**Nuclear and Particle Physics**
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**Lecture – 01**
**Introduction**

So, this course is on a nuclear and particle physics. Today, we shall give overview of the topics that would be covered in the course. In short this course is on the constituents basic constituents of all matter around us and we will discuss what are the properties of these constituents and we will also discuss what are what are their dynamics and what are the guiding forces that dictates their behavior interactions.

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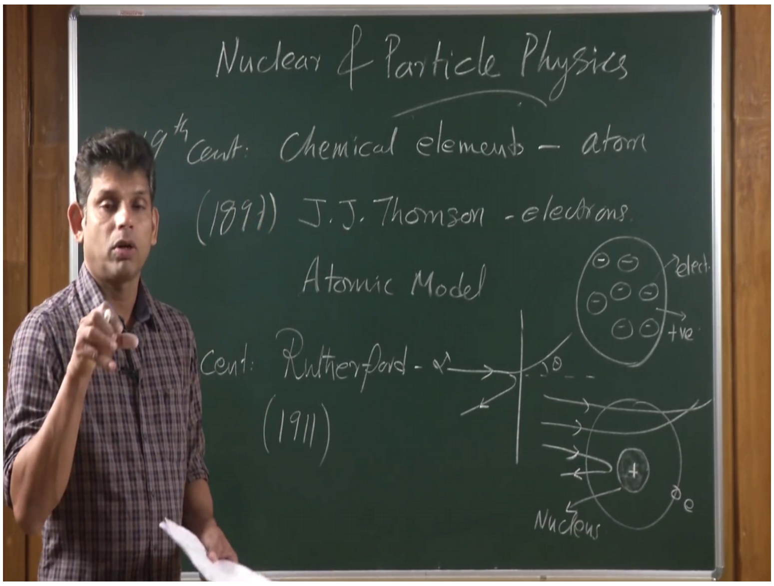


We shall start in the second half of the 19th century; we had good understanding of what is the constitution of the universe by, then at least considering your matter that we are familiar with, it was established that we can think about something like less than 100 basic chemical elements which make all this matter around us. So, we have the understanding of chemical elements and the smallest unit of that is called atom and experiments to understand further what are the properties of these chemical elements, what are their constituents, etcetera had been going on what are their chemical properties what are the electrical properties, etcetera.

So, by 19 by 1897 experiments of J. J. Thomson led to the discovery of presence of electron in the atoms. He studied the cathode rays closely did try to understand what their properties are, how do they behave under electric field, how do they behave under magnetic field etcetera and establish that they have. Firstly, electric charge atoms of the chemical elements were known to be electrically neutral, but now we have an electrically charged particle present in matter.

He proposed an atomic model rather he is working with Lord Kelvin and other collaborators and other leading people in the field. They had suggested that, but it is basically mostly due to Thomson that atom looks like a positively charged sphere kind of positively charged matter and of a somewhat uniformly distributed positive charge. So, I have positively charged sphere you can consider and so, this is a positively charged sphere with negatively charged electrons embedded in it.

So, where are this negatively charged particles that is coming out as part of the cathode ray they are there in the atom distributed in this positively charged matter that is Thomson's model of an atom. So, these are the electrons then in the early years of 20th century a series of experiments by Rutherford and collaborators had something slightly different to say, what did they do?

They had alpha particle Rutherford's experiment they took what a thin gold foil and send this alpha particle on to it, if Thomson's atomic model was correct the scattering of this alpha particle due to the positively charge the unit I mean uniform sphere positively charged sphere atom would be kind of a mild scattering. Gold foil, thin gold foil can assume that the gold atoms are there in the line or in a plane of the paper take the plane of this is the gold foil say.

So, it is a thin layer so, and then alpha particles bombard it they will see this thin plane of gold is made of atoms of gold. So, this alpha particles will see this there will be a electromagnetic repulsion and they will scatter so, this scattering is then if it is something like a uniformly spread out in their sphere then it will be kind of a (Refer Time: 07:42).

So, that is what was expected, but then Rutherford and his team look closely and specifically look for things like I mean the large angle scattering of this alpha particles by which we mean this becomes large more than 90 degrees and then what happens they will kind of comeback, they will they specifically look for whether there are alpha particles which are scattering back and they did indeed find a small fraction of these alpha particles which are sent to this gold foil do come back.

Now, there is a little bit of a trouble that Thomson's atomic model will face in explaining this large angle scattering and Rutherford proposed that it may not be the case like this and by 1911, he kind of proposed this name with in a clear way that look at it this fashion think about as if all the positive charges in an atom focused or concentrated in a small volume or a small core of the atom. So, atom as a whole has a small much smaller than the atom itself tiny core inside it which contain all positive charge.

So, the concentration or the density of the positive charge in that atom is very large in that small core outside there is no positive charge. So, you have a positively charged core and he said electrons are not in that orderly they are moving around that had its own problems, but basically he said we will worry about the problems and make it what to do with volume the electron and, but at least his experiments the alpha particle scattering experiment could be explained ins in a way that if whenever you sends alpha particles close to this core.

So, whenever you the fraction of these alpha particles in the beam which fall close to this nucleus go near the nucleus will return they will not be able to go at small angles scattered like small angles other things can actually go with some angle and then further smaller angle here.

But when it is going to kind of go directly towards the core positively charged core then they will have a large angular thing and brittle. So, this core is basically called the nucleus so, there is a positively charged nucleus and electrons let me denote it by e, electrons revolve around this thing. Problem with this model is that classically electrodynamics tells us that accelerated charge particle emit energy lose energy.

These electrons which are moving in moving around they say is accelerated because whenever something move take deviate from a straight line that is what is happening here when they move in a circle or any orbit closed orbits or circular orbit or curved paths and they deviate from the straight line and then that deviation means there is an acceleration.

So, this acceleration will cost the electron accelerating electron is going to lose its energy and we what happens then it has to keep on losing its energy and then it will fall and as it moves around you will lose balance between the centripetal acceleration and then this thing unless you come closer the radius have to keep on reducing for lower smaller and smaller energy electrons then ultimately it will fall inside that is the. So, this is the stability of this model is in question I mean it is not possible classically.

Later on quantum mechanics takes over and then gives a way out of this, but that is not going to be our story we will go for the focusing on this core the nucleus. So, that is the kind of beginning of this picture of atomic nucleus.

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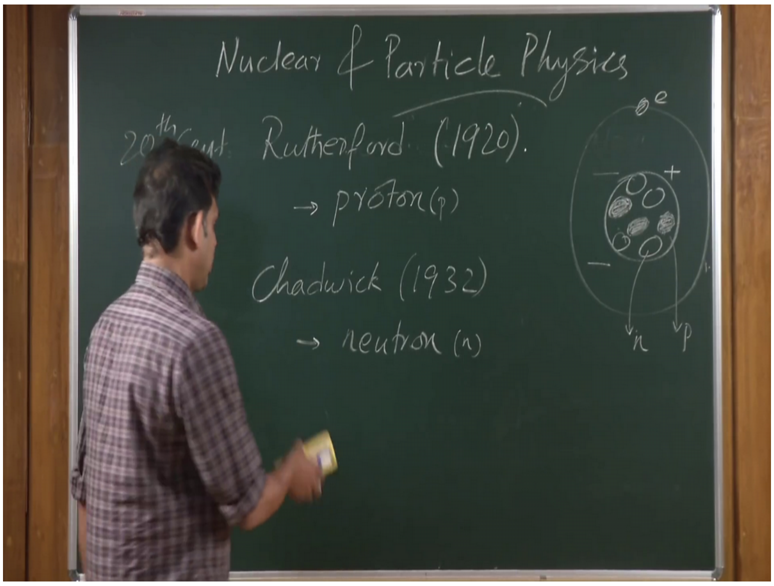


Now, let us look closer and then see what are the further development there so, we are talking about early 20th century where Rutherford and team had been many many people, but mainly Rutherford. By, 1920 he established something remarkable they could understands nucleus of different atoms understand meaning they could figure hydrogen atom as its nucleus, helium atom as its nucleus, heavier elements atoms of heavier elements of heavier nuclei etcetera.

Now, his experiments established that this nucleus is kind of not a single unit. Apparently, nucleus of heavier elements contain nucleus of hydrogen atom. So, this is the atom electron nucleus and then if you look at this closely it is they are they contain nucleus of hydrogen atom. Let me fill that for clarity of this one so, hydrogen atom yes it is filling it will not fill all of it will come to that, but this is something which is remarkable and then we call that the nucleus of the hydrogen atom as proton.

So, proton is established as part of all the nucleus experimentally it was seen that it can be it is there in many atoms that Rutherford studied and then he suggested that its part of all atoms, that is one thing and then later on other experiments; let Chadwick to discover in 1932 another constituent which is electrically neutral present in the nucleus along with the proton. Now proton is electrically charged neutron is electrically neutral, both of these so, in a sense the way I have made this cartoon we have the proton and neutrons let me denoted by n in the atom atomic nucleus.

So, that is kind of the modern picture of atom along with the quantum mechanics and the rules of the quantum mechanics putting. Now, let me look at this nucleus more closely and some of you who are been closely looking at what, we are doing must have already noticed one peculiar thinking happening here. Look at this nucleus, it has protons different many protons and heavy a nuclear like gold nucleus of gold atom etcetera is expected to have more protons.

They are confined to a small volume I can also indicate what is the reasoning, although we will come to this size of nucleus etcetera later. Basically it is of the order of 10 power minus 15 meters that is the kind of size of nucleus whereas, the size of atom in something like 5 orders of magnitude larger.

So, this pictures highly any zoomed in to the neutron and then the not note to the scale at all the constituents ok. So, the in a size of 10 power 10 meter atoms 10 power minus 10 meter atom these positive charges are focused. So, concentrated or put in a small volume which has spherical volume you can take and has a size a radius of 10 power minus 15 meters so, very small.

Now, you look at it you have this positively charged protons coming together sitting together there must be a repulsive coulomb force or electric repulsive force between them what about that they may be repelling each other pushing it each other. Suddenly, that is a question and that is a question that has to be addressed by Rutherford's atomic model.

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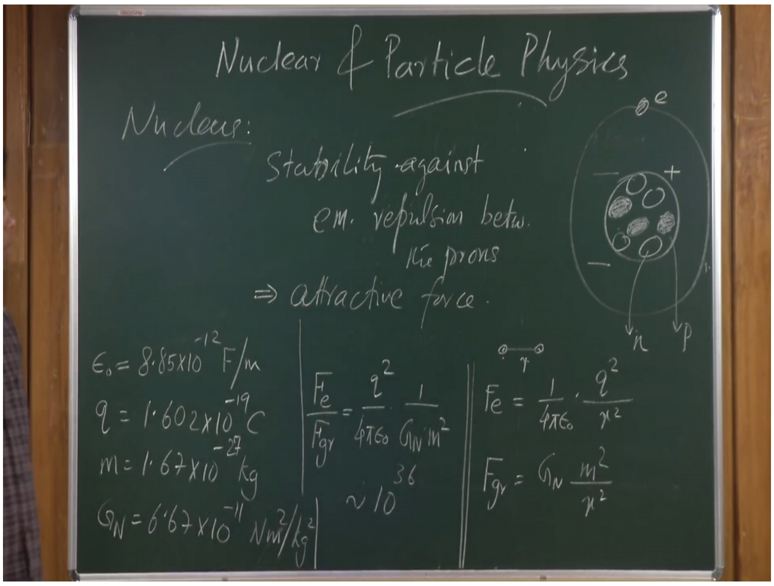


So, when we come to the nucleus stability of the nucleus against electromagnetic force or repulsion between the protons neutrons are there, but they are electrically neutral they do not take part in this electric interacts electromagnetic interactions. So, then protons will repel each other so, how are they grouped together. We need something which is attractive or which is going to attract these 2 protons together there has to be an attractive force.

So, that tells you that there is some attractive force between the protons then only they will sit together stay together and maybe also between the protons and neutrons and protons and neutrons etcetera.

Now, let us look at 2 protons separated by a distance between these 2 sum or of this there. There is an electric force I will write only the magnitude direction is between the line joining along the line joining the centers of these protons. So, electromagnetic force is 1 over 4 pi epsilon 0 q square the charge of the proton times the charge of the other proton is q square divided by r square the distance between these.

What kind of attractive force that we are familiar with we are familiar with the gravitational force which I we know is attractive in nature so, they will attract this things.

Now, see whether that can fit the fit it fit here fit in here, what is the gravitational force in see between 2 protons. It is the Newtonian gravitational constant then the square of the mass of this constant and then this r square. Let us compare these 2 and then see which one is bigger so, we need some attractive force which is bigger than larger than the repulsive electric force.

So, let us take the ratio of the electric force and gravitational force you will get 1 over 4 pi epsilon 0 q square in the numerator r square cancels when you take the ratio between these 2 G N the denominator m square in the denominator we need. So, epsilon 0 is equal to 8.85 into 10 power minus 12 in units q charge is 1.602 into 10 power minus 19 coulomb masses 1.67 into 10 power minus 27 kilogram G N, Newtonian gravitational constant is 6.67 10 power minus 11 Newton meter square over put all these things together and you get the ratio of electric repulsion electric loop electrostatic repulsive force between 2 protons and gravitational attractive force between the same protons at the same distance is equal to or of the order of 10 power 36 positive 10 power 36.

So, electric force apparently is much much stronger than the gravitational force it is something like 10 power 36 times larger than the gravitational force. So, definitely that is not going to help us so, this will not help.

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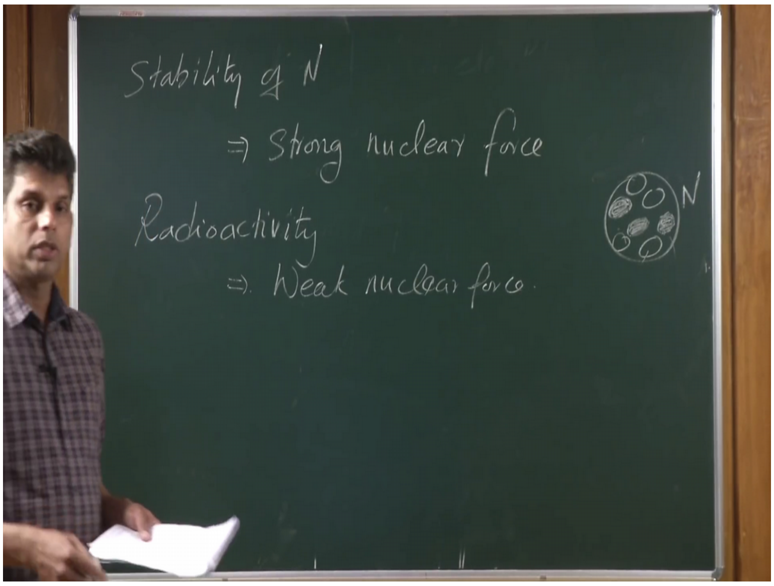


Therefore, for the stability of the nucleus let me just write it as N denote this thing by N of the nucleus against the electromagnetic repulsion of the protons which are close together. We require some strong force and it is a it is found in nucleus nuclear force this strong nuclear force is not seen other ways. We are not seen it until then meaning we are not come across with that it was there all through, but we are not really we you were not aware of that see.

Now, we looking at it looking at the nucleus we see that there has to be something there to glue these protons together. Now, this is something which we just call at strong nuclear force and we will come to the properties of this as we go on we will see that the nuclear force is confined to small distances within the nucleus or at the size of the nucleus and that is why we do not see the presence of these outside at large distances.

So, they should have that property that as we look at things at large distances these are negligibly small that is one thing, then another thing that leads to us this is coming from so, another property that is coming from the observed radio activity of the nucleus. This is basically the spontaneous disintegration of nuclei some nuclei are not stable, they disintegrate, they split emit certain rays radiations alpha particle alpha radiation is one of those beta and gamma these are the normal radioactive emissions.

We will come to the specific details of those later, but now this has to be again caused by some interaction; how does this happen. If there is a strong interaction and then its they gluing together the protons and neutrons then what happens when something disintegrates; how does that happen.

So, to explain that we need another force which is simply called the weak nuclear so, beta decay or any other nuclear decay happens because of the weak nuclear force. So, we will come to this and the properties of these, etcetera, as we go on so, that is the kind of purpose of our courses the starting point of our course would be to kind of start the look at the a nucleus in closely and then properties of their nucleus like mass charge size of this then there is one another thing like when you look at this we can actually think about 2 protons and ok.

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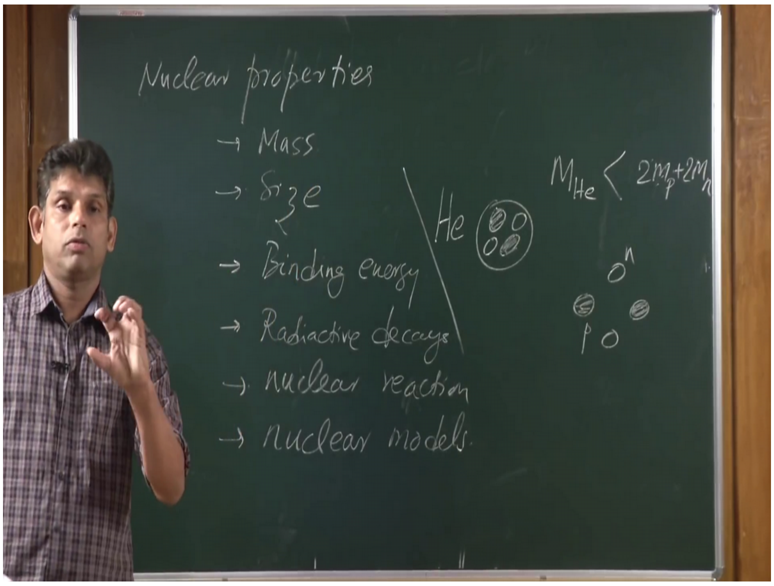


So, let us look at the helium nucleus helium second elements it has 2 protons and 2 neutrons. So, if you take 2 free protons and 2 neutrons bring them together they should ideally form this kind of a thing so, the conditions are set so, that they can come close to each other. So, that the nucleus strong nuclear force will be binding them together and then they will form helium.

Now, when you look at this and look at the mass of the helium atom and the mass of 4 or 2 protons mass of 2 protons plus mass of 2 neutrons then there is a difference between sum of the 2 sum of the constituent masses or mass of the constituents sum of the masses of the, but protons and neutrons inside this helium atom is larger than the mass of the helium. So, when they come together and make as nucleus they lose some mass, some energy is lost, some mass is lost this is called mass defect or this is basically kind of called the binding energy.

We will come to the details of this binding energy and whether we can kind of make a estimate of these for a nucleus specifically is what kind of cones I mean what are the different things that make it make the binding energy large. So, that the nucleus is stable and so, we will come to that later then we will talk about radioactive decays, nuclear reactions some of these we will discuss in some details and models of nucleus.

We only said that they come together and then form that is the constituent, but like in the case of atoms we had to actually give very in a kind of specific details of, how the nucleus is formed and then what are the properties of that etcetera. When they are there and then what are the kind of energy levels of these or what type of a, what is the kind of gen in general picture of the nucleus or the model of the nucleus. So, there are these nuclear models then that we will discuss.

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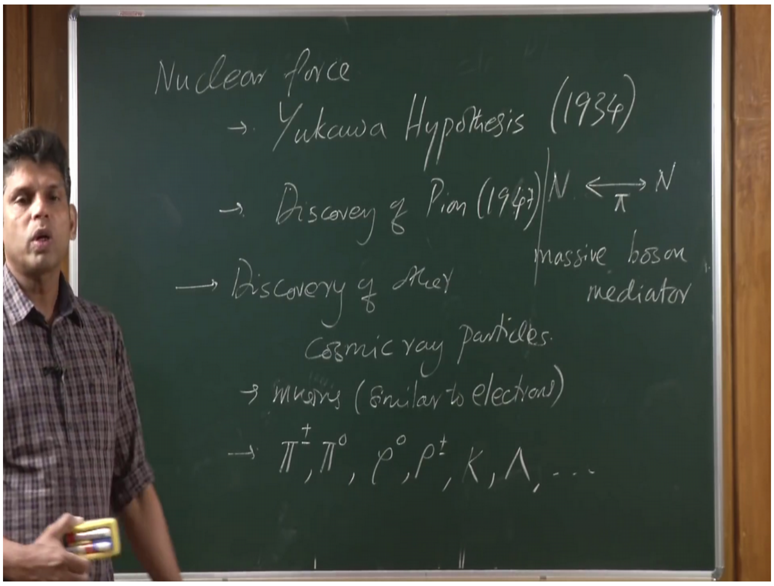


Now, we will continue talk about the nuclear force we will talk a little more about the nuclear force and nuclear force. There was a hypothesis put forward by Yukawa, 1934 to understand the nuclear strong nuclear force where he said think about the nuclear force between 2 nucleons or 2 nuclei as if happening with the exchange of some particles. So, he predicted the existence of massive they have to have mass so, we will come to some of the details later massive bosons, bosons are integers spin particles.

So, massive bosons mediates strong nuclear force that is in a sense you cover hypothesis and what are these bosons people look for those and finally, in 1947 some such scalar particles were discovered spin 0 particles were discovered. So, they are called the Pions and now they were finally, at some level at the nucleon, nucleon, nucleon, proton, proton, interaction, proton, neutron, interaction, etcetera. One can understand by this nuclear whether Yukawa’s hypothesis of exchange of protons sorry exchange of Pions between protons. This is the kind of interaction mediating the interaction or making the interaction happen.

Then they were many other particle where discovered in the cosmic rays, examples are muons. In a very short description muons are particles similar to electrons , but much heavier than electrons then there are other particles. So, pions come in different charges neutral pions plus minus pions rho 0 rho plus minus heavier particles something similar to pions then came in once and then lambda particle etcetera. This was the all these things happened in the towards the middle of this 20th century.

So, we had many particles which are not really otherwise seen in the day to day normal matter. Now, this had been one of the difficult piece one of the difficult period to classify them and understand such many different particles. So, now, let us say a classification of particles had to be done.

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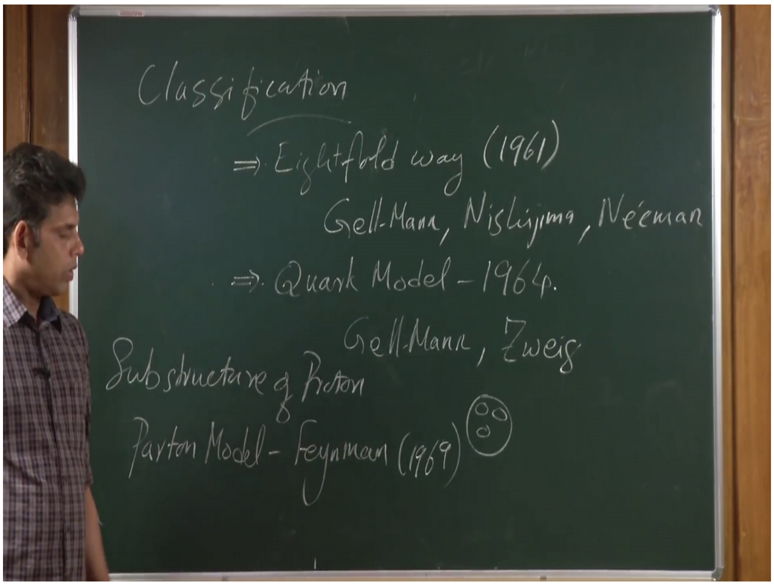


Many different ways were tried and then there is something called particularly called Eightfold way of Gellmann, Nishijima and Niemann ok. Some of this now what we do is kind of give information’s we will definitely get back to these and then tell the details some of the details at least of all these that yes.

So, today we are actually trying to say; what are the things that we are going to do in the course of time that is going to come in the next lecture onwards ok. We will sit on I mean will spend sufficient time on each of this and then discuss further, we will definitely look at this that is why I am we are mentioning that here. So, this classification of this in an in a proper way had been done and this is something which is now thought of us a good turning point of understanding of these particles and this led to what is called the Quark model.

We just kind of a established by 1964 again Gallmann and Zweiz in some kind of a short way this means that there are. So, if you look at the when you look at the protons they have constituents, they are made of tiny a particles tiny a constituents.

Also the substructure of proton was proposed by Feynman in what is called Parton Model by Feynman by 1969 also. So, these are the kind of he was trying to explain the experimental results scattering experiments how that can fit in and then he suggested that we can actually think about protons as if made of smaller constituents which we simply called patterns ok, patterns are tiny things inside the protons.

Now, that is what kind of also the classification an eightfold way etcetera leads to and then saying that there must be basic units small constituents which may these protons. Not only these protons according to the quark model, but many other such a big the particles like pions and rho may zones etcetera which we mentioned just before and they all are made of smaller units called plox.

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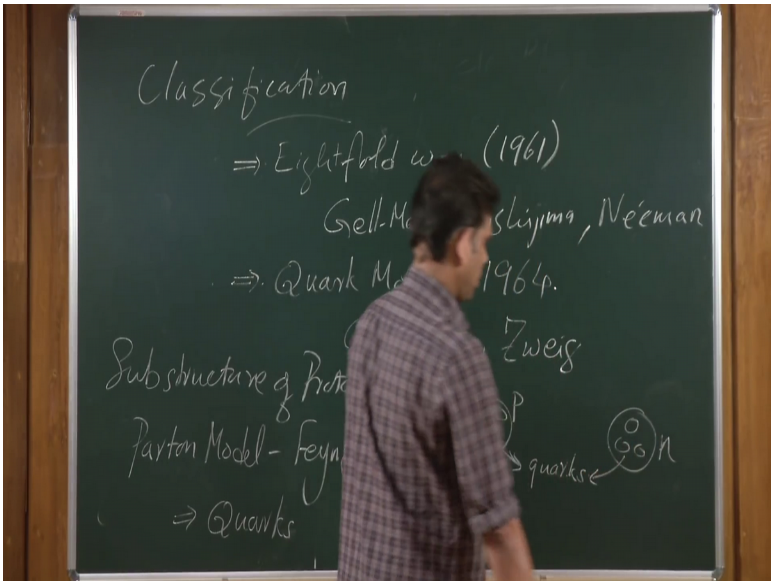


So, these are quarks they named they are known named quarks. So, this is the proton proton is made of this quarks, neutron is also made of quarks. There must be a different combination they have there must be many different types of these quarks and different combinations of them etcetera so, that proton is a proton and then it is different from neutron. Otherwise if it is all the same type of protons and then same number of these things then how will this differ from each other ok?

We will come to the properties of that later and now look at kind of what is the summary of the situation; so, summarizing that we have the modern picture of the atom, modern picture of the atom.

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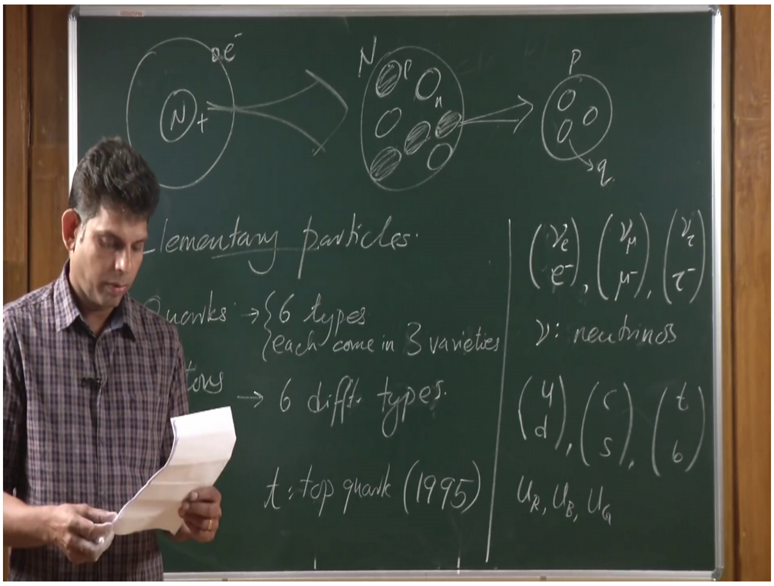


We have the nucleus positively charged and electrons moving around this negatively charged electrons. When we zoom in when we zoom in we get larger picture and that is basically the nucleus being made of protons and neutrons many of them and then again in turn each of these we look at and then they say a proton is made of quarks that is how it goes.

Now, we can ask the questions of many what is at least this part of the properties of these; what are these calls, how many of them are there etcetera. So, to so, at the moment we can actually consider these quads as elementary particles meaning we do not know I mean at least to the level that we have brought quarks are without any sub structure, they are elementary.

So, quarks and there are other type called electrons I mean like electrons which are called leptons. So, quarks and leptons there are 6 different types of quarks and each of these come in 3 different varieties, 6 different types of electrons like electron like particles or the leptons. They are actually put in together put together in groups usually because reasons for this thing we will come to this kind of grouping data.

So, there are electrons and muons and tau electrons all of these particles are negatively charged different dead masses and then there are what are called the neutrinos. They are electrically neutral when it comes to quarks there are u d c s t b 6 different types of this 6 different types of this, each of these actually come in different 3 different varieties; u itself comes in u r u b u g different levels 3 levels. It is conventionally called it is called color charge and again there are reasons to call it color, it has nothing to do with the photons or the light or the color that we see in your common day to day life nothing to do with that, but they come in different varieties.

There are certain reasons for that this thing because when we combine these 3 different varieties then we will get a color neutral or thing which is not going to be interacting strongly kind of a combination. So, there are we will come to that later of this has top quark t is the top quark which was discovered as late as 1995. So, it is all happening in our time right and very interesting.

So, we will discuss some of the interesting facts about this thing you continue for a little more and then stop the overview soon. So, now, we talked about the participants of this , but then the other thing is then elementary particles are kind of classified and then looked at then we have what is called fundamental forces.

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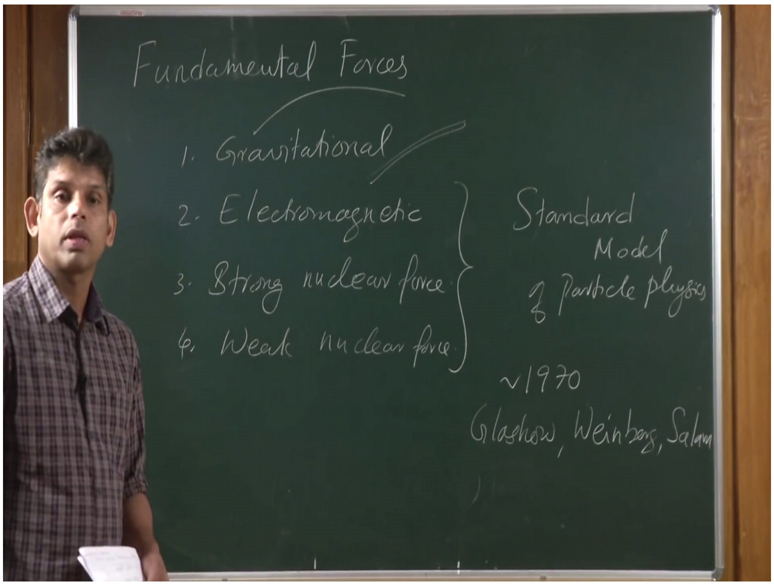


What are the forces of the forces of which dictates the dynamics of this thing, we know about gravitational force which is definitely there all around us. Then we know about electromagnetic force which is also there in our common experience day to day experience and we talked about the strong nuclear force and we also talked suggested that there should be some weak nuclear force.

Gravitational force we already saw that it is too small compared to the electromagnetic force and strong forces to be larger than that electromagnetic force and weak force actually comes in between and then these ah. So, the gravitational force as such has not much of a role to play in the dynamics of elementary particles it comes into play in large scale structures or formation of large scales gets its structures where we have large mass big bodies.

So, we will not really be a discussing that in this course rather we will be talking about only these and this description is given in kind of a specific theoretical model which is called as the standard model of particle physics, which was in a sense established by 1970 or 69-70 by Glashow, Weinberg and Salam.

So, we will discuss as we go on a little bit about these things and specifically we will actually talk about what is the mathematical framework of this model and its essentially what is called the Gauge Field Theory.

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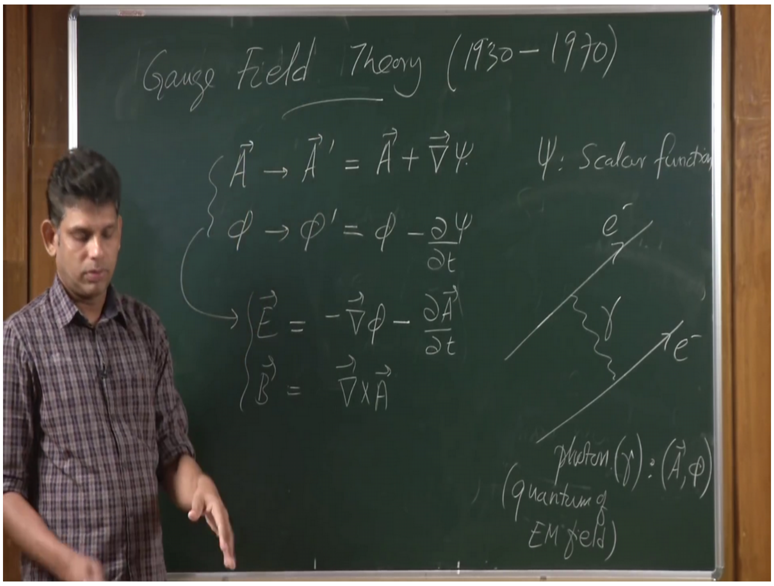

So, this was the development in kind of 1930 to 1970 and everything and then people establish this as one of the ways to understand the dynamics of the elementary of the wave fundamental forces that the elementary particles experience.

So, a short description of this gauge symmetry in which dictates the gauge field theory can be understood by looking at how the electromagnetic potential or electromagnetic vector potential and the electrostatic potential to their; they behave. So, they have a kind of an arbitrariness in it in the sense that if we transform or change this A the potential magnetic potential to some other potential.

So, that it picks up it is some addition of some gradient of some scalar part along with saying that phi this scalar potential is changed to phi minus time derivative of same function where psi is some scalar function some function.

Then this together will give you the electric fields E is equal to minus gradient of phi we are familiar with this minus dou a by derivative of a with respect to time and magnetic field is essentially call of A. So, if you change A to A prime and phi to phi this E is not going to be affected according to this so, there is an arbitrariness in this we go or in the other sense it is a symmetry. This is this transformation this change of this one is called the transformation of A to A prime and that transformation is called the gauge transformation do not worry about the terminology.

Now, we will come to that in slightly more detail and then try to give a basic introduction to this as in this course. So, in a kind of picture of the gauge field theory gauge field theory essentially this boils down to this fact that is what I wanted to tell today, that when we look at the introduction interaction between an electron and a positron or an electron.

This can be understood similar to not exactly the way, but something at least in the way that you have a had thought by happening through the exchange of some particles and this particle for electric interaction electromagnetic interaction is called the photon; which is essentially the quantum of electromagnetic field which is described I mean denoted symbolized by the gamma here is essentially represented by this mathematically by the vector potential and the scalar potential they describe the photons.

And now there is a very consistent beautiful way of understanding this interaction between 2 charged particles through the exchange of such photons mathematically considering the gauge transformations, gauge symmetry and the gauge field theory engine will come to that discuss this. Now, this is something which is talking about the electromagnetic force and what Weinberg, Salam and Glashow their proposals, their studies and many other people studies later on led to the picture that other forces so, electromagnetic force is known now.

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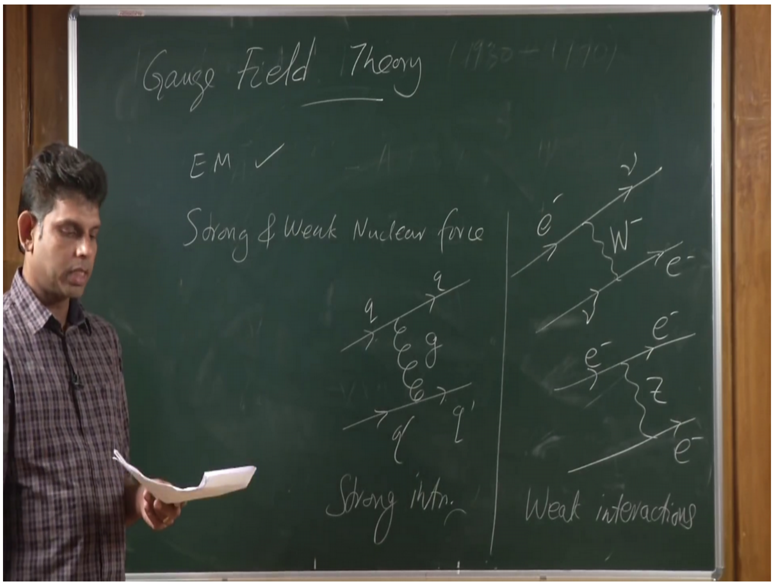


We can study this thing this leads to the quantum electrodynamics and then strong and weak nuclear forces can also be understood as if happening through the exchange of this particles such for things.

So, for example, electron and electron or positron can interact, let us take electrons through the exchange of what is called a weak boson, which is similar to the photon. So, this has to either charge some neutral particle will go the details will come too late so, this is how it goes.

There could also be electron and electron going as an electron , but then interacting this is very similar to the photon (Refer Time: 58:52) neutral electrically neutral and strong nuclear force this is the story with weak force and strong forces also similarly happening through exchange of some other mediators which are called the glue they glue together strong ok.

So, this is basically the strong interaction so, that is kind of I mean picture of these gauge field theory or interaction of particles under the fundamental forces, picturized through the gauge field theory and exchange of quantum of the fields ok; that is the kind of thing that the standard model will be describing.

And we will discuss some details of this in this course and if time permits we will also discuss I think at least we will I will give you some flavor of this what I am going to tell because that is something very topical and then that is what is happening now. This gauge field theory description has a little bit of a trouble in understanding the masses of the particles ok.

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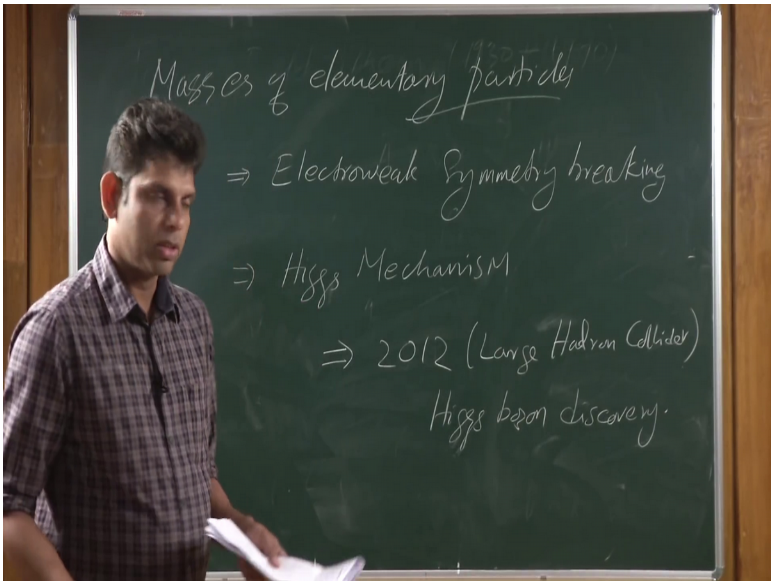


Now, this we will need something called Electroweak Symmetry breaking and Higgs mechanism. I am just giving you the words as definitely without describing it; it does not really make too much sense, but let me at least just tell the book I mean intermine named them there is something called electro the symmetry that we talked about the transformation and invariance of this electric and magnetic field etcetera under the change of the potential and similarly for other forces it is called the symmetry.

Now, that symmetry has to be broken so, the electroweak symmetry breaking has to be he is needed to discuss the mass of this part. We will come to a little bit about that and the mechanism to do that, now we he is one of the mechanisms which was proposed is called the Higgs mechanism named that the proposal Higgs; Peter Higgs and this led to in 2012 just a few years before by Large Hadron Collider or LHC discovered, the Higgs boson.

There are many things that are yet to be known experimentally as with as well as theoretically about the Higgs boson about the electroweak symmetry breaking and there are beautiful and then many different interesting ideas that are there in this thing.

So, we will discuss these in a very short way at least I will try to give you a flavor of this. Then there are also a few things that other things that I want to discuss say for example, there is something called the I mean if you look at the universe as a whole we will this will be the last few minutes of this particular session. So, basically we will be half many thing many other things that is happening which is apart from the Higgs boson and the properties of that.

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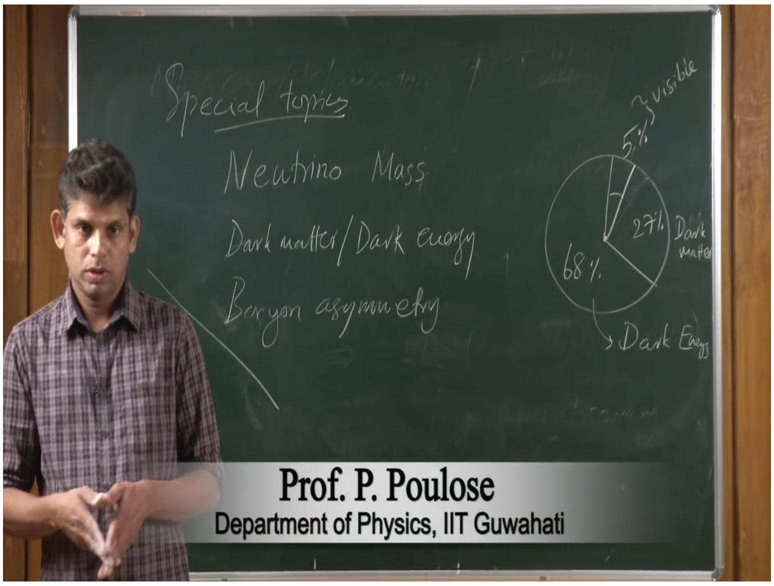


For example, there is something called the I mean we I already introduced this there are particles called Neutrinos and neutrinos in the standard model description because starting from the beta decay, where this was proposed and then subsequently discovered.

There it was thought that the neutrinos have no mass they are of course, have very tiny mass even if they even if they have it at all and recently we have established that they do have some mass. They have to have some mass to describe certain other phenomena and that is an issue in the sense that it is not an issue to how the mass, but the it is that understanding of how the neutrinos was a generated mass or what is what type of mass it was etcetera are not clear and that is active topic of research currently.

The other thing is we can ask the question like what are the constituents of the universe so, usually what we do is so, actually look outside look at the universe; get information and how do we get information. We look at the stars look at the stars and receive the information in the form of light see that is how we see the stars, that is light. Then we also see I mean we have special equipments which can actually see other electromagnetic radiations apart from visible this thing, apart from light this gamma ray and x ray etcetera or a whole spectrum of electromagnetic thing can be brought radio astronomy will prop radio wave signals etcetera.

So, comparing all these that or trying to see all those things together I mean looking at all this we can actually try to ask the question like what do we know about this universe and what can we make an estimate of the matter particles there etcetera. So, and there are also in cosmological models which tells us what is the maximum what is a constituent mass of the universe and what is the mass of the universe.

Now, this at the moment gives a kind of a picture which is something like not understood clearly. So, apparently observations lead to this fact that only about 5 percent of the total mass of the universe is understood through the visible observations that we do. When I say visible it includes all spectrum of electromagnetic radiations that we can see with our naked eye with our instrument etcetera.

Something like 27 percent is again supposed to be matter and that is not seen that is called the dark matter. So, dark matter let me write it as dark matter rest of it something around 80 something like 68 percent is essentially not even matter, it is some form of energy and its dark energy see something which is not understood.

So, dark matter and dark energy this is something which is not included in the standard model and in not non I have to do and there is also other question of Baryon asymmetry which is essential to which is in the senses like there are matter and antimatter like electrons and protons those of you who do not know do not worry about it, but we will describe it later.

So, basically there is a large number of particles against antiparticles. So, when you look at the universe it is all made of one type of particle the particles electrons, protons etcetera. There are antiparticles corresponding to every particles like positron is an antiparticle of electron and the proton is an and the particular proton etcetera which are to be there for consistency of standard model and our theoretical understanding and we have also seen them in the laboratory. So, we can make them we can actually study them, but when you look at the universe as a whole we do not see any of them naturally.

So, naturally we see only particles not antiparticles so, this asymmetry of this is not understood in a way that is big active the topic of research today and in general then all these things lead to the question of how do we actually extend our theoretical understanding going beyond the standard model going beyond the standard model and then that is the one of the basic mean things research that is going on in the current this thing.

So, such we will discuss some of these special topics in an appropriate way that is the kind of overview that I can give you as what would happen in this course as we go along starting from the next lecture.