihilation point where the configurations are symmetrical. The λ_{max} is changing by the Wien's displacement law in many textbooks.

$$\lambda_{\max} = \frac{b}{T} \quad (7)$$

> where $\lambda_{\max}$ is the peak wavelength, T is the absolute temperature of the black body, and b is a constant of proportionality called *Wien's displacement constant*, equal to $2.8977685(51)\times10^{-3}$ m·K (2002 CODATA recommended value).

By the changing of T the asymmetrical configurations are changing too.

The structure of the proton

We must move to the higher T temperature if we want look into the nucleus or nucleon arrive to $d<10^{-13}$ cm. If an electron with $\lambda_e < d$ move across the proton then by (5) $2(m+1) = n$ with $m = 0$ we get $n = 2$ so we need two particles with negative and two particles with positive charges. If the proton can fraction to three parts, two with positive and one with negative charges, then the reflection of oscillators are right. Because this very strange reflection where one part of the proton with the electron together on the same side of the reflection, the all parts of the proton must be quasi lepton so $d > \lambda_q$. One way dividing the proton to three parts is, dividing his oscillation by the three direction of the space. We can order 1/3 e charge to each coordinates and 2/3 e charge to one plane oscillation, because the charge is scalar. In this way the proton has two +2/3 e plane oscillation and one linear oscillation with -1/3 e charge. The colors of quarks are coming from the three directions of coordinates and the proton is colorless. The flavors of quarks are the possible oscillations differently by energy and if they are plane or linear oscillations. We know there is no possible reflecting two oscillations to each other which are completely orthogonal, so the quarks never can be free, however there is an asymptotic freedom while their energy are increasing to turn them to the orthogonally. If they will be completely orthogonal then they lose this reflection and take new partners from the vacuum. Keeping the symmetry of the vacuum the new oscillations are keeping all the conservation laws, like charge, number of baryons and leptons. The all features of gluons are coming from this model. The mathematics of reflecting oscillators show Fermi statistics.

Important to mention that in the Deuteron there are 3 quarks of +2/3 and -1/3 charge, that is three u and d quarks making the complete symmetry and because this its high stability.

The Pauli Exclusion Principle says that the diffraction points are exclusive!

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.

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 order, 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.

The Higgs boson or Higgs particle is a proposed elementary particle in the Standard Model of particle physics. The Higgs boson's existence would have profound importance in particle physics because it would prove the existence of the hypothetical Higgs field - the simplest of several proposed explanations for the origin of the symmetry-breaking mechanism by which elementary particles gain mass. [3]

The fermions' spin

The moving charges are accelerating, since only this way can self maintain the electric field causing their acceleration. The electric charge is not point like! This constant acceleration possible if there is a rotating movement changing the direction of the velocity. This way it can accelerate forever without increasing the absolute value of the velocity in the dimension of the time and not reaching the velocity of the light.

The Heisenberg uncertainty relation says that the minimum uncertainty is the value of the spin: 1/2 h = d x d p or 1/2 h = d t d E, that is the value of the basic energy status.

What are the consequences of this in the weak interaction and how possible that the neutrinos' velocity greater than the speed of light?

The neutrino is the one and only particle doesn’t participate in the electromagnetic interactions so we cannot expect that the velocity of the electromagnetic wave will give it any kind of limit.

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 source of the Maxwell equations

The electrons are accelerating also in a static electric current because of the electric force, caused by the potential difference. The magnetic field is the result of this acceleration, as you can see in [2].

The mysterious property of the matter that the electric potential difference is self maintained by the accelerating electrons in the electric current gives a clear explanation to the basic sentence of the relativity that is the velocity of the light is the maximum velocity of the matter. If the charge could move faster than the electromagnetic field than this self maintaining electromagnetic property of the electric current would be failed.

Also an interesting question, how the changing magnetic field creates a negative electric field?
The answer also the accelerating electrons will give. When the magnetic field is increasing in time by increasing the electric current, then the acceleration of the electrons will increase, decreasing the charge density and creating a negative electric force. Decreasing the magnetic field by decreasing the electric current will decrease the acceleration of the electrons in the electric current and increases the charge density, creating an electric force also working against the change.
In this way we have explanation to all interactions between the electric and magnetic forces described in the Maxwell equations.
The second mystery of the matter is the mass. We have seen that the acceleration change of the electrons in the flowing current causing a negative electrostatic force. This is the cause of the relativistic effect - built-in in the Maxwell equations - that is the mass of the electron growing with its acceleration and its velocity never can reach the velocity of light, because of this growing negative electrostatic force. The velocity of light is depending only on 2 parameters: the magnetic permeability and the electric permittivity.
There is a possibility of the polarization effect created by electromagnetic forces creates the negative and positive charges. In case of equal mass as in the electron-positron pair it is simply, but on higher energies can be asymmetric as the electron-proton pair of neutron decay by week interaction and can be understood by the Feynman graphs.
Anyway the mass can be electromagnetic energy exceptionally and since the inertial and gravitational mass are equals, the gravitational force is electromagnetic force and since only the magnetic force is attractive between the same charges, is very important for understanding the gravitational force.

The Uncertainty Relations of Heisenberg gives the answer, since only this way can be sure that the particles are oscillating in some way by the electromagnetic field with constant energies in the atom indefinitely. Also not by chance that the uncertainty measure is equal to the fermions spin, which is one of the most important feature of the particles. There are no singularities, because 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 greatest proton mass.

The Special Relativity

The mysterious property of the matter that the electric potential difference is self maintained by the accelerating electrons in the electric current gives a clear explanation to the basic sentence of the relativity that is the velocity of the light is the maximum velocity of the matter. If the charge could move faster than the electromagnetic field than this self maintaining electromagnetic property of the electric current would be failed.

The Heisenberg Uncertainty Principle

Moving faster needs stronger acceleration reducing the dx and raising the dp. It means also mass increasing since the negative effect of the magnetic induction, also a relativistic effect!

The Uncertainty Principle also explains the proton – electron mass rate since the dx is much less requiring bigger dp in the case of the proton, which is partly the result of a bigger mass m_p because of the higher electromagnetic induction of the bigger frequency (impulse).

The Gravitational force

The changing magnetic field of the changing current causes electromagnetic mass change by the negative electric field caused by the changing acceleration of the electric charge.

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 $M_p = 1840\ M_e$. 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. [1]

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 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]

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 Casimir effect

The Casimir effect is related to the Zero-point energy, which is fundamentally related to the Heisenberg uncertainty relation. The Heisenberg uncertainty relation says that the minimum uncertainty is the value of the spin: 1/2 h = dx dp or 1/2 h = dt dE, that is the value of the basic energy status.

The moving charges are accelerating, since only this way can self maintain the electric field causing their acceleration. The electric charge is not point like! This constant acceleration possible if there is a rotating movement changing the direction of the velocity. This way it can accelerate forever without increasing the absolute value of the velocity in the dimension of the time and not reaching the velocity of the light. 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 is not a point like particle, but has a real charge distribution.

Electric charge and electromagnetic waves are two sides of the same thing; the electric charge is the diffraction center of the electromagnetic waves, quantified by the Planck constant h.

The Fine structure constant

The Planck constant was first described as the proportionality constant between the energy (*E*) of a photon and the frequency (*ν*) of its associated electromagnetic wave. This relation between the energy and frequency is called the **Planck relation** or the **Planck–Einstein equation**:

$$E = h\nu\,.$$

Since the frequency ν, wavelength λ, and speed of light c are related by $\lambda\nu = c$, the Planck relation can also be expressed as

$$E = \frac{hc}{\lambda}.$$

Since this is the source of Planck constant, the e electric charge countable from the Fine structure constant. This also related to the Heisenberg uncertainty relation, saying that the mass of the proton should be bigger than the electron mass because of the difference between their wavelengths.

The expression of the fine-structure constant becomes the abbreviated

$$\alpha = \frac{e^2}{\hbar c}$$

This is a dimensionless constant expression, 1/137 commonly appearing in physics literature.

This means that the electric charge is a result of the electromagnetic waves diffractions, consequently the proton – electron mass rate is the result of the equal intensity of the corresponding electromagnetic frequencies in the Planck distribution law, described in my diffraction theory.

Conclusions

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. 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. 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.

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