Laser: Fundamentals and Applications
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Lecture – 02
LASER and it is history

Hello and welcome to day 2 of the first week of this lecture series. In the 1st class we learnt about various different possible applications and their real life Applications of Lasers and I try to convince you that it is worth learning little bit about this laser. How we are going to do it throughout the course.

At this point I would like to very quickly tell you about my plans. First few lectures we will concentrate on learning the fundamentals of lasers the unique properties we mentioned about certain unique properties, coherence, collimated, monochromaticity, high power and so on. Now how do they you know originate a little bit in greater detail we will learn about you know properties then we will you know go into the laser instrumentations.

We will talk about the technicalities, knowing the principle of laser action how one can you know go and make a laser. What are the different types of lasers one can make one you know we will look into those things? And what are the different types of applications of different types of lasers that you know one can achieve that we will talk about it and last 3 weeks or nearly 4 weeks of this course we will concentrate on the application part where we will go from a little bit basic applications to quite advanced level of applications. So, as I said in my first lecture there will be put for everyone in this course**.**

So, we will try to keep this course as less mathematical as possible whereby it is necessary of course, we have to otherwise we would like to you know keep it pretty much basic. Now let us try to you know look into the basic things about the laser. So, in order to know about laser first I need to know what is the full form of this term called laser.

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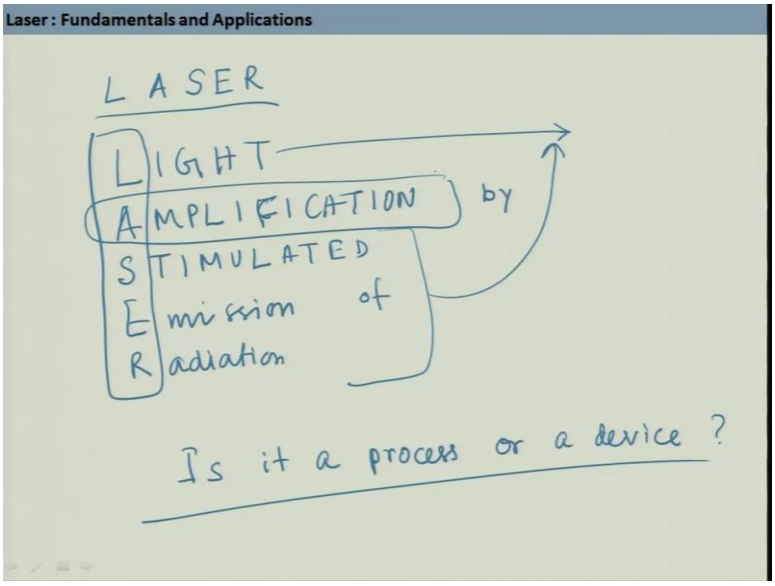

So, I have Laser I am sure many of you have learnt about at least this you know full form of laser for those who do not let me explain it. This laser has a full form as Light Amplification by Stimulated Emission of Radiation now if I take out this part I get my laser

Now, if I look into each and every term here then I have one main thing is light it deals with light. Now let me ask you the question here is laser a process or it is a device. So, is it a process or a device? The answer is both what we have writ10 here that light amplification by stimulated emission of radiation this is a process and this process is called laser process and the device which you know brings about this process is also known as a laser. So, they are synonymous, you can use it for the device as well as when you are talking about the process you call it a laser process.

Here again coming back to this process we have a term called light and what kind of light that also comes out from this particular statement that is stimulated emission of radiation. So, at least I can see that the stimulated emission of radiation whatever that is gives rise to some light what kind of light this light is amplified. If I do not know anything I just want to understand from this acronym, what is this process then it tells me that if I induced a process called stimulated emission by giving some light then that light is amplified probably many times many fold and this process gives rise to my laser action.

When I say about stimulated emission of radiation there is also a term called emission. In order to understand this laser process or laser action we have to know what is stimulated emission and for that matter what is an emission how emission occurs. So, we need to learn about a different physical processes that takes place when light interacts with matter.

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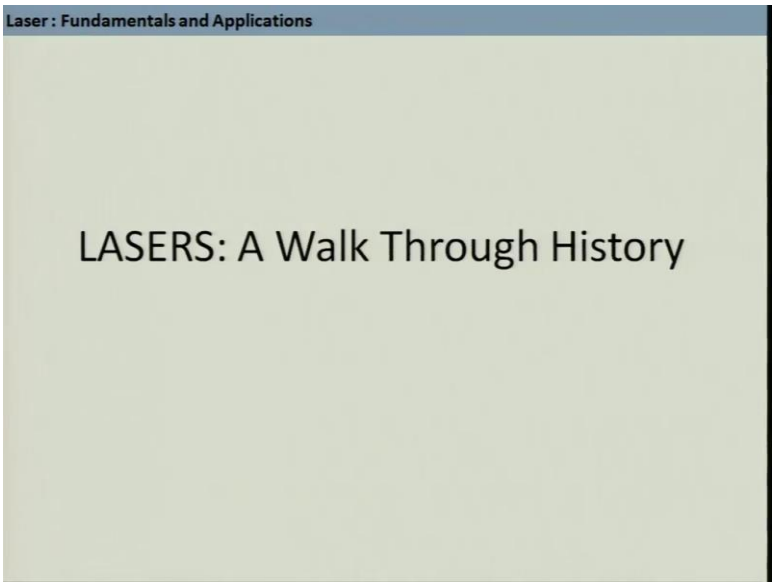

So, if I want to know about laser I need to.

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So we will talk about detail laser action we explained in detail in a while about the different light matter interactions, learn about absorption, emission, stimulated emission, and then how the stimulated you know emission are light which gets amplified to give laser output. Before going into that detail which is our main aim we should know a little bit about the history of laser invention.

By now you know that we need to know about stimulated emission then we can go to the laser action. So, how this you know a fort of getting something like lasers started when did it start let us have a look at that let us have a walk through the history of laser development so.

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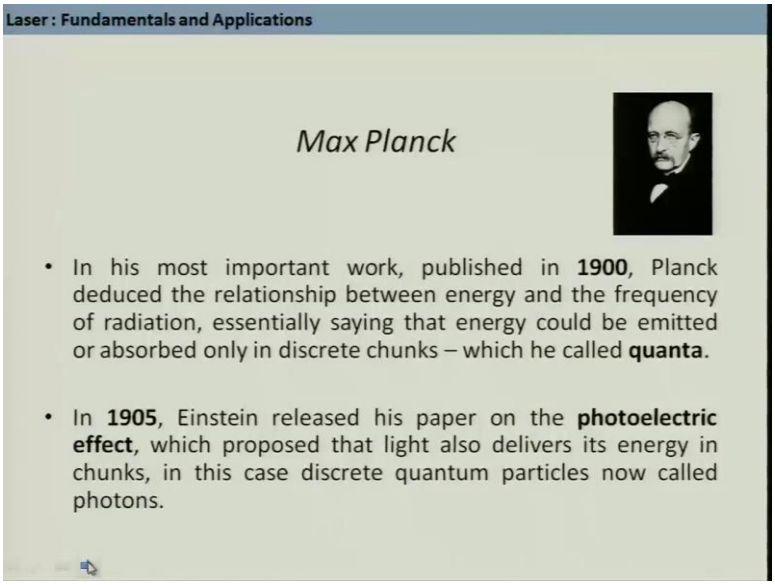

They are 2 people who without whom nothing of the sort nothing like laser or anything would be possible at all they are Max Planck and Albert Einstein, you may not find a very direct relation between you know Max Planck to the laser discovery immediately. But if you think about the idea of you know having a transition between 2 states in an Atom or ion or Molecule by a definite amount of energy discrete amount of energy which is termed as a quantum if that idea was not there if that idea was not given by Max Planck we would not achieve anything like laser at all we would not have the idea of stimulated emission.

So, the idea of this you know discrete transitions by absorbing a certain amount of light, certain point of light, given by Max Planck you know helped developing the field of quantum mechanics. Now this was at the time of 1900 in 5 years from that Albert Einstein wrote his famous paper on photoelectric effect which of course, led to Nobel Prize for Albert Einstein and in this photoelectric effect one thing came out also that you know this light has a particle nature which is photons. So, like which you know in some way it supports the Planck's work.

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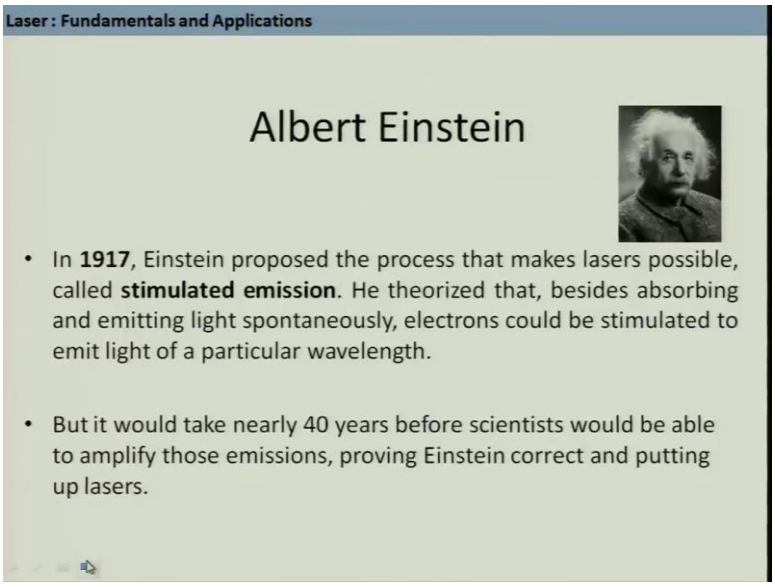

Now the main idea of something like laser came from a work of Albert Einstein again in 1917 he first talked about this stimulated emission we will talk about that in a while. So, what he said that before this quantum mechanics were there people knew about absorption of light they knew emission of light without any external perturbation; that means, emission spontaneously or spontaneous emission there is another thing called stimulated emission. Einstein talked about this stimulated emission and this process if can be amplified then one can get laser.

So, that 1917 the work done by Einstein in 1917 actually forms the basis of laser development. So, from then people tried to develop a device which could amplify which could first generate stimulated emission in a controlled way and then amplify and generate that amplified radiation. Now it was done in 1917 by Albert Einstein, but it took nearly 40 years 43 years actually to mate layer this. So, how did you know it happened?

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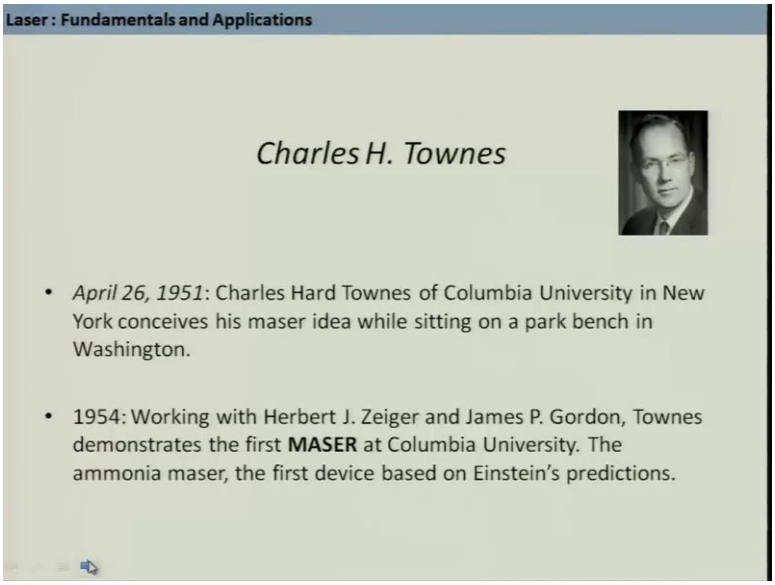

We will soon see that though you know when we talk about laser first thing comes to our mind is you know in optical frequency things happening in optical frequency.

Now, we will we will learn in a while that getting an amplified output from a stimulated emission process is easier at longer wavelength, but very tough at shorter wavelength. So, high frequency generation is difficult. So, at optical frequency getting this amplified stimulated emission was a fairly a big challenge. So, the first successful formation of a device which could you know deliver an amplified radiation in a born out of stimulated emission was in the microwave frequency range. And this was called at that point of time as Microwaved Amplification of Stimulated Emission of Radiation or in short is called MASER.

So, Maser was the first step towards inventing laser that is at optical frequency. You know the person who basically drove this research and became successful was Charles Townes. So, Charles Townes at Columbia University while working with some of his colleagues Herbert Ziegler and James Gordon he first got this Maser which uses ammonia as the gain medium we will know what a gain medium is. This development of maser at least proof the point that Einstein made in 1917 way back then. Still there was no realization of this you know amplified stimulated emission at optical frequency.

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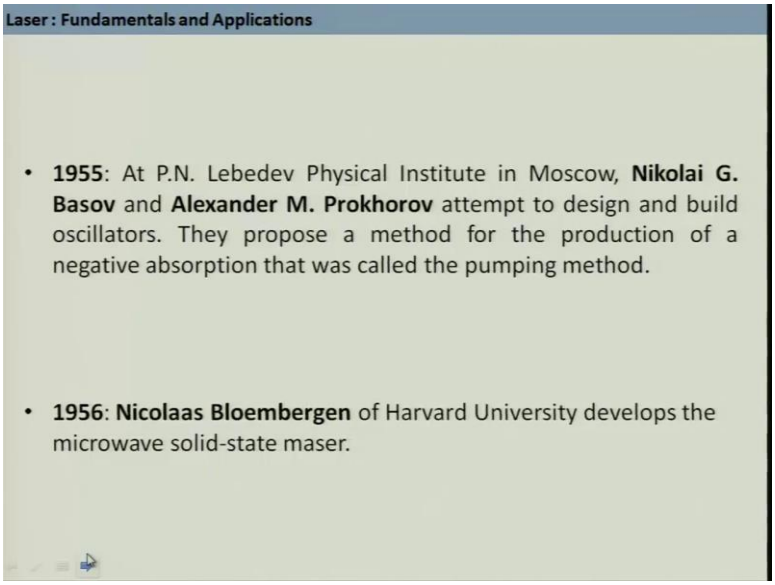

When Townes was working at Columbia University at the same time there are couple of scientists at negative institute in Moscow Nikolais Basov and Alexander Prokhorov they were also trying to develop laser.

Now, they were building a oscillator which is very much required oscillator or estimated you need it for making a device like laser. They were also working at that point of time and we will see that these 2 people in a Basov and Prokhorov they also got the Nobel Prize shared the Nobel Prize with Townes. Now there are many other people who were working in the field of maser and trying to develop laser one of them was Nicolas Bloembergen who actually worked on one of the finest applications of laser there is non-linear optics and obtain Nobel Prize later on.

All these names that are writ10 and my stones that they have achieved one should really appreciate that.

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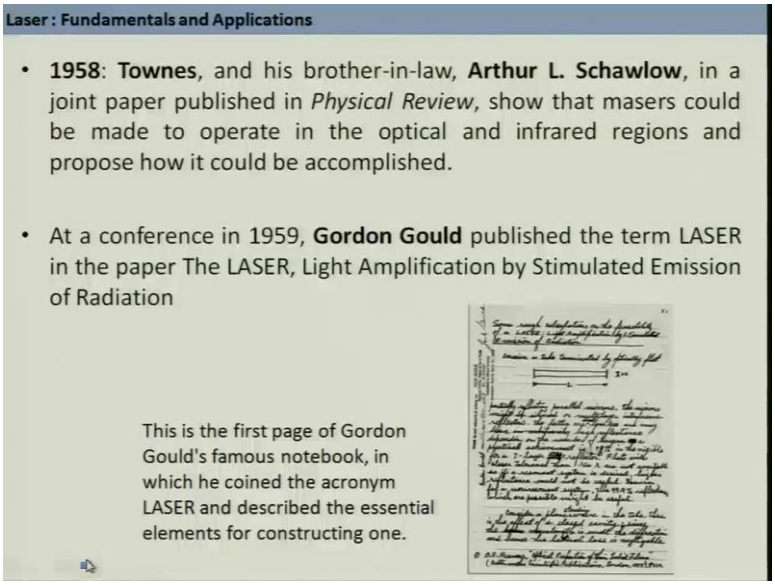

And that is my aim and that is the reason I am Putting this brief history talking about it today, now after making this major Townes and Schawlow wrote a paper in 1958 which is a you know one of the finest paper that they wrote in physical review the journal physical review, where they actually showed that it is possible to convert a maser into a laser that is so called optical maser that was the term that was used at that point of time, but optical maser and Townes and Schawlow showed that optical maser is possible.

And another person Gordon Gould he was also trying to do the same thing and he chalked out his plan to you know form this optical maser or laser, and he even gave this beautiful name laser he is the guy who used or alter this term for the first time at light amplification by stimulated emission of radiation in 1959 in a conference where he was presenting his paper and you can see on your screen that copy of the notebook of Gordon Gould where he has described how one can actually give make this laser, but till then no luck with laser.

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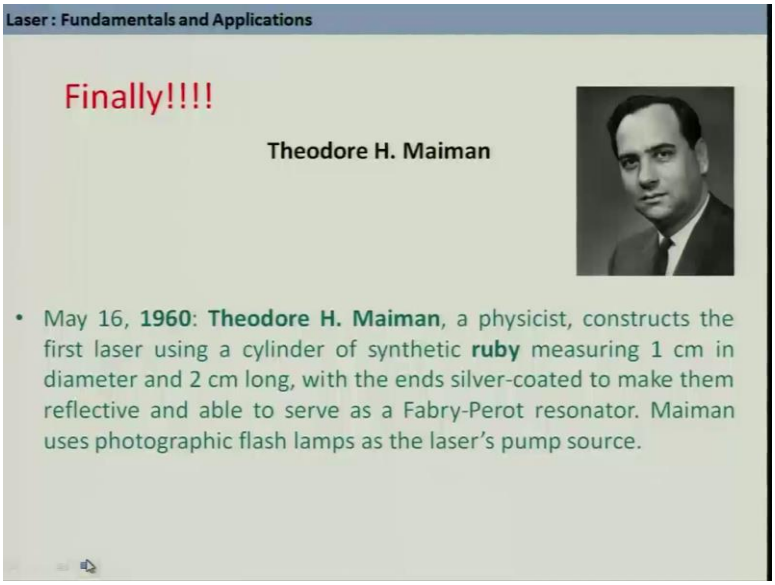

Finally, in 1960 a scientist called Theodore Maiman who is a physicist he ultimately got lucky and made the first optical laser. He used a crystal of a ruby to get output in the visible range that is at 694 nanometer and got it to lase. And that was the first instance when people saw that yes laser is actually possible. So, he got a something called an a pulse ruby laser that is the light does not come out continuously it comes in pulse. It comes and off comes on and off on and off, they come as a train of you know bunch of photons. So, just to show you that, what was the first instrument that he used to form this laser. I have given you 2 images one is the image of the Ruby Laser that you formed on your left side and on the right bottom.

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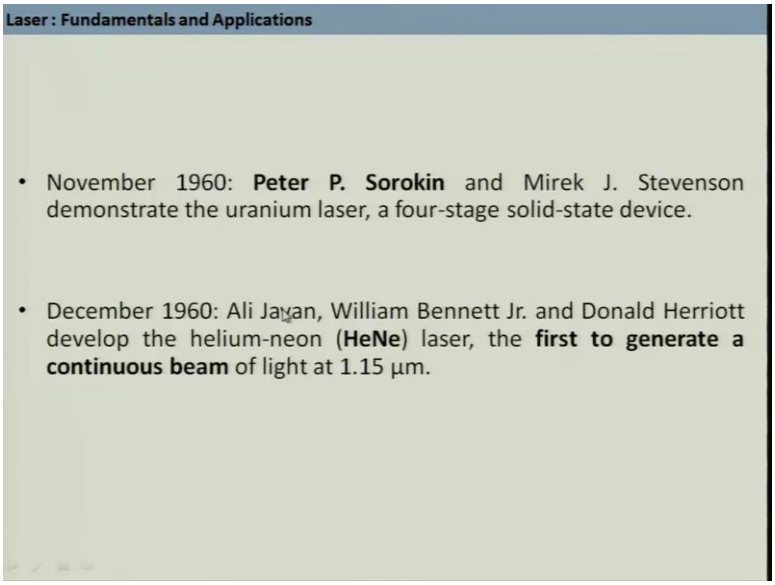

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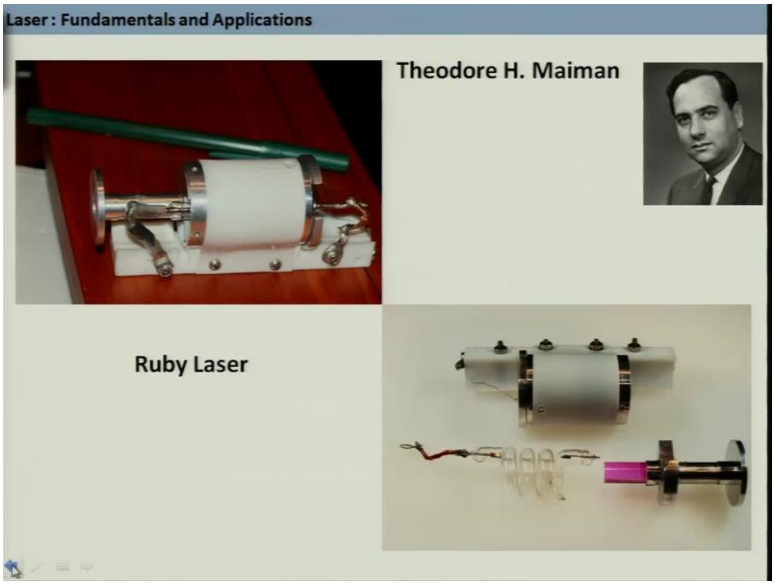

You have the components of this laser and you know you can get this images in a very easily have technique from Wikipedia and this is Theodore Maiman. After that there were you know a huge effort to build lasers out of different materials. So, there are certain criteria that a material should you know satisfy in order to be able to work as a laser a produce a leasing action.

One of them was Peter Sorokin who demonstrates it in the same year when Maiman into first materialized, this ruby laser that uranium can be used to form a laser. And the first

gas laser remember ruby is a solid crystal and the first gas laser came into the picture in the form of helium-neon laser by Javan Bennett and Herriott in the 19 in year 1960. And one more important thing is that this helium-neon laser, which is very of 10 called HeNe in short gives a continuous beam of light as opposed to the Ruby Laser that Maiman invented we just positive in nature all right.

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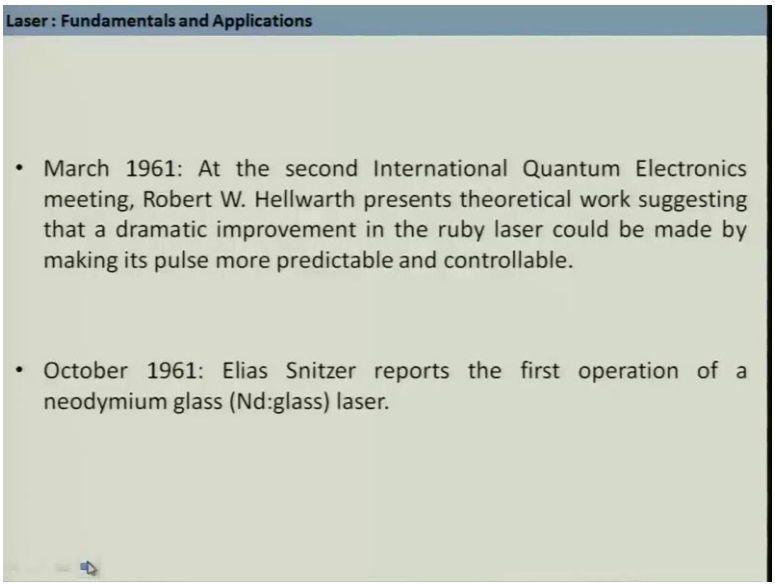

Let us keep going, there are several other works done by different people some of them I have mentioned in the slide.

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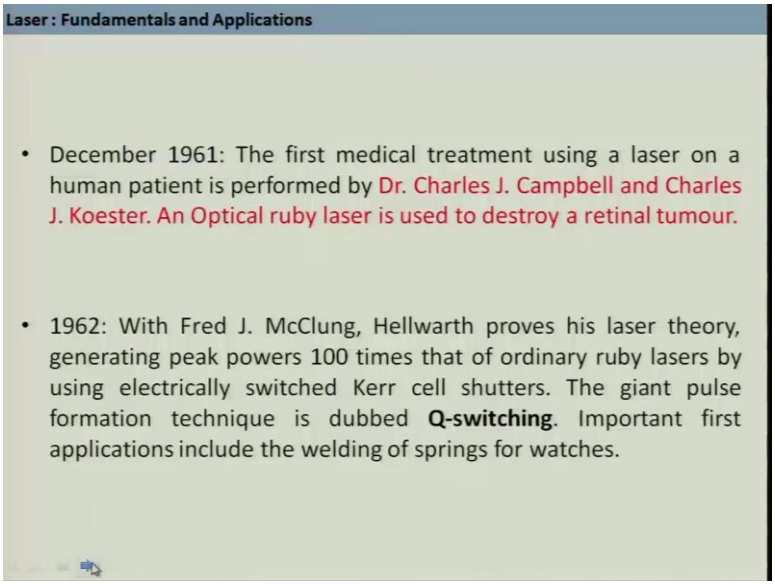

Here comes right after 1 year of it is invention this Ruby Laser was applied in the treatment of retinal tumor to destroy retinal tumor ruby laser was used. Now you know interesting thing is when laser was invented nobody was sure what they can do with laser. So, they were true less they were just trying to make it, but after it is you know invention actually turns out that you can apply to various different places and this is the first example where laser was used in medical science, where they used for destroy retinol tumor using ruby laser. Then there are several other techniques came into the picture for example, something called Q-switching we will learn about it and mode locking.

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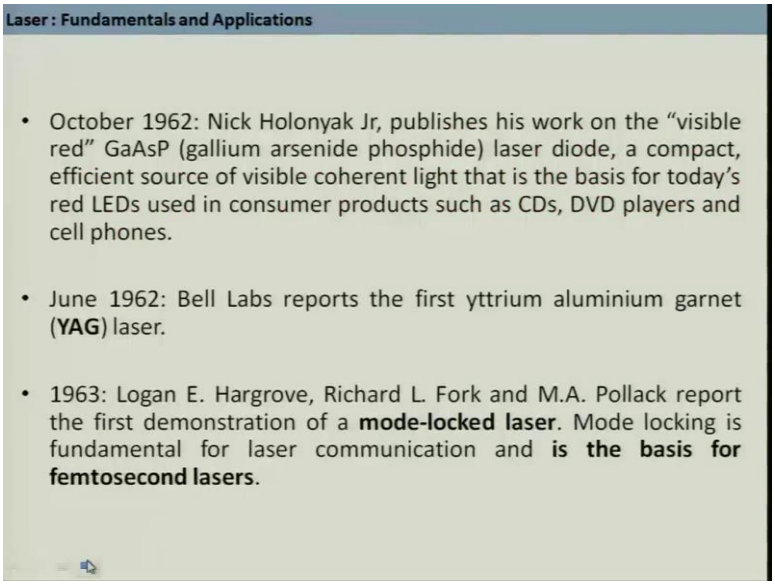

These techniques that become available people were you know working hard to develop a better laser different types of lasers and one of the lasers that defines a wide applicability is yttrium aluminum garnet or in short YAG laser.

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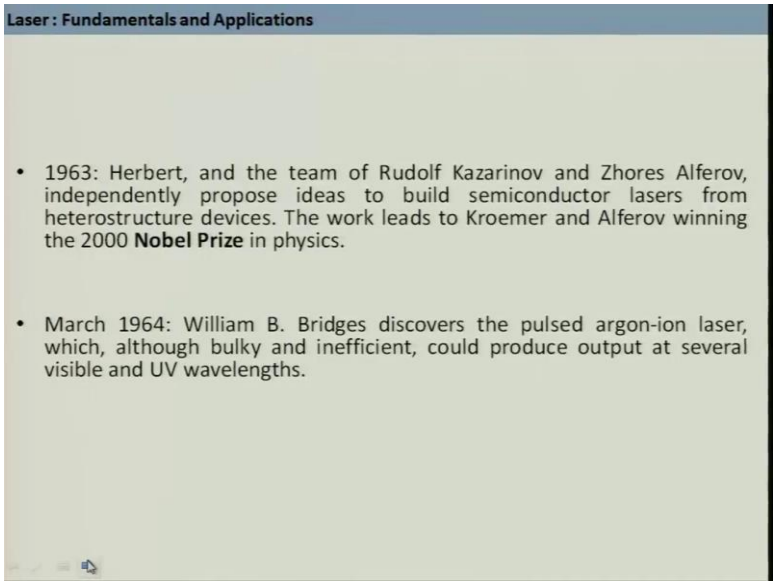

This YAG laser were first made in 1962 in the bell labs ultra fast lasers, you know found it is a boost when this mode locking technique was built and carbon dioxide laser was invented by Kumar Patel in 1964 which is one of the most important laser for industrial applications I talked about this you know cutting, welding, painting, cladding, everything is basically done using carbon dioxide laser. Because it gives a huge power ND:YAG laser came into the picture in 1964 and laser mode locking and phase locking was done in 1965 several you know Nobel Prize were awarded to the physicists who have been working toward this you know laser development Charles Kao was one of them who received a Nobel Prize in 2009.

Now first Dye Laser which is a solution phase you know gain medium was developed by Sorokin and Lankard in 1996 we will talk about dye laser quite a bit there are other kinds of laser for example, excimer a laser was invented in 1970 and in this way you know several different other lasers have been built. So, far and the field of you know laser technology is quite advanced now a days. So, I hope I could tell you about the brief history of the laser develop. So, in the next class we will start looking at the principles of laser action.

Thank you very much.