**Laser: Fundamentals and Applications**
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**Lecture – 01**
**Unique properties of LASERs and their applications**

Hello and a very good morning. Wherever you are let me welcome you to this course whose title is Laser Fundamentals and Applications. This is 20 hours course and this course is basically intended for undergraduates or you know those people who want to learn the basic of fundamentals of lasers and their applications. But nevertheless those people who have some already have some basic idea about laser you know this course can benefit them as well, because toward the later part of this course we would like to cover certain applications some of them will be state of the art applications which are quite advanced in nature.

There will be food for everyone pretty much. Today is the first day of this lecture series and you know let us start this topic by asking the very fundamental question that is why should we study laser why should anyone study laser.

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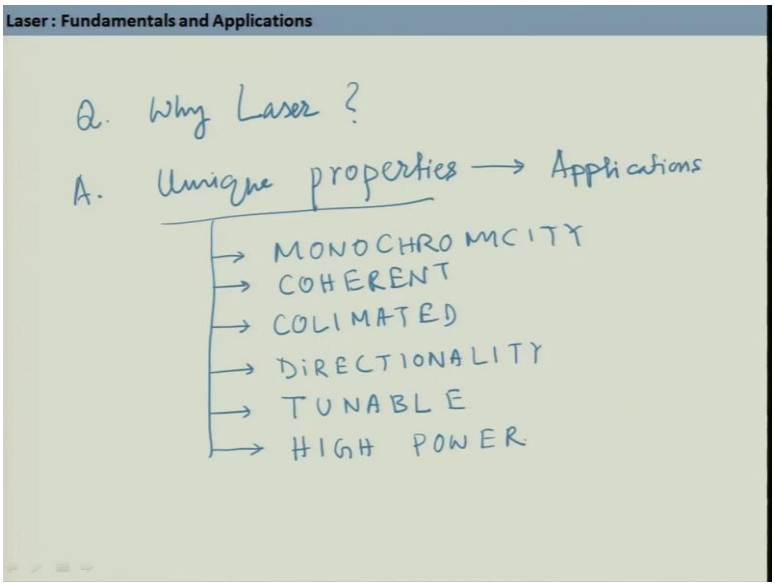


The question that we asked first Why Laser? Now the laser is probably the one of the most important inventions of the last century if not the most important you know invention. When I say that that pretty much answers that why should one you know

study the laser. If I want to answer it little bit more explicitly then what I should say is the answer is that it is important to because of it is unique properties.

Unique properties of Laser which leads to very unique applications, anything any invention or discovery becomes really important when it actually leads to certain applications in you know practical life or in real life then people you know like to know more about that particular topic or the particular thing, when it is said that the laser has unique properties. So, what kind of unique properties we will talk about those properties in greater detail as we progress, but let me tell you a very few things. When I talk about this unique properties we can name a few first is this laser light has a property which is called Mono Chromaticity that is the you know laser light has a very very narrow line width if I look at the spectra of any laser output it will be really narrow.

So, that is called a monochromatic radiation or near monochromatic radiation. So, depending on what kind of laser one is looking at can get a really monochromatic radiation, which is a you know big advantage if you want to do certain kind of applications beat a of fundamental type or be it practical real life application. Second thing is that laser light is Coherent in nature. When I say this term coherent; that means, that all the you know photons coming out from laser has the same phase. All the photons when they have same phase or they are in phase we call that light beam as a coherent beam, this is a huge advantage which is not available in all other light devices that gives different types of light different wavelengths of light different frequencies of light but laser gives size to this coherent beam.

The laser gives a light we of 10 call laser beam why because this comes out like a Colimated beam. The laser light is Colimated, moreover they have Directionality. They can be highly Tunable meaning that I can start from one particular wavelength, and I can go to a different wavelength, and I can scan through a huge range. So, this is called tenability; this Tunability is a huge advantage for any light source. And another most important properties of this lasers are that they can have really high power. The energy density of the laser beam is extremely High there are different terms used for that one can use a term called fluence which measures this you know in other way the you know power of the laser beam.

One can have a very High Power average power or there is something called peak power which we will discuss more and more in detail. These lasers can be you know having really large or high power which can be used in you know different industrial applications like a one can use it for you know cutting or welding you know melting you know various different materials. These are certain unique properties of this laser and as you can understand that if some light coming out from some device due to certain processes have this particular set of properties they can be used in various different things.

Now when I say that it can be applied to various different sectors what do I mean how you know why it is the range of application. Let us look at that. So, let us name a few of the applications.

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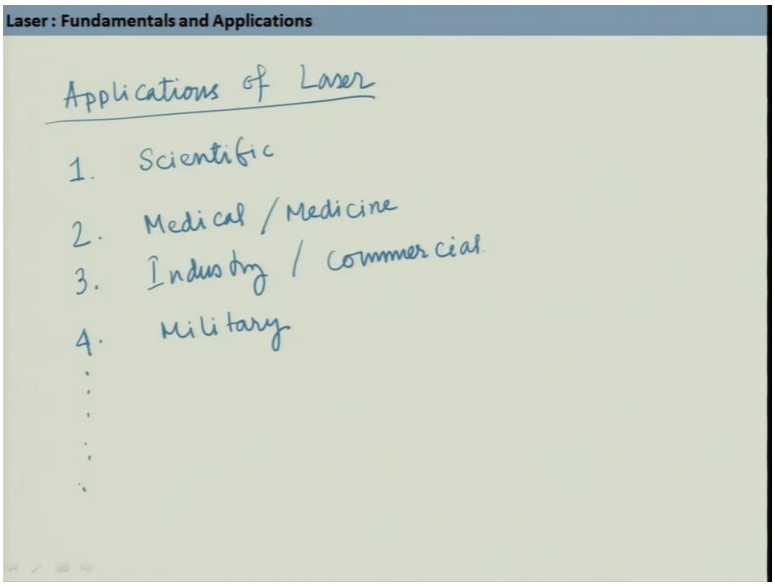


So, Applications of Laser, now laser can be applied in various different sectors as I said earlier. For example, it can be used in a Scientific application, it can be used in Medical science or Medicine, it can be used in Industry or Commercial purposes, it can have application in defense and there are many more different you know sectors that we can name; essentially if you think of any particular area where you know you look for an application of a device laser is a device which can probably find application in all those areas this is so versatile.

Let me give you a bit glimpse about what are the different types of applications in all these sectors like in a scientific sector, or you know medical science, in industry, or in you know military science, what are the different types of application that one can you know achieve using lasers.

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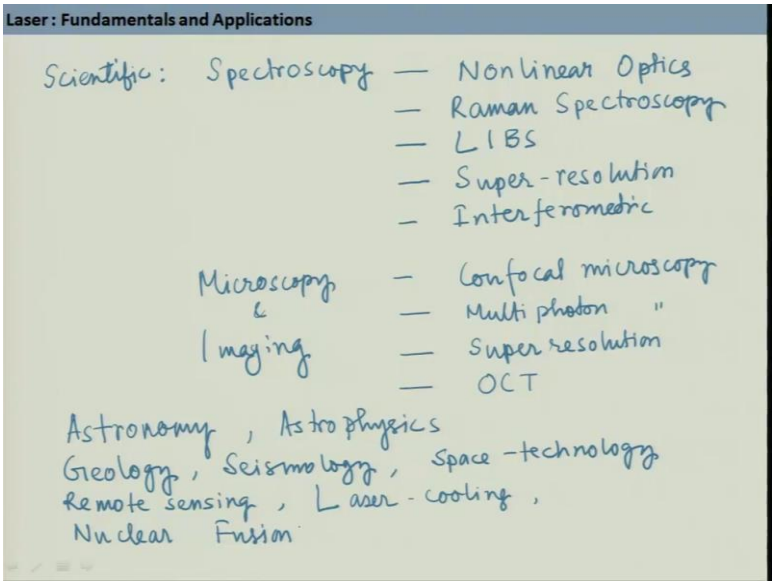


So, first let us talk about the scientific; Scientific applications. So, there are varieties types of you know scientific projects where laser can find these applications. Let us first start with something called Spectroscopy most of you perhaps know what spectroscopy is it is a subject area where it deals with light matter interaction right. This particular topic can give information about you know molecules and materials, their you know structure, their properties, and various other things. Now there are you know various different kinds of spectroscopy and laser finds you know their applications in pretty much all the different types of spectroscopy that you can think of except a very few.

One of the largest contributions of lasers in this domain of spectroscopy is probably the Non-linear Optics, where people you know generate newer frequencies by you know combination of you know different input frequencies we will talk about non-linear optics in quite detail at a later part. And we have Raman Spectroscopy we know Raman process is a very you know weak interaction of light with matter and you need a really high intensity light source to obtain Raman Spectra. So, laser had make Raman Spectroscopy really easy in that sense because it can provide a really high intensity of light there is

something called laser induced breakdown spectroscopy various super resolution spectroscopy can be obtained using laser why because earlier we mentioned that it can be really a monochromatic light source right.

So, if I want to have a very specific transition from one state to another in a particular molecule. I need to have a specific frequency of light or specific wavelength of light and that can be an achieved using laser a high monochromatic beam. So, Super-resolution spectroscopy can be achieved using laser various different Interferometric technique can find laser applications.

So, if I think about microscopic or imaging, if I talk about Microscopy and Imaging. Today's microscopy particularly optical microscopy cannot be thought without you know the use of laser in it. So, you will name any optical microscopy laser is used if you talk about Confocal microscopy you need lasers, you want to have Multi photon microscopy you definitely need laser without laser you cannot have multi photon microscopy. And many of you may be aware that you know multi photon microscopy is you know one of the wonderful today tools today that you know people use in biology, medicine, material science and why not.

The latest Nobel Prize in the field of you know optics and microscopy went to molar sniffing hell and basic. They got this Nobel Prize because of the invention of super resolution microscopy; the super resolution microscopy or imaging could not be achieved without having the laser in hand. So, super resolution when we called super resolution microscopy here it is sincerely points to the spatial resolution that is how you know how you can separate 2 points in space which are very close enough.

You know if you can resolve 2 points in space then you have a certain resolution now if I bring these 2 points very close to each other you may not be able to resolve that and 2 points may you know appear to be a single point. Now if you have a technique which can you know give you the ability to resolve even that you know extremely closely spaced points you essentially achieving something called super resolution? This is a very gross way of saying this we will talk about it in detail then we will explain what super resolution technique is. And there is other you know microscopic techniques which are being using being used very of 10 in industry and particularly medical industry is called optical coherence tomography you need a laser to do that.

There are other you know areas in you know scientific research where without laser you are almost you know you cannot do much. So, what are those areas if we can start looking at that if you talk about Astronomy you have laser application Astro physics, Geology, Seismology, Space-technology, Remote sensing where you find application of lasers in a particular way in terms of leader.

Lasers are used to do a particular form of cooling; cooling atoms and molecules which is called laser cooling. Of course, you can understand without a laser you cannot have laser cooling and this is of paramount importance in certain research areas there are certain other areas like Nuclear Fusion where laser is being used now. So, you know that nuclear fusion requires a very high amount of energy. Laser as we said that can provide very you know high power light pink and this high power light beam if it is concentrated one can actually produce a huge amount it is you know it is rather humongous amount of energy which can even lead to nuclear fusion.

So, you can you know you can guess that you know how vast is the application and I have just talked about a few topics under scientific research where laser finds this application you know every now and then. And basically if I you know tell you the truth without lasers most of this you know scientific topics would not be possible to you know deal with. Now if I look into the application of lasers in the field of you know medical science or medicine.

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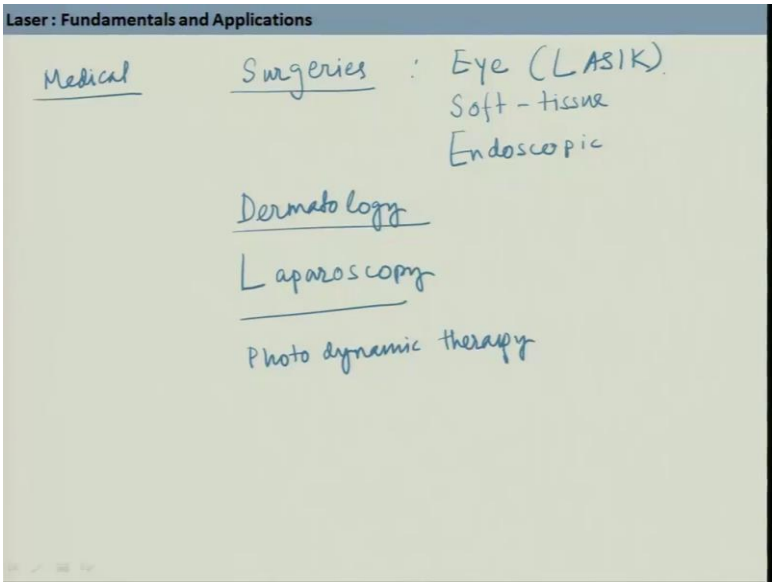

Medical application what you can think of you know many of you probably know, many of your you know relatives, parents, or you know teachers, friends might be telling you that I have gone through a laparoscopy.

These laparoscopic surgeries are also assisted by lasers. So, first place you know there are you know n number of different surgeries that are done by laser or assisted by lasers. If we name a few Eye surgery is regularly done using laser. So, many people come and tell you that we have done this cataract operation, cataract surgery how did they do it they say oh we did through Lasik, what is Lasik? This is a laser assisted process. So, there are other type of surgeries that you can do with laser very regularly it is done that is Soft-tissue surgery many times many occasions. So, people have you know troubled ligament or tendons and all and these are operated using lasers. They are various Endoscopic surgery that are done using laser actually as a matter of fact this endoscopy process itself is done through laser it is assisted by laser and if you are going to do endoscopic surgery many occasions you do it by using laser.

This is a it is almost a kind of non invasive process and you do it little bit from outside. There are different other things like I mentioned about non invasive technique, regarding a dermatology. Now, a days most of the dermatology you know treatments are done through laser. So, in dermatology you find laser application as I mentioned in the very first minute of this slide Laparoscopy is done using lasers, there is something called Photodynamic therapy this is particularly used in case of you know removing, or you know killing tumors, or malignant cells like cancer cells, you use laser light to do the job.

We might touch upon this particular part of photodynamic therapy during the application part when we will talk about the applications. There are many other types of applications in medical science that are there and we are not going to you know talk about everything what I am trying to do in this first class is to give you a glimpse of the areas where this can be applied and some of this we will discuss in detail and if we talk about industrial.

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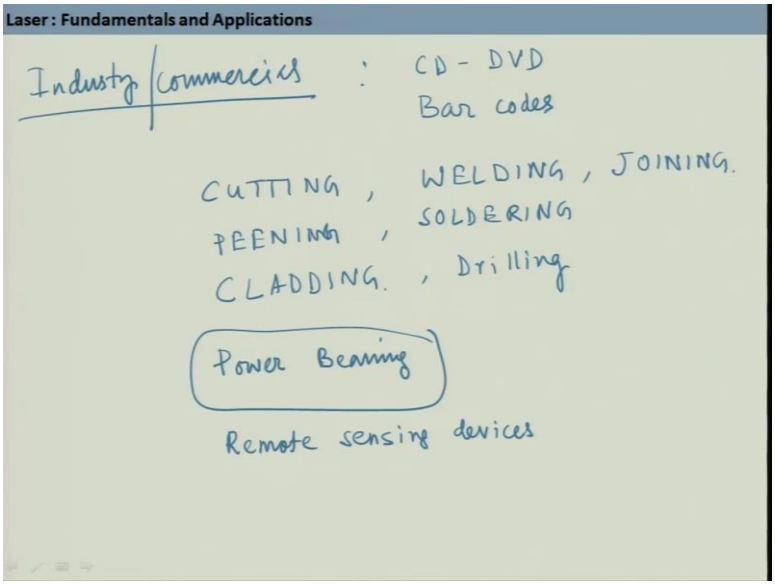


So, Industry or Commercial applications, you take simplest thing that you use every day you find applications laser, you take print out of your papers or you know picture anything what do you use you use a laser scanner. You know read or write data in optical devices like CD - DVD.

There what you use you use a laser to do the job. So, this you know storing the data and retrieving it from that particular device is done by laser. So, use it in CD- DVD. This optical drives storage devices you use in you know reading the barcodes, whenever you go to a market a mall you buy some stuff and you know shop owner will scan some area of the product where there will be some burrs which you know contains the information regarding price and other things and that barcode is scanned by using laser.

These are you know very simple things that you come across every day; there are various other things that you that you know where laser is used. In machining industry or you know engineering words people it to you know cut, and you know weld, or peen, you know metals, in a large scale right. So, in steel industry, in railways industry, you need to you know do cutting, and welding, and peening, soldering, joining, various different things. So, in every of you know each and every process that I just mentioned for example, like Cutting, Welding, Joining, and then Peening, Soldering these are you know certain process where you know the metallurgist you know which metallurgist use very now and then and in industry these are done in a large scale. And all these processes can

be done using lasers. So, there are now terms called laser cutting, laser welding, laser peening, andso on.

There are other type of processes where laser is regularly used as you know Cladding, Drilling. So, on you know in case of you know macro machining, or macro material processing, and even in micro material processing, or micro machining laser is very regularly used they are used in you know additive manufacturing every now and then. There are you know certain other aspects which are you know very very important for industry particularly in space industry. There is something called Power Beaming. So, what is this power beaming? You know for the you know spacecraft this power beaming through laser it is a possible solution to transfer energy to the climber of a space elevator. So, you can imagine how important role that place in the space industry cell.

They are you know apart from this one you know if you open any commercial website today. You will see there are various controlling devices particularly remote controlling devices. There are you find the application of lasers. So, laser is used in the Remote Sensing devices which are based on you know optical sensing mechanism, apart from remote sensing there are various other different types of detectors or sensors which are you know where lasers is used. Another important area that many of you might be aware of is the area of Optical Communication where you need laser. Apart from that you know on a lighter note whenever you see some party going on or any you know musical program you see something like laser show or laser display and nowadays it is so, common now just think about there is no laser, there is no laser show.

II can you know go on and on, but you know to tell you what at the different areas where laser have their functions. That is another important area which will just mention that is in the area of defense or the military applications. Laser is being used as a you know as a is an as an ammunition it is abuse you know to destroy, objects, or a the weapon. So, it is being used as a weapon apart from that the defense industry use laser to you know sayings or detect traits coming in different form that can be a missile you know or you know that can be some intrusion at the border. So, in all this thing cases laser you know is used either to detect the trait or to eliminate the trait.

In military industry usage of laser has gone up like super exponentially, we will not talk about military applications that much. So, you know by now I guess you were convinced

that laser really has a vast application in various different sectors in your day to day life everywhere. If something has such a wide application applicability. It would not be wise not to know at least the basic things about that particular topic or that particular device in our case that is laser. So, we at least need to knows something about this laser and that is exactly what is our aim in this particular course to learn some basics of this laser and to know about certain applications that this laser can have. So, with this I will conclude today's class and we will meet in the following class with something you know about the history of laser and some other staffs.

Thank you very much.