

Things That "Matter"

An Outline of the Physical Universe

1. The False Elements	2
2. The True Elements	9
3. Break Up and Combination of Atoms	17
4. Electricity and Magnetism	21
5. Light and Time	28
6. The Particle Zoo and Big Bang	35

1. The False Elements

Some people always supposed that matter contains small parts, unseeable to the naked eye. The ancient Greeks called these, atoms and made wild assumptions about how they connect and build up matter. An other, just as wild but philosophical approach looked for the principles behind all matter and picked four basic appearances: Earth, Water, Air and Fire.

Earth, contains all the known minerals and metals, so it's hard to imagine, that one single common factor would be in all these. Indeed, the practical people of ancient times didn't worry about this, rather developed the melting, cleaning and mixing of metals to form alloys. Even the historical names: Stone, Bronze and Iron age, refer to the times of using these materials.

Water, is needed for all forms of life, so it was regarded to be more than just the most neutral, tasteless and transparent liquid. Later in the middle ages, a separate element, a "life elixir" was searched for, to grant eternal youth.

Air, is even more elusive than water! Of course, we are aware of it through breathing and as wind. Pumping extra air into a container like a balloon, bag pipe or a tire, could be used to measure the increasing weight and thus show, that air itself has mass and weight. More paradoxical is when we suck out the air from a container. This so called vacuum has a negative pressure, that is it wants to suck everything in. Yet this is an illusion and in reality, the outside normal air wants to go in due to its own pressure. This pressure is due to the weight of our whole atmosphere, pushing the air itself together. At sea level the pressure is about one kilogram on every square centimeter, so our body is carrying tons in total. Of course, this is compensated from the inside of our body, where the same pressure holds. Deep sea animals carry the pressure of the water too. This adds every ten meter another kilogram on each square centimeter. So, at 1000 meters deep, the pressure is 100 times bigger than the normal air pressure. On high

mountains the opposite happens. Since we have less atmosphere above, the pressure is smaller and the air is thinner. That's why mountain climbers need breathing masks, just like divers for underwater. The ear has a cavity, that is totally closed by the eardrum and fairly closed towards the nose. So rapid change in the outer pressure can not equalize at once through the nose and thus causes a pressure on our eardrum.

Later, when vacuum was understood as the pressureless empty space, it was still imagined, that a so called Ether is filling it. So our whole cosmos would be in this infinite ocean of Ether. The new heliocentric or solar centered system pictured that the sun is standing in the Ether, while the earth with its atmosphere is orbiting and spinning in it. In daytime, the sunlight is so strong that we don't see the stars. The white stars of the night sky are similar solar systems as ours, or maybe even whole collection of solar systems called galaxies far far away and thus seeming to be points. The yellowish stars on the other hand are the planets of our own system, reflecting the sun. With telescopes some white stars split into more or some even to be a cloud of stars. The planets all show through telescopes that they have a "plane" surface, that's why they are called planets today. Earlier the white stars were called, standing or fixed stars because they stay the same to each other and only "turn around" together every night, due to the spinning of our earth. The planets, on the other hand, were called, moving or wandering stars, because when observed night after night, they change their place among the fixed stars. Today we know, that the big collections of solar systems, the galaxies are also turning. So the question of what is the ultimate center, standing in Ether would be quite puzzling. More importantly however, the basic assumption, that light is traveling in the Ether like sound in the air, turned out to be false. The speed of light is not only incredibly big: $c = 300\,000$ km at every second but it is the same for any observer, regardless of his own speed in the Ether. Einstein's theory of Relativity finally proved, that the Ether can not be detected by any physical process, so it should be regarded as a phantom,

just like the negative sucking of the vacuum earlier. The absolute speed of light is quite unnatural but we have to accept, that our sense of "natural" is limited to human scales. This is easily proved by the previously mentioned motions of galaxies. Stars in the galaxies move very fast and yet from our view they seem extremely slow. Remember that fast airplanes can also seem sometimes almost as standing in the sky.

This illusion can be better understood mathematically. Imagine a whole plane with markings, for example like an infinite chess board, rotating in itself around a fixed C center very slowly, say once in a million year. Then lets look how fast various points of the plane, that is squares of the board, are moving! The C center of course is standing still and squares nearby are only moving very slowly. But if we look at places further and further from C , then these are moving faster and faster. We can find squares with any speed, with even bigger than the speed of light. Since this is impossible, it shows that our mathematical infinite chess board is physically impossible. Galaxies are giant rotating discs and though the solar systems on their edge do travel with high speeds, the speed of light is far bigger than even these.

Fire, can light up matter and cause bigger fires, so it seems that it has a hidden ability to start an avalanche in the matter, changing it into its burnt form like charcoal or ash and release heat. Today we know, that fire itself is just heat in action and the spreading of it, that is the avalanche is caused by the matter itself, without any special hidden help from the igniter heat. So the search for a secret matter in the igniting flame was quite hopeless. Others were looking more into the resulting heat. This too had a strange relation to matter though. The ashes that remain after a fire can weigh only a fraction of the original matter. But if we place a closed container on a scale and inside we burn something, then the scale doesn't change. This seemingly would prove the idea that heat is matter, but when the container cools down the scale still remains the same. On the other hand if we open the container even while it's still hot, the scale drops at once. This proves that the weight went

into the air of the container and then left after opening. Indeed, air is a mixture of oxygen, nitrogen and carbon dioxide. Burning uses oxygen and combines it with parts of the matter, mostly with carbons, in case of a wood. The combined carbon dioxide molecules are heavy but one by one can still be carried away by the continuous hittings of the air parts. So at a campfire, the heavy blocks of wood, all go up in the air atoms by atoms! The weight doesn't disappear, it's all up there as carbons in the extra carbon dioxide that was formed. Thus it seems that not only the igniter heat isn't any special matter but also the resulted heat is just a side affect, when matter changes its form. This makes even more sense if we assume that the little parts of any matter are in constant motion and when a piece of matter absorbs heat it simply makes its parts move faster. The parts themselves can move in many different ways, like flying, spinning, twisting, even shaking and rolling, depending on their shapes and whether they are parts of a gas, solid or liquid. All parts have a certain fix amount of energy but it is divided into two. A much bigger portion is hidden and only a smaller is transferable to neighboring parts. The different parts and their different possible motions get an equal share of the transferable energies in the long run because of the constant bouncing or pushing each other. The equalized transferable energy at a place is the temperature. When we touch something, our skin senses the temperature because the parts of the object are hitting the parts of our skin and our skin's parts are hitting the object. The balance of whether we get or give more hits in a contact, will decide whether we feel warmth or cold. So we never actually sense an outer cold, only a loss of heat. Also, when we open the fridge, it's not the cold that comes out and touches our skin, but in fact the outside heat rushes in including from our skin. This new picture, also explains why we feel metal objects colder. They simply can absorb faster the heat from our fingers. The air in a room takes a little heat from our skin continuously too, but it is so small, that our skin replaces it, without us noticing the heat

loss or "cold". So, "cold" is another of the human phantoms like the sucking of the vacuum or the Ether.

The flame, that can start a forest fire is simply a very high temperature, that is able to make the wood parts break out of their cages, use some of their hidden energy as transferable and lit, that is uncage other wood parts. The cages that are built into the structure of matter, have many forms and levels. Strangely and luckily, the smaller ones are harder to break. Still, a sufficient local "kick" can always start an avalanche if other suitable matter is around. Thus, a forest fire, the chemical reactions forming compounds and the nuclear bombs, are all the same in principle: Avalanches of energies breaking through the local cages. All this is very simple but if we return to the campfire, we'll find another big problem: How does the heat warm us up? Oh, that's easy we might say. The burning wood heats up the air around it, that is the air parts are flying faster and these, hitting our skin, speed up the shaking of our little parts. That's nice, except anybody who actually sat next to a campfire can tell that though we feel the warm air, we also feel a direct, radiating heat coming from the fire. And indeed, if we put a glass between us and the fire, a little heat comes through at once, before even the glass could warm up and heat the air on the other side. Also, in a house with triple windows, when a winter sun shines in, it warms up the house through the cold windows. Finally, we can even realize, that all the sun's heat must come in this radiating manner because it travels through the empty vacuum before it reaches the earth's atmosphere. Also, that's why vacuum flasks are made shiny, so they not only stop the heat transfer by the air but reflect the direct radiating heat too. This all reminds us of the light and indeed, the radiating heat and light are the same thing with different appearances because the common thing, the so called electro-magnetic wave has a frequency that determines its effect in contact with different matters, especially with our senses. So we only see light and only feel heat but in most sources they are together. Sunlight is always warm and with special goggles we can see heat too. There are even wider

ranges of this same wave: X-rays, radio and TV signals and nuclear radiation. Then of course Relativity talks not only about the fixed speed of light but also the fixed speed of heat and so on. What's more, Relativity can derive from this c speed the famous energy-mass relation: $E = mc^2$.

This law is so important, it changed all other laws as well. The most important law of nature is the conservation of matter. It means, that matter can not appear or disappear, it must come from or go into other matter. Since the most obvious property of matter is mass, it's not surprising that the conservation of mass is also true and became the exact form of the matter conservation. The campfire was a perfect example of this. The wood's mass seemingly disappeared but actually went up in the air. The second most important law is also a conservation, the conservation of energy. This is less obvious than the first and indeed, some people tried to create "Perpetum Mobile", machines, that work forever without investing energy. The exact name perpetum mobile only refers to motion forever, so the parts of matters, solar systems and galaxies could be regarded as perpetum mobile. But, if we used these to get energy out of them they too would change their motions so they are not perpetum mobiles in the real sense. The fact that real machines run on fuel clearly suggest, that matter contains energy and perhaps can be changed to energy. This of course, would contradict what we said, that heat is just a by product of the burning wood changing into carbon dioxide. In general too, all machines have exhaust materials that seem to amount to the same mass as their fuel. A car's emission if collected would weigh the same as the petrol it used. But this is an illusion! It weighs a tiny bit less. The loss is that turns into energy. This mass loss is so little that no human measurement can detect it. But if the loss is so little then how can it drive a car for weeks? We can definitely measure that energy. Well that's the first, quantitative point of Einstein's formula. The conversion between the energy and mass form of matter is c^2 . The speed of light is already huge and its square is even more. So something that is not measurable as mass is

still measurable as energy. In reality, the cages built into the build up of matter are the storage place where this incredible energy is locked away. A cup of water could supply the energy need of the whole planet for days. But all this could still be misunderstood as a new conversion of mass into energy. Beside the huge conversion rate expressed formally in the Einstein formula, a hidden qualitative meaning is that mass and energy are the same. So not only the visually easy part is true that every mass contains huge hidden energy, but in reverse too, all energies have tiny masses. For the radiating heat it is not that surprising. Of course this also means that all electromagnetic waves including light have tiny masses. But much more surprisingly, even when energy is gained by merely motion or motions of the parts that is by temperature increase, the mass must slightly increase. Thus, Einstein's energy-mass law, has the simple but shocking meaning, that the mass of a matter is not exactly the total of its parts but also depends on how the little parts are moving in it. Thus, the official weights of a weight set are "unreliable" because in hot their parts are moving faster, so they are heavier. In extreme heat, the weight set itself could burn into radiating heat, not leaving any "ordinary" matter. This disappeared or radiated heat is still matter though, with mass. So the total mass did not change. Not being "ordinary" only means that the parts didn't remain in the caged levels of the atoms, rather they all changed into heat. So most of the Greek philosophers were right in their feelings against the mechanical view that all changes of matter can be explained as simple recombinations of unchangeable little parts.

2. The True Elements

In the middle ages, the philosophical Aristotelian elements were accepted by the church but with more and more experiments by the alchemists and then by the chemists, a reacceptance of the atomism was happening. This time of course, the atoms were not just hypothetical little parts but experimentally proved new elements. The four most important of these were: Hydrogen, oxygen, nitrogen and carbon. Two of the old, false elements were effectively unmasked with the help of the new ones.

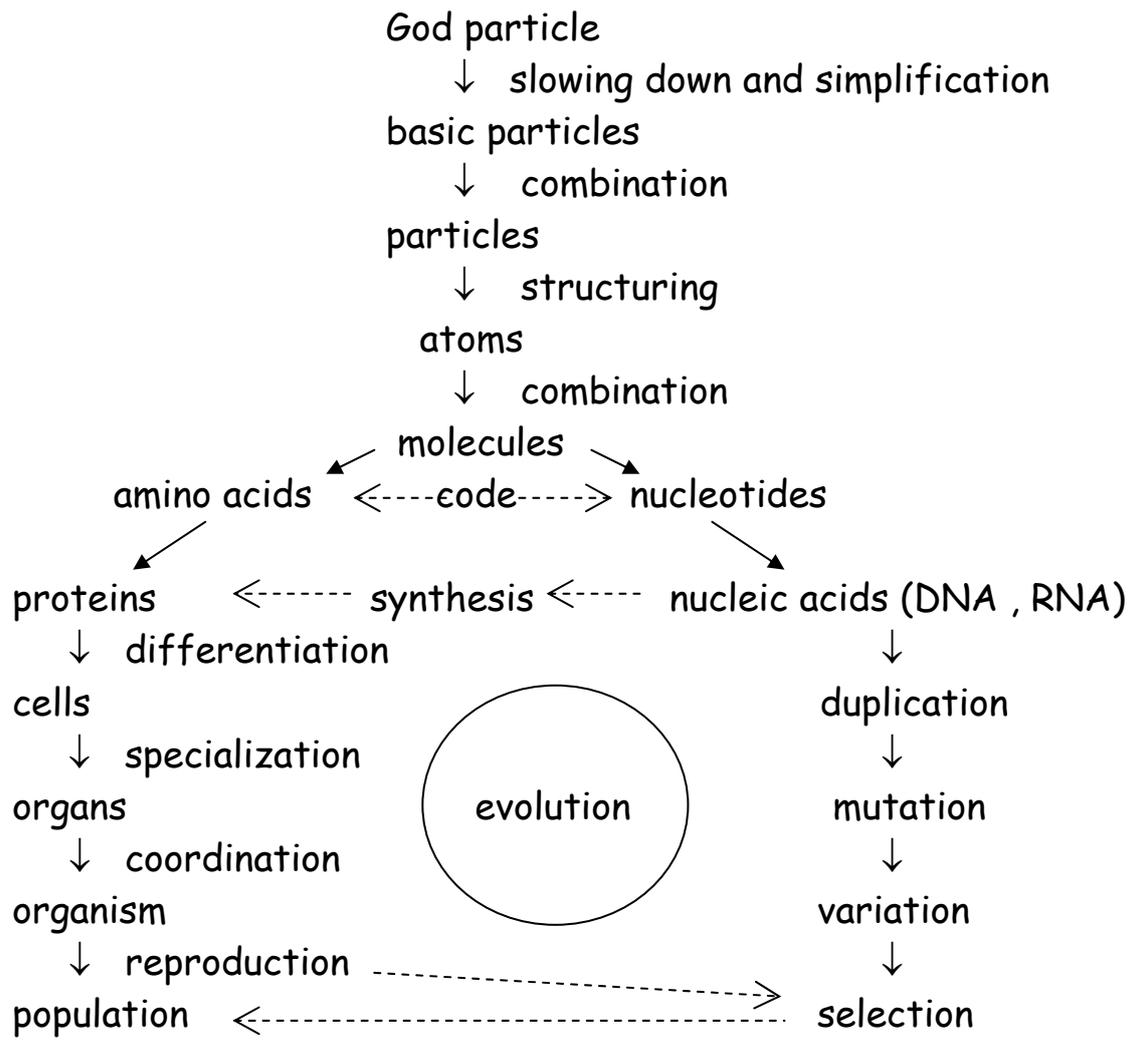
Water turned out to be H_2O , that is the collection of little units called molecules, that each contains two hydrogen and one oxygen atoms connected. Most amazingly, hydrogen and oxygen are normally gases and mixing them won't make water. We need the initial "kick", a flame. Then, the hydrogen burns in a bang into water. Only two to one ratio will combine though. The rest of the hydrogen or oxygen remains in gas. To separate water into H and O, is much harder.

Air as we mentioned already, is a mixture of three gases: oxygen molecules = O_2 or O_3 , nitrogen atoms = N and carbon dioxide molecules = CO_2 .

The new real elements or atoms grew in number and chemists put them in a so called periodic table, organized by their weights and characters. In the twentieth century, it turned out that atoms are not little bricks but instead have structure and are themselves built from little units, called particles. Finally, it also turned out that particles can have structures too, built from basic particles. We might think, that then these will have again smaller parts, and so on, and thus the final "atoms" will never be reached. This is not so! It's true that the basic particles are under renewal as a grand unification theory, but this time it's quite different. They won't be built from even smaller units, instead will be shown to "evolve" from a single original "God particle". This original state of the matter was traveling with the speed of light, but it was more complicated than light or heat. The basic particles of

today are the slowed down, heavier variations or still light speeding but simpler remainders of the original God particle. This makes sense, even from our previous chapter. Firstly, the speed of light is absolute, all other slower speeds are relative to an observer. Secondly, even the masses behave like this and as we said, the official weights reach their full weight only when burning into light speeding heat.

So we have a five leveled structuring of matter as: God particle, basic particles, particles, atoms, molecules. Biology had its own four leveled structuring of livings as: cell, organ, organism, population. Most amazingly, even the connection from the molecules to the cell has been solved as the well publicized DNA or genetics. The crucial discovery was, that all living things on earth have a common coding for reproduction. In detail: 20 amino acids build up all proteins and through them the cells. Four nucleotides build up all DNA-s. The 20 amino acids are coded into triplets of nucleotides. Thus, the building up of proteins and cells are determined by sequence of codes on the DNA. To carry out this building or "synthesis", other coded RNA molecules are used too. The NA stands for nucleic acids. The DNA itself is reproducing by simple duplication. Putting this in its place, we have the Ten Commandments of matter as:



After this grandiose view, we have to return to the atoms. The structure of atoms, resemble the solar systems but with two special features of the small atomic sizes:

1. Quantuumness means, that some properties can take up only fixed values, so they don't change continually but jump to these values in steps.
2. Probabilitism means, that some properties can not be specified exactly, they have a fogginess visually or rather an uncertainty when tried to be measured.

Best example to see these two features is the atomic analogue of the planets. These are particles called electrons but:

1. They can orbit only on fixed shells, unlike the planets in a solar system.
2. They don't actually orbit on paths like circles or ellipses, instead all over the shell as a cloud.

The analogue of the sun, the so called nucleus, is much harder to explain. Right now it's enough if we accept that it contains two kinds of particles, protons and neutrons. The number of protons is fixed for every specific atom or element and it is called the atomic number. For example, the carbon's atomic number is 6, so its nucleus contains 6 protons. The number of neutrons can be different for an element. For example, most carbon atoms contain 6 neutrons but some can contain 8. These less frequently occurring atoms of an element with different number of neutrons, are called isotopes because in the periodic tables these were located at the same place. (Same = iso, place = tope) In these tables of elements, beside the atomic numbers, the masses of atoms are also given as compared to one proton's mass. Since the neutron's mass is almost the same as the proton's, an atomic mass should be a whole number plus the minute masses of the electrons. But in the tables the masses are the averaged weights of the isotopes found on earth. For example, the carbon's mass is 12.011. The .011 part is not only due to the electrons but also to the rarely occurring carbon isotopes with 8 neutrons. Especially interesting is the # 1 atom, hydrogen, which has the

atomic mass 1.008. This shows that most frequently a hydrogen atom has one proton in its nucleus and no neutron at all. The .008 part comes from the single electron and very rarely occurring hydrogen isotopes, with one or two neutrons. By the way, these were so important that they got special names as deuterium and tritium. Heavier and heavier atoms have more and more extra neutrons. For example, the # 26 Fe = iron has atomic mass 55.847 but # 79 Au = gold has already 196.97. An interesting case is the # 52 Te = tellurium with atomic weight 127.6 and the following # 53 I = iodine with atomic weight 126.9. This shows that iodine has less heavier isotopes than tellurium, and those extra heavy isotopes are increasing the averaged weight of tellurium to exceed iodine.

The number of electrons is the same as the number of protons. Not only their numbers but also their orbiting shells are fixed. Basically, the orbiting electrons fill up bigger and bigger shells as the atomic number increases but, the shells have limits on the number of possible electrons on them. The first shell can have two electrons, the second can have 8, the third 18, the fourth 32, and so on. In general, the n -th shell can have $2n^2$ many electrons. The n^2 is logical because on an increasing body, that's how the surface increases. For example, a dice with one centimeter edge has 6 cm^2 surface but with two centimeter edge has $6 \times 2^2 = 24 \text{ cm}^2$ and so on.

The 2 multiplier in $2n^2$ suggests that the electrons might form some kind of pairs on each shell. A natural idea could be that the orbiting direction is behind this coupling. But remember, electrons are not planets! They not only must orbit on fixed shells but they orbit on the whole shell all the time, like a moving cloud, including all directions already. In spite of this, as unbelievable as it sounds, electrons are spinning around themselves just as planets do. We could be skeptical and say that this won't help again, because the spinning, just like the orbiting is a foggy variation around all directions. Unfortunately we are right. Lets remember that in atomic sizes everything has two opposing features, sharp jumps and fogginess. One thing of course, can not be sharp and foggy at

the same time, but one thing's describing features can. The electron orbit size is sharp, it has to be on fixed shells, just like there are only fixed car tire sizes available. But the electron path is foggy like fast running or turning tires. Okay, then what is the sharp about the electron's spin? Can it be the size again, meaning the strength? No, it's always the same. Maybe the planet analogy still has some good points to offer. Indeed, lets look at the orbits and spins of the planets! The orbit times, in other words the length of a "year", is only depending on the distance from the sun, but the spin time, that is the length of a "day", is arbitrary for all planets. Yet there is a feature that is usually not contained in the "year and day" data of planets, namely whether the spinning is forward or backward compared to the orbit. Something similar exists even at the foggy directions at electrons and this sharp feature is the spin.

The increasing order of filling the bigger and bigger shells, is not absolute. There are "jump-outs" and "drop-backs". In fact, these expressions can refer to two totally different situations. One happens in time, for one atom, while the other refers to the build up sequence of different atoms.

Sometimes in an atom if an electron gets energy, namely accepts or "absorbs" light, it can jump out to a bigger shell but then later it will give back, that is "emit" the light and drop back to its original shell. The glow in the dark objects are practical applications of this.

The other more important meaning of "jump-outs" and "drop-backs" is happening at the filling order of bigger and bigger atoms. Up to # 18 Ar = argon everything is perfect. Hydrogen has one electron, helium has two on the same smallest shell and that fills that shell. Lithium's third electron starts the second shell and then beryllium, boron, carbon, nitrogen, oxygen, fluorine and neon, finish the second shell. Natrium = sodium with its 11-th electron starts the third shell and then magnesium, aluminum, silicon, phosphorous, sulphur, chlorine and argon place up to 8 electrons on the third shell. This shell, could carry up to $2 \times 3^2 = 18$ electrons, but the next

element, kalium = potassium jumps out with its 19-th electron to the fourth shell. From here on, at every element there will be one or maybe even more unfinished shell under the outmost one. Thus, all new electrons have three possible choices:

1. Continue on the outmost shell.
2. Continue in an inner unfinished shell.
3. Not continue, rather start a new outer shell.

This last, jump-out, only happens in four other cases, besides the mentioned kalium = potassium, namely: # 37 Rb = rubidium, # 47 Ag = silver, # 55 Cs = caesium and # 87 Fr = francium. The second inner continuation can happen with a special twist, namely that the new electron also "takes with it" an other already occurring from the outmost shell. So for this electron it can be called a drop-back.

For example, the first element after kalium = potassium, is calcium, which continues on the fourth outmost shell started by kalium. Then, scandium, titanium and vanadium continue in the inner third shell. And then, chrome not only places its new electron in this inner shell, but also grabs one of the two electrons from the fourth shell, so causes a drop-back. Then Mn = Manganese places its new electron right back to the outer shell, replacing the one that dropped back. Then, iron, cobalt and nickel again continue on the third inner shell. And then, copper again causes a drop-back and the following zinc replaces the dropped back outer electron. By the way, this "instant replacement" of the dropped back electrons is not a rule at bigger elements.

As we said, the nucleus requires more and more extra neutrons and after around # 90, the set of protons and neutrons becomes unstable. Physicists were able to make atoms up to # 109, but these "live" only for fractions of a second. So in practice there are roundly about 100 elements. Of course, there are more isotopes of the same element, that is different neutron numbered variants. All together there are about 1000 isotopes. For chemists, the isotopes of an element are unimportant because they behave the same way in chemical reactions. For atom physicists, the difference in isotopes lead

to the biggest discovery of the 20-th century, the nuclear power. But there is a less known, yet more peaceful use of isotopes and that is the isotope dating of old remains. The instability of the nucleus already occurs in atoms under # 90 but very rarely. Since such break up of atoms is random, it has a fixed probability under a given time. These break up probabilities are different, not only for the different atoms but also for the different isotopes. For example, the "normal" carbon atom with 6 neutrons has almost zero probability of breaking up, even under huge times, while the 8 neutroned isotope is much more likely to break up, namely in 5700 years each has 50%, that is half chance of breaking up or staying together. This would suggest, that in the universe, the number of these carbon isotopes should become halved after every 5700 years and so by today we could hardly find any. But lets not forget, that atoms are in constant change in the universe. Even just on the earth, the atmosphere due to the cosmic rays, that attack its upper regions, is able to form new atoms. So the air's carbon dioxide has the same carbon isotope proportion for millions of years. Sadly, after the hydrogen bomb experiments in the fifties, this delicate ratio of carbon isotopes in the air had changed so dramatically, that the leading countries had to sign the ban on overground explosion experiments.

Animals, get their carbon from their food, that is from other animals or plants. Plants get it from the air. So eventually, all carbon comes from the air and thus when the animal or plant died, it contained the normal rate of isotopes. After that however, the halving at every 5700 years is really starting and so by checking the isotope rate in a remain like a bone or wood, we can establish when it died.

3. Break Up and Combination of Atoms

We mentioned the rare and random break up of the nucleus already. This can happen in two ways: Either both of the broken nuclei grab at once electrons around them, so two complete atoms are formed, or if one of the broken off parts is too small then it flies away so fast, that it can't collect electrons, instead causes particle rays. The first case is called fission, the second, radioactivity. In fission, the produced smaller atoms require less neutrons in total, than the original atom had, so the unused neutrons fly away and can even break up. So fission can also cause particle rays. However, if a flying neutron accidentally hits a nucleus, then that might break up. This of course leads again to extra flying neutrons and if these new ones hit again nuclei, and so on then a neutron avalanche will develop. Unfortunately, the term "chain reaction" got accepted, but we should see why it is misleading: When a line of standing dominoes knock each other off, this "domino effect" is the one that should be called a chain reaction. Sometimes we put two dominoes in front of one to split a chain into two. Imagine if we could place two or even more dominoes in front of each new again and again. The floor is not big enough to do that, but that's exactly how the number of neutrons is increasing. The avalanche of the snow is not the perfect analog either but at least suggests the increasing "snowball effect". For a neutron avalanche, three conditions are needed:

1. There must be enough unstable atoms in the matter, so the flying neutrons can hit one.
2. There must be some "moderator" atoms, that slow down the flying neutrons because too fast neutrons can be easily absorbed by some nucleus. This seems illogical but the fact is that most of a too much extra energy is transformed into the "melting in" of the neutron and the remaining little energy is not enough to split the nucleus. If however, the neutron is slower, then its energy is not enough to be glued to the nucleus, but it is enough to break that.

3. There must be more than a "critical" size of the matter, so that the flying neutrons don't leave it before hitting some atoms.

In atom reactors, a fourth condition is added, namely "control" atoms, usually as cadmium or boron rods hanging into holes of the fissioning matter. These absorb neutrons, thus can slow the avalanche or stop it if dropped completely.

In atom bombs suitable matter with conditions 1. and 2. is placed in two or more pieces, each under the 3. critical size. When the bomb is dropped, usually already before hitting the ground, the pieces are combined and thus exceeding the critical size, an uncontrolled avalanche takes place.

Radioactivity has three rays: α = alpha, β = beta, γ = gamma. α ray consists of two protons and two neutrons, which of course is the same as the nucleus of the second element, helium.

β ray is fast moving electrons and we could think that they are simply the two excess electrons of an atom when it loses the α parts from its nucleus. But how could those shell electrons fly out with the high speed of β rays? More importantly, it turned out that though α and β rays usually appear together, it is not always the case. Some matters only emit one or the other, so the two rays are caused independently. The truth behind β emission is that, a neutron of the nucleus changes into a proton, with shooting out an electron and an even smaller particle called anti neutrino. Thus, the atomic number increases by one. Sometimes even single neutrons can split up the same way, that is: $n \rightarrow p + e + \bar{\nu}_e$, where the last is the sign for the anti neutrino.

γ ray is similar to light, which as we mentioned can be stored and regained by the orbiting electrons. However, after the amazing nuclear origin of the β electrons, we can't even be surprised that the γ ray is also a nuclear version of the "normal" light and heat.

The fission of atoms suggests that smaller atoms are more stable than bigger ones, but under the #26 Fe = iron, the fission becomes more probable again. Of course, the α ray

shows that helium must also be the most stable atom, in another sense. Indeed, the stability function has two peaks, one at helium and one at iron. After falling back at lithium, it has smaller jumps, to some even numbered atoms (Be, C, O, Ne).

The opposite of the natural break up of heavy atoms would be if small atoms could combine, that is "fuse" together into the most stable helium or iron. This never happens by itself, so there must be a gate that stops it. There is nothing new in this, after all the heavy atoms have a gate too because most of them stay together. The only difference is that the "fission gate" is "leaking", while the "fusion gate" is "tight". But they are both special cases of the general "cages" in matter, that we mentioned at the false elements. Just as by a neutron avalanche, we force the fission gates to open, maybe we could force fusion into helium or iron and then gain more energy, than we invested for the forcing. The fusion to helium is simpler because the only smaller atom is hydrogen. And indeed, in hydrogen bombs, hydrogen isotopes, deuterium and tritium, are forced into helium by blasting an atom bomb around them but at once causing an even larger explosion of the fusion. In the sun, due to the very high temperatures, fusion takes place continuously. In earthly conditions, a continuous and controlled, so called "cold" fusion has not yet been achieved. Since hydrogen isotopes are plenty in the oceans, this could mean free and clean energy for mankind.

As the particles tend to combine into nuclei and these with electrons into atoms, the atoms tend to connect and form the materials we see around us. Most of the time, some atoms first combine into molecules. For example, as we mentioned, hydrogen and oxygen gas mixture can be burnt into water. In truth, this small explosion is a molecule forming avalanche, after which every oxygen atom will be connected to two hydrogen atoms, making up a H_2O water molecule. Another, slower avalanche is the also mentioned burning of a wood, that forms CO_2 carbon dioxide molecules. Molecular matters have the perfection of being identical at every point. In contrast, man made alloys are not molecular. Amazingly, if to a melted

metal a tiny amount of other metals or carbon is mixed, then after it is cooled down, its properties will be changed completely. Since these added atoms are not regularly repeating as they would be in molecules, only randomly, depending on the mixing, therefore some places can have too many, other too few of the special atoms, causing errors in the alloy. For example, the rust spots on cheap stainless steel, are signs of missing carbon atoms.

The two ways of atomic connection, molecular and non molecular, can be found not only between different atoms as compounds and alloys, but among identical atoms of an element. Oxygen for example, is rarely in single atoms as O , instead two of them form O_2 oxygen molecules or sometimes three of them form O_3 ozone molecules. Unlike oxygen and carbon dioxide, the third gas in air, nitrogen, is in atoms. Non molecular solids can even have "multiple personalities" just like oxygen had different molecules. Carbon for example, is not only coal or the soft pencil lead, graphite, but also the hardest crystal, diamond. The difference is merely in what shape of grids the carbon atoms connect, looser cubes or tighter pyramids.

The connection of atoms are caused by the interactions of the outmost electrons and were viewed as giving or sharing of electrons among atoms. The best however is to imagine that when atoms connect, they open up their outmost shell, so that these shells can stick together. In molecules, this means a common outer "bag" where all the outer electrons are shared. In non molecular matter, the connected outer shells form a "glue" expanding in the whole mater. Both molecular and non molecular matter allow the vibration of molecules or atoms. Indeed, this is the main form, of heat conservation and conduction. So matter is like a system of vibrating spider webs. Small heat only vibrates the system more. Bigger heat breaks it up and even bigger can destroy the individual webs or kill the spiders, that is the nuclei too.

4. Electricity and Magnetism

Electricity has two everyday appearances, electric forces and electric current. The first happens for example, when bodies rub each other, after which they can attract small pieces of matter. The pullover when taken off, attracts our hair or little papers. Electric currents flow in metal wires if they connect two ends of batteries or plugs of electrical supplies. The glowing of light bulbs in our flashlights or in our room lamps, are caused by the current going through the special wires in the bulbs. Since the batteries and plugholes don't attract even the smallest piece of papers, we might think that electric force and electric current are caused by two different electricity. In fact, it's even more surprising, that the electric force of our pullover can pick up papers but doesn't harm us, yet the electric plugs can kill us. That there is a connection between the "two electricity" can be seen from sparks. They appear when we walk on some carpets and then touch metals, but also when batteries or plugs are not properly connected. Best example is, "nature's spark", the lightning. The friction in clouds can cause such big electric forces that strike down to the closest sharp metal or wet object. In the object, an electric current, will continue towards the ground. So after all, electric force can kill us too.

The real reason, behind the two appearances of electricity, is a much simpler duality, namely the two directions of electric force, caused by the two signs of electric matter. We can see this if we let a rubbed plastic object attract a little piece of paper. Amazingly, after the paper touches the plastic, it is repelled at once. We can explain this as follows: Matter contains equal amount of negative and positive electrical particles, so they cancel out each other. Rubbing the plastic, we transfer only one kind, say negative particles, so in the plastic they become more than the positive ones. In other words, the plastic now has an excess negative charge and so it attracts positive and repels negative particles. Of course, a little paper has the same amount of positive and negative

particles, so it should be attracted and repelled equally, canceling each other. In reality however, the positive particles in the paper move a little bit towards the plastic, while the negatives try to move to the opposite side of the paper. An electric force is bigger if charges are closer. Thus, even though the positive and negative charges are equal in the paper, the positive ones being closer to the plastic will cause a bigger attraction than the repulsion caused by the further negative charges. So, they won't cancel each other after all, rather the paper is attracted. The excess negative particles on the plastic don't feel good together, they repel each other too, so when the paper touches the plastic, some of them escape to the paper. Then the simple repelling of the two negatively charged bodies conquers the temporary attraction that was caused by the displacement. The paper is repelled.

As we remember, in the atoms, the protons and electrons are equal in number and indeed, they are the electric particles. By convention the electron is regarded negative and the proton positive. The electric forces within the atoms, explain some facts but contradict others. First of all, the attraction between protons and electrons seems as natural the cause of the electron's orbiting. Planets orbit because of the gravitational force and gravitation is a totally universal force, so it acts between protons and electrons as well. But it is so weak in the atomic sizes, that the electrons with their high speeds would fly away at once, unless the much stronger electric force would keep them in orbit. The repelling between the electrons themselves explains why they keep away from each other and never collide. This of course, still doesn't explain why the electrons orbit on fixed shells and neither why they never fall into the nucleus. But the biggest mystery is how the protons, that repel each other can stay so close together in the nucleus or why the neutron can split, separating into the proton and electron. The real explanations will be through the basic particles but in view of the electric force, we can already talk about nuclear forces, that conquer the electric force. Two

ranges of these forces are acting. One "strong" is bigger and one "weak" is smaller than electricity.

In molecules, the common outer bag of electrons disrupts the equal distribution of charges, so in spite of having the same number of protons and electrons in total, the molecule will have charged spots. If the molecule is symmetrical, then the symmetrical ends are identical in charge too and only the middle is different, but if the molecule is asymmetrical, then it can have oppositely charged ends.

Electric currents can easily be explained: When a wire connects opposite electric points, then one end of the wire accepts, while the other loses electrons. This of course, causes the movement of the whole glue system of free electrons, like a long string of carriages at a train. In reality, the free electrons still wonder but they have an after all tendency of moving along the wire. Asymmetric molecular matters like water can also carry electric current by alignment and movement of the molecules.

Magnetism, just as electricity, has two appearances: Permanent or iron magnet is used, for example, in a compass, while electric magnet, that works only as long as the current is flowing, is used at junk yards to pick up scrap metal. Just as there are two signs of the electric charge, there are two magnetic poles, north and south, named by the earth's magnetic directions. Moving charges, bring about magnetic poles around them. Opposite moving direction or opposite charge sign make opposite poles. That's why a moving piece of matter will not cause magnetic effect. Indeed, not only the charges of the matter cancel, but the poles it would create too. When a current flows in a metal or liquid, the charges still cancel, but the caused magnetic poles don't, because only one signed charges are moving. At metals, the negative electrons. This leads to continuous magnetic poles around the wire. To get a common main direction of poles, we can form a loop from the wire. In the center of the loop, the same directional poles add up and cause a much stronger force than the opposite poles

outside the loop. For an even stronger magnetic force, we can make a coil.

Household electricity is alternating its direction 50 or 60 times a second, and even the lightest compass couldn't change its direction that fast. So the electric leads seemingly don't effect a compass. Yet, if a small compass is flicked to spin next to a loop or coil in rhythm with the alternating current, then it keeps on spinning because the strongest push or pull is always in the same direction and will compensate the friction. In essence, that's how electric motors are working.

Just as a current in a wire makes a magnetic field around it, conversely, the magnetic field can force the flow of a current in a wire. But there is a big difference! A fixed current makes a fixed magnetic field, while a fixed magnetic field, for example holding a strong magnet next to a wire, will not cause current in the wire. Only changing magnetic fields can force the flow of currents. This can be achieved in three ways:

1. We can move a magnet (either permanent or electric) closer and back next to a standing wire.
2. We can move a wire next to a standing magnet.
3. We can place an electro magnet next to a wire and then without any motion, just by altering the strength or alternating the direction of the electro magnet, will cause changing magnetic field and thus flow of electric current in the other wire too.

This is how we generate and transform household electricity.

This electricity is not free, it costs money, somebody has to work for it. This is true in nature too and it explains the strange asymmetry, that current can make a fix magnetic field, but fix magnetic field can not make a current. Indeed, if a piece of magnet could continually produce electric current in a wire, then everybody would run his household on magnets. If we want to use magnets to create our own electricity, we can do so, but we have to move them, we have to work again! This principle of "no free energy" or the conservation of energy as we called it before, even tells us the directions of currents and magnetic fields. Indeed, it seems first that though the

magnetic field must move, we can create free electricity by just starting a changing current, which then would produce a changing magnetic field and that again a changing current, and so on going forever. What happens of course is, that the new magnetic fields are always opposite to the original one, so instead of strengthening, a weakening and stop will occur. By looking at the energies, we can at once tell things about the forces, without going into the details of the exact rules. For example, we all know that a bigger magnet tries to twist a smaller one into the same pole direction and then they attract each other. If the small magnet is in opposite position, and we don't let it to be twisted around, then it will be repelled by the big one. Now, this forced repelling must be a bit bigger than a twisted attraction would be, by the following argument: The big magnet is already losing some energy by twisting the small into the same position, thus leaving less for the attraction. On the other hand, our forceful counter twisting is investing energy, thus leading to a bigger repelling. Unfortunately, there is a fact we forgot about, namely that magnets are made of iron! So when the small magnet is repelled it is also attracted as an iron, weakening the repelling. Of course, if the small magnet is an electro magnet, then it doesn't have to be made of iron. Connecting two equal but opposite electro magnets, we could even test the bigger repelling. Indeed, holding them in line with the pole direction of the big magnet we should witness a weak repelling. Connecting a lot of pairs of opposite electro magnets in all directions, we don't even have to force an alignment because the system should be repelled regardless of its position. Amazingly, any piece of matter is exactly such system with billions of tiny electro magnets connected. Indeed, the orbiting electrons are loops of currents, that is magnetic poles perpendicular to the orbits. Of course, there are two opposite pole positions in every direction. If every orbiting electron in atom has such opposite pair, then they cancel each other and we have a non magnetic atom, while if there are pairless orbits, then the atom will have a magnetic pole. This doesn't mean of course, that the whole matter is magnetic,

because the different atomic magnets can cancel each other too. The atoms, can tilt a little in different positions, so neighboring ones might influence each other but still, the random positions can't form a common pole. If however, we place the matter in an outer magnetic field, then even just a little tilting of the magnetic atoms toward this outer direction, will produce a total magnetic tendency toward this outer field and so the matter will be attracted. This can be observed for many elements but this weak, so called paramagnetism is not the well known attraction of iron, which is called ferromagnetism for the obvious reason that # 26 Fe = ferrum = iron. Less known is that the following cobalt and nickel have also strong ferromagnetism, while stainless steel doesn't. The proper name for ferromagnetism should be spin or domain amplified paramagnetism, because it works in the following way: The already mentioned neighboring effect of atoms are highly increased in Fe, Co, Ni, due to the unpaired electron spins and thus so called domains will be formed in them with fairly common magnetic poles. Of course, again the domains will cancel each other, so these metals don't show magnetism in themselves. If however, they are placed in outer magnetic field, then not only the individual atoms but the whole domains will align. What's more, the preferred, that is more aligning domains will grow and take over the opposing ones, so an even much stronger total alignment is achieved. Finally, we can return to our original idea of connecting a lot of opposite electro magnets. Matters with all paired electrons and thus with no atomic balls are exactly like that. So according to our hypothesis obtained purely by the energies, these should be repelled by magnets. But lets not forget that the repelling was only true for aligned pairs and so only for totally rigidly connected system, while atoms can tilt towards the outer field. The tilting, that was the cause of paramagnetism for matters with magnetic atoms, is killing this opposite, repelling magnetism for non magnetic atoms. Luckily, the tilting itself is restricted due to the structure of matter and so there are elements that are actually repelled. Strangely, the strongest

effect is at # 83 Bi = bismuth, that has an odd number of electrons, seemingly contradicting that all electrons should be in pairs. But let's remember that some of the outer electrons are free in the common glue system. It was Faraday who first realized that a bismuth ball is actually repelled by a strong magnet, and he called this diamagnetism. This amazing phenomenon proves at once, that magnetic force can not be a simple analogue of the electric force. Indeed, electric charges always attract non charged objects. But even the para and ferro magnetic attraction is clearly different from the electric attraction by displacement, because the attracted piece of paper will be at once repelled, while an attracted iron stays on the magnet. The excess charges escape to the little paper, but there are no magnetic charges, that could escape to the iron. It's only the motion of electrons that causes magnetism. What's more, if the iron remains in a strong magnetic field for long, then its atoms and domains stay in their forced positions and the iron becomes a magnet itself. So after all, permanent magnets are also just complicated systems of electro magnets. Then of course, magnetism as such can be regarded as a new special electric force, appearing only between moving charges.

5. Light and Time

From Relativity, it turned out that magnetism, the extra electric force due to the motions, is not a special feature of electricity, rather follows from the right way of looking at motions in general. A standing charge has only electric field around it, that is, it attracts or repels other charges. If it moves, it causes magnetic field too, that is, it will cause side forces on other moving charges. But if an observer moves together with the charge, he thinks it is standing. Thus, different observers see different appearances, one sees electric and magnetic field, the other only electric. The final reality of forces and facts of course must be the same, regardless how we combine it from electric and magnetic components. So, magnetism is simply a relativistic effect of electricity.

There is however, a strange and most important twist in electromagnetism still remaining. When lightning strikes, beside the electric forces, the caused burning current and the strong magnetic disturbances nearby, there is the effect that gave its name, the light, that we can see miles and miles away. The motion of charges in the lightning or in any light source, is not only the source of a relativistic force field around it. Instead, the electric field is changing in a way, that causes a magnetic field which causes again a new electric field and that again a new magnetic field, and so on. An infinite electric-magnetic-electric- self sustaining wave is born. That's light! As such, this force field, that was simply the description of observers, becomes independent, a "thing" that can travel through the whole cosmos. Of course, radiating heat, X and gamma rays, radio and TV signals are all basically the same as light.

The electromagnetic waves are not caused by the two signs of charges, rather by the relativistic effects of electric forces. So, we could ask why the most important force field, gravitation, doesn't show similar self sustaining waves. We have to realize that an electron's charge is huge compared to its

mass. To imitate the electromagnetic waves for gravitation, we would have to make fast or sharp changes in the speeds of large bodies like the moon. So, there are gravitational waves around us, but they are so weak that we can't observe them yet. Though the gravitational waves are not yet detectable, an even newer particle theory of the four forces (gravitation, electricity, strong, weak) is accepted. This solves the mystery of how the seemingly subjective concept of force field becomes objective as wave, by claiming that force fields are objective from the beginning. Namely, waves and force fields are both radiations of particles. Newton, who was a believer of particles in the case of light, would be happy to learn, that even gravitation is caused by particles. So its not only the same force that makes the moon orbit and an apple fall, but also they are both caused by the interactions of the always radiating graviton particles from the earth, the moon and an apple. A concept of force particles solves an other problem that was already bothering Newton, namely the unrealistic instantaneousness of force fields. In theory if we could place a mass somewhere instantly, then it would cause an effect in the whole universe at once, which is absurd. With force particles, the effect must spread with a certain speed. Not surprisingly, this is the speed of light. As it always happens, the new theory "solved" the mystery by creating an even bigger new one: If a force field is the radiation of particles, then all masses that create gravitational fields, and charges that create electric fields, should lose some of their mass and energy in time. This is not happening because of the "fine print", a crucial difference of the force particles. They are radiations of only "virtual" variants of the particles that form the actual wave pockets. This virtual variation is possible because of the probabilistic feature at small sizes. It saves the day, because a standing lone body doesn't radiate actual gravitons and doesn't lose its mass. The lone body is only radiating the "possibility of losing something". If an other body comes nearby, they exchange such virtual gravitons and then we experience the everyday gravitational force. This force is still happening

without losing mass but now the keeping of mass is not only a consequence of the virtuality of the gravitons, but also of the equal exchange. Finally, if a lone body is accelerated, then it "shakes off" real gravitons, leading to gravitational waves and real loss of mass. The same three levels go for electricity: A lone charge only radiates virtual, that is "possible" photons. If an other charge is nearby, they exchange some virtual photons causing the electric force. Finally, if one charge is accelerated then it emits light, that is real photons, thus losing mass too.

The natural question earlier was: What kind of reality lies behind the probabilistic appearances? But now this question seems to be challenged by the virtual particles! Indeed, a continuing chain of only probabilities, is actually doing the forces between bodies. So maybe there is no hidden reality! The probabilistic appearance is the deeper reality itself and the virtual particles are the best example, because through their exchange, probabilism becomes force. Einstein never gave up the "natural" question of looking for a hidden reality behind probabilities. So the new virtual particle picture, not only would please Newton, but maybe could convince Einstein too.

Einstein's reluctance against probabilities, was especially strange because the probabilistic, limited description of reality has a similar analogue in Relativity too. As we remember, it turned out that the Ether, filling the cosmos was a phantom. Then of course, to say that a rocket moves with a certain speed in deep space, is meaningless. It can only move with a speed compared to something else. This perfectly corresponds to two everyday experiences. Firstly, on a fast train, we can be totally unaware of the train's speed. We can play chess, dropped objects fall straight down, and so on. Secondly, if two observers move relative to each other, then they both can regard it as one is standing and the other is moving. They can even assume combinations of speeds to an absolute third system. So only, the relative speed of the observers is absolute, that is objective This strange double meaning of relativity and absoluteness is not the crucial meaning of

Relativity though. The outside world is obviously not the same for two observers, simply because they are at different places and move with different speeds compared to the outside objects. But these differences seem to come from the obvious additions and subtractions of distances and speeds. For example, if a train goes with speed s towards a station and a cowboy shoots a bullet with speed b forward from the train, then the bullet will approach the station with $B = s + b$ speed. These additions that cause the relativity of the systems in describing the outside objective world are also causing the absoluteness of the inside experiments. The dropped object in the train will inherit the train's speed when we release it. The distinction between what is outside and what is inside seems obvious. But amazingly for light, this distinction is immaterial. No matter whether we create light inside or let it in from outside the speed is always the same. This contradicts both idea of light as wave in the ether or bullet from a gun. The already mentioned facts that Einstein destroyed the concept of ether and photons are particles, suggest that somehow the bullet idea still won over the wave. The price of this win was to change how actually bullets move. Mechanics had to be changed. Most amazingly the theory that gave the clues how to do this, was the wave theory of light. Indeed Maxwell's electromagnetic equations showed that the speed of light must be fix in any system. So these equations seemed to contradict the very assumption that they were based on, namely the ether. The only explanation could have been that the ether mysteriously distorts matter that travels in it and thus distorts the measuring devices too, to create the fix speed of light. Einstein chose a lesser mystery, namely that time is not absolute. More importantly, this relativity of time boils down to the relativity of simultaneousness. In other words, the meaning of "now" is relative. This is not so absurd! The "now" for a "here" is quite obvious. We just look at our watch. But the now of an other place is clearly delayed. Indeed, if we look at a church clock, then the time we see is a bit earlier because it took some time to reach our eyes. First of all, this

delay is so small that we can't notice it. But even if we get time signals from far distances, we can make corrections for the delays. So the "now" and thus time too, can be synchronized among objects that are far away. The real problem starts if an observer is in motion. His corrections will not be the same as a standing one's. If two flashes arrive at a P point at the same time, then that flash was earlier, which has the longer distance from P. Of course, if P is exactly the same distance from the two sources, then the two flashes had to be simultaneous. If the signals reach the middle point at the same time on the station, then according to the station, they will definitely not meet in the middle on the train. Simply because the two points move away, while the signals are traveling. The observer in the train will also claim that if the signals were simultaneous for him, then they can't be for the station. From these, it also follows that if two observers are moving relative to each other, then they will both find that the other's time goes slower than their own. We might disregard the importance of this, if we realize that two observers traveling with a fix speed to each other, can only be at the same place once. So they can never confront each other about their time differences. But what if we could bring the two observers face to face again after a certain time. There are two ways we could do this. Either, they have to go on a curved path, or they have to go forward and back. In either case, forces could be felt just as we feel when a train curves or changes its speed. The chess pieces tip over, dropped objects fall stray and clocks change their rhythm. We have the following dilemma: Which way of returning of the observers is better, big curve with small side force for a long time, or a sharp u turn. Actually, none of them are good. The long, small force interrupts the clocks continuously so the added effect can be big. The short big forces, on the other hand, can be fatal, that is break the clocks completely. Now if a clock survives, will it still be affected depending on the size of the force? This seems very unlikely. So lets go for this choice. An other advantage of this choice is that if we know how time slows down on straight trips,

then we can use that for the two return trips. This leads us to the so called "Twin Paradox". The two observers are taken as twins, so their ageing difference sounds more striking. There are four levels of this paradox: The first is merely what we claimed above: If two twins travel away from each other in opposite directions, with fix speed, both will claim that the other's time slows down. The second is a possible reuniting of them with the puzzling question, whether there will be indeed an age difference between them and if yes, what decides which one will be younger? The third level is when we go into the details and realize, that for the twins to leave each other and reunite requires speed changes. Such motions can be only described by *General Relativity*, but with a trick we can use *Special Relativity*. Indeed, suppose that one of the twins was in a rocket that never changed its speed and only the other was accelerating or turning or slowing down. Then his description of the other twin is correct, except for the short periods of speed changes. So, if the time delay is determined mostly by the fix speed periods, then his twin will be indeed younger when they meet. On the other hand, the twin's description can not be used at all, because it was a system that went through speed changes. This level is the first real physical paradox. Not only in the sense that time actually slowed down, but also that a difference in description became reality. So, description and reality can not be separated. If we still try to force how the actual ageing is created from the relativity of time, then we get the fourth and deepest level of the Twin Paradox: Indeed, above we claimed that the short, big forces can't have long time effects. As Nitché said, "Whatever doesn't kill you, makes you stronger". Clearly not quite true for clocks, but still it seems plausible that the ageing differences are happening under the straight journeys. So the short acceleration after leaving, the turn around and the final slowdown shouldn't cause the youngening. This is also supported by the fact that the time delay can be calculated from the two straight trips, there and back. So then the fact, which of the two twins becomes younger will be determined by the short speed changes that

don't determine the youngening. We could even try to make a stronger version of this paradox by starting with both twins accelerate from each other equally for a short time, then travel apart and finally one of them turn back and catch up with the other. In this version, up until this turn around, they are totally symmetrical, so we have no idea which one will be really younger. And yet, part of the youngening depends on this first trip away from each other. In a sense, they are both potentially youngening, while traveling away from each other and at the turn around of one, it becomes actual for that one, while only theoretical for the other. But this case is very different from the previous, because both systems made accelerations, so Special Relativity can not be used at all. Einstein would say that we are wrong in our connection of description with reality. Ageing is caused neither by short accelerating periods nor by periods traveling with fix speeds. Ageing is caused by inner biological effects, under its own local time. We are only lucky that we can calculate ageing differences from relative trips if the trips also satisfy some conditions of comparability. There is no common reality behind the two ageings, when they are apart. As they get closer and closer, a common reality is forming and that includes the good third Twin Paradox. Then of course, we can ask: Is there a deeper reality, not only for places connected by signals, but for all separate places, a reality beyond Relativity? Einstein obviously denied such reality, yet he believed in a reality beyond probabilities, beyond Quantum Mechanics. Both Relativity and Quantum Mechanics describe reality in a strange way, that limits our very description of reality. Both are connected to the concept of time. Relativity, universally, while Quantum Mechanics, locally. The Twin Paradox and Virtual Particles are crystallized special situations, where the self limited descriptions lead to unquestionable realities, that could hardly be imaginable within full, non self limited descriptions.

6. The Particle Zoo and Big Bang

The beta rays, that is the splitting of the neutron into proton, electron and anti neutrino, was just the first in a long sequence of puzzles and discoveries, leading to the zoo of nuclear particles. Luckily, just as the zoo of elements collected in the periodic table, are the atoms built from three particles, proton, electron and neutron, similarly, all particles of the particle zoo can be built from basic ones. What's more, this new system also contains the idea of the virtual particle representation of forces. This gives an easy way to introduce the system: Gravitation, the force of mass has only one direction. Electricity, the force of charge has two directions, attraction or repelling, and the charge itself has two directions. We introduce a new, three way "charge", which we call "color", because just as plus and minus makes zero, the three primary colors, red, yellow and blue, make white. Color is the reason of the strong nuclear force but now there are more than three "directional" forces, corresponding to all possible color changes. As it turned out, we need eight so called gluons as the particles of the new color force. Combined in a table:

properties:	mass	charge	color
forces:	gravity	electricity	strong
particles:	graviton	photon	gluons

The force particles travel with the speed of light. While "normal" matter can't reach the speed of light, these special particles can't slow down. The strong force has an other new feature beside having the three variants of its source, the color and the eight variants of its particle, the gluons. Gravitation and electricity both increase if the distance is shorter. In fact, at zero distance they would become infinite, but this can not happen because the distance of objects must be taken as the distance of their centers, which can never become zero. On the other hand, the strong force becomes weaker under certain closeness. This so called "asymptotic freedom" means, that particles kept together by the strong

force can still move around, they don't have to stay "stuck dead". So finally, we have to reveal the new basic matter particles, that can carry not only mass and charge, but also colors. They are called quarks. These are the secret bricks, that build up protons, neutrons and more than hundred other particles too. Actually, according to the asymptotic freedom, there can be infinite many variations with counting the different inner motions. Since protons and neutrons don't have color, they must be built from triplets of quarks to give white. This is not a special case, all particles built up from quarks lose the colors and we call this the "law of confinement". Since the proton has + 1 charge, while the neutron has 0, there must be at least two kinds of quarks. The simplest way to achieve the proper sums is: $-\frac{1}{3} - \frac{1}{3} + \frac{2}{3} = 0$ and $+\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = 1$.

The $-\frac{1}{3}$ charged quark is called "down" = $d^{-\frac{1}{3}} = d$

and the $+\frac{2}{3}$ is called "up" = $u^{+\frac{2}{3}} = u$. Thus, our new equations

for the neutron and proton are: $n = d d u$ $p = d u u$.

The down quark can change into up as: $d \rightarrow u + e + \bar{\nu}_e$.

If this happens to one of the down quarks in a neutron, then: $n = d d u \rightarrow d (u + e + \bar{\nu}_e) u = d u u + e + \bar{\nu}_e = p + e + \bar{\nu}_e$ gives a new, inner picture of how beta rays are born.

The moving quarks under their prison of strong force in the protons and neutrons are reminding us of the atoms where the moving electrons were under the electric force. The analogy goes much further: Just as the atoms connect by the "out leaking" electric force to form molecules, similarly the proton and neutron have out leaking of the strong force and this is what keeps the nucleus together.

The new system of particles is not finished yet! There are three directions of continuation:

Firstly, every matter particle has an anti pair. We already met the anti neutrino, $\bar{\nu}_e$. At the other three charged particles, instead of the bar, we can simply use opposite sign of charge:

with bar		with sign		name
\bar{e}	=	$\overline{e^-}$	= e^+	= anti electron = positron
\bar{d}	=	$\overline{d^{-\frac{1}{3}}}$	= $d^{+\frac{1}{3}}$	= anti down quark
\bar{u}	=	$\overline{u^{+\frac{2}{3}}}$	= $u^{-\frac{2}{3}}$	= anti up quark

Amazingly, when we take the anti pair of a quark, its color becomes anti color. A color and its anti color makes white and so, a quark with its anti quark can form a pair. Such quark pairs are called mesons.

Secondly, the four matter particles, d , u , e , ν_e are only the first generation and two new sets exist, so:

first generation	second generation	third generation
d = down quark	s = strange quark	b = bottom quark
u = up quark	c = charmed quark	t = top quark
e = electron	μ = muon	τ = tau
ν_e = electron neutrino	ν_μ = muon neutrino	ν_τ = tau neutrino

In theory, there might even be an infinite sequence of newer and newer generations, that are not observable for us anymore. This is suggested by the fact, that the newer generations contain heavier and heavier corresponding particles, so more energy is required for their production and so, less probable is their existence. This reveals the philosophy behind our system of basic particles: They are the original units, that started to combine and populate the universe. Today, if we look around, we only see the remaining combinations as protons and neutrons, forming atoms, then molecules, and so on. So this is like a cosmic natural selection, the "better" species survive, while the "worse" die out. But here everything is probabilistic, so "die out" only means "more rare", that is harder to find. The most puzzling is the duality of matter and anti matter particles. If originally they were equal in amount, then pure chance caused, that today we see one in abundance, and the other as a curiosity.

Finally, the third continuation is that, maybe the basic three force particles and four sequences of matter particles are themselves the result of an earlier, simpler unity, some kind of God particle. This so called "Grand Unification Theory" is well on the way and its first success was to interpret the already mentioned weak force as special case of a common electro-weak force. That's why we didn't mention the w^+ , w^- , Z weak force particles as basic. These are simply rare versions of photons with large mass and therefore, short range. Most importantly though, they are not only force particles, but the results of quark changes: $d \rightarrow u + W$ and then $W \rightarrow e + \bar{\nu}_e$.

This suggests a general idea, that all matter particles should be finally special cases of force particles. One consequence would be, that quarks could change not only into each other, but directly into electrons and neutrinos or their anti pairs, and so the seemingly totally stable protons could split too, like neutrons do. An other consequence could be, that the neutrinos that seem to travel with the speed of light, would be actually a bit slower. Only a bit, because they are so small. Then indeed, all matter particles would be just slowed down and mass gained force particles.

These complicated models of particles couldn't be worked out solely by the facts of natural radioactivity. To produce nuclear particles, so called accelerators were built. These can speed up already known particles and collide them with "target" atoms, which will split and give out a whole range of particles, depending on the used particles, their speed and the target.

There is however a natural source of particles too, the so called cosmic rays, coming from all over the universe. Luckily, most of the harmful of these are stopped by the outer atmosphere, while others like the tiny neutrino go through the whole earth without any collision. The most amazing fact is, that the two groups of particles: the nuclear, manufactured in accelerators and the cosmic ones, flying in space are the same. This not only shows that the micro cosmos is the same as the big cosmos, but also supports the "Big Bang" beginning of the universe. Indeed, the cosmic rays are simply the remains of

those nuclear particles, that didn't form nuclei, then atoms, molecules, stars and planets. The word "simply" of course turned out to be incorrect again, because some stars can blow up, producing new cosmic rays.

The expanding universe could have two futures. If the world is dense enough, then the gravitation would turn the expansion around and the universe would return into a "Big Crunch". If the total mass is not enough, then the expansion will never stop and lead to a cold, thin emptiness, the "Big Chill".

Lately, the big chill scenario had been proven by new measurements, which is a big surprise to most physicists too.