Colloids and Surfaces
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Lecture-10
Origin of Scattering

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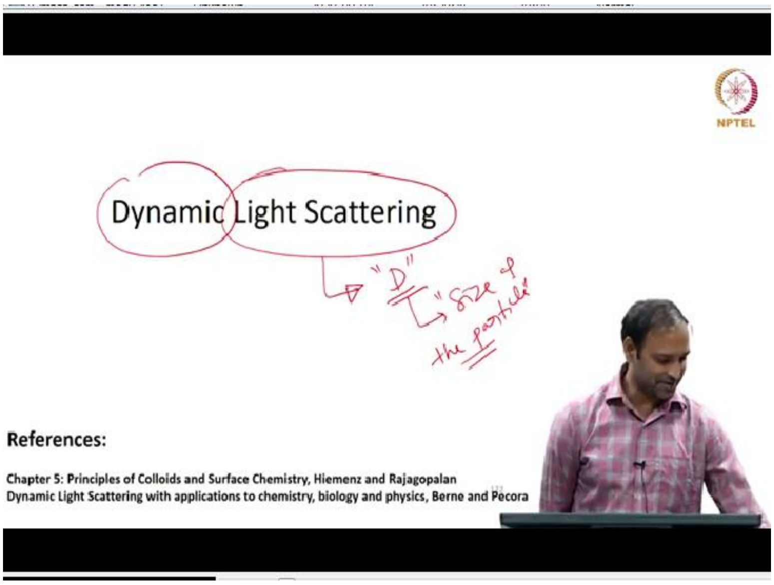

Okay, so I just want to spend a little bit of time talking about something called as a dynamic light scattering technique, again in this you have a way of extracting the particle diffusivity okay and from that you can get the size of the particle okay, yeah any thoughts what do you know anything about Brownian motion, sorry anything about dynamic light scattering, what is it. Any basics of scattering, no okay let us okay.

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All of you may know this right what is this, yeah this is a laser show right, I mean you know very popular right and why do you get this fascinating beam of light, why do you think you get these things, this is not nothing to do with the color of light I do not know if you have gone to any laser show you will see that they make something right I mean you know if you have clean air you would not get this yeah right.

They create some synthetic particles right, some fog or smoke like thing or something like that right, only then you see this right, yes right. So, in that case you can think about you know this liquid in air dispersions okay or particle in air dispersions right we talked about this right there are different classification of dispersions and one of the dispersions are you know if you have a dispersed species could be liquid or a solid particle.

And that is in air right. So, in something like a laser show your continuous medium is the ambient air and they have created some particles okay which essentially scatter light okay.

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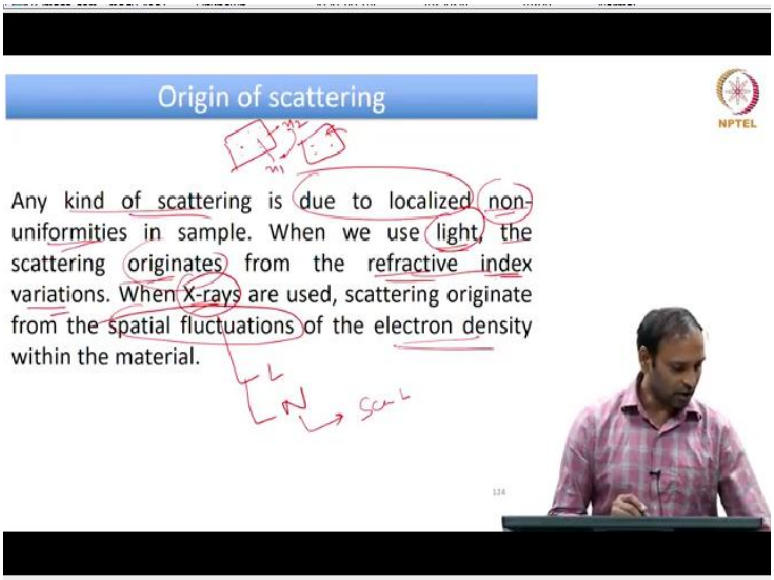

Now okay so the origin of scattering right. So, any kind of scattering okay is due to what is called a localized non uniformities in the sample okay, it becomes clear from the previous example right, if I had only air clean air, then you would not see these colors right. So, you need to have a localized non uniformities okay. In this case what do I mean by that is you should have may be air with some particles okay or liquid some particles right.

That is okay the particles in that case constitute non uniformities in the sample okay. Now people use different light sources in experiments okay, you can use a visible light okay or white light right or you can use x-rays okay, you can use lasers, you can use neutrons okay and depending upon the light source that you use okay, the scattering is kind of attributed to different reasons okay.

If you use visible light okay then the scattering originates from the refractive index variations okay I have a particle that has some refractive index n1 a fluid medium that has some refractive index n2 okay, only when you have the refractive index difference is when you will have scattering okay So, now what I mean by that is if I want to do a dynamic light scattering measurements okay.

If you have a fluid which has a refractive is n1, if I have dispersed species whose refractive index is very close to that of the medium itself then you cannot do scatting experiments okay, the same thing is true for microscopy as well, when you are doing microscopy experiments if I have a solution okay and you can do these experiments okay, people do what is called as refractive index matching right.

That means there are some classic videos in youtube you can look it up okay I have a container, I have glass you know this say a beaker right and there is a glass light okay. Now when there is nothing in the container because there is enough refractive index difference between the glass and the ambient air which is right you can see the glass rod right.

Now what you do is you put water you can still see the glass you know rod because there is again a refractive is difference between your water and the rod right. Now if I replace this with you know fluid you know maybe up to this level and you know and if that fluid has same refracted index the only thing that you will see is what is above okay that immersed portion you would not be able to see okay.

So, therefore depending upon okay in scattering okay the scattering originates from either the refractive index difference or if you use x-rays uh what is important is the spatial fluctuations in the electron density within the material okay, that is what gives rise to scattering when you do when you use x-rays okay. Similarly when you use neutrons people talk about what is called a scattering length density difference okay.

So, you can read up a little bit about this you know when you go back the idea is there has to be some heterogeneities or non uniformities some difference in particular properties and that is when you can carry out scattering experiments.

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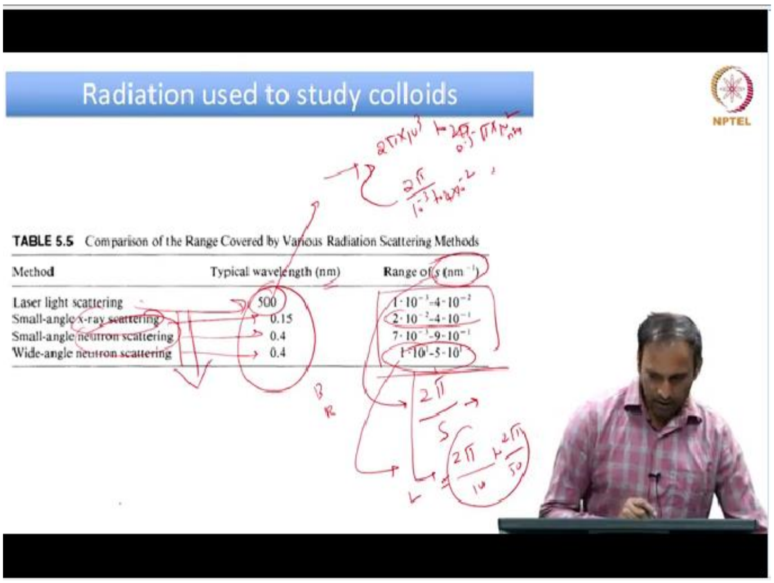

So, these are typical wavelengths right, if you use laser light typical wavelength of the laser light is about you know it will be in depending upon whether you use blue laser, red laser okay, your wavelength would vary but typically you can say is about 500 nanometer, if you use x-ray scattering okay, this wavelength is smaller okay. If you use again neutron scattering again the wavelengths are much smaller.

So, depending upon the wavelength that of the light that people use that will give you the length scale, that you can obtain from scattering measurements okay and that length scale is kind of expressed as some parameter again not important at this point which is expressed as nanometer inverse and 2 pi by this parameter okay S will give you the length scale that you can obtain from the scattering experiments okay.

Let us think about it okay. So, 2 pi divided by is 10 power - 3 to 4 into 10 power - 2 right. Therefore the length scale that I can get from scattering experiment when I use a laser light it is 2 pi into 10 power 3 to 2 pi into 0.5 pi into 10 power 2 right okay that is in nanometer okay. Now let's do the same thing for this one okay. So, these numbers are smaller right, if I look at 2 pi divided by these numbers these numbers are smaller right compared to these numbers okay.

That means if I want to measure size of smaller things okay if I want to measure the size of smaller things okay I should use the light source whose wavelength is smaller okay, that is what I wanted to say okay.

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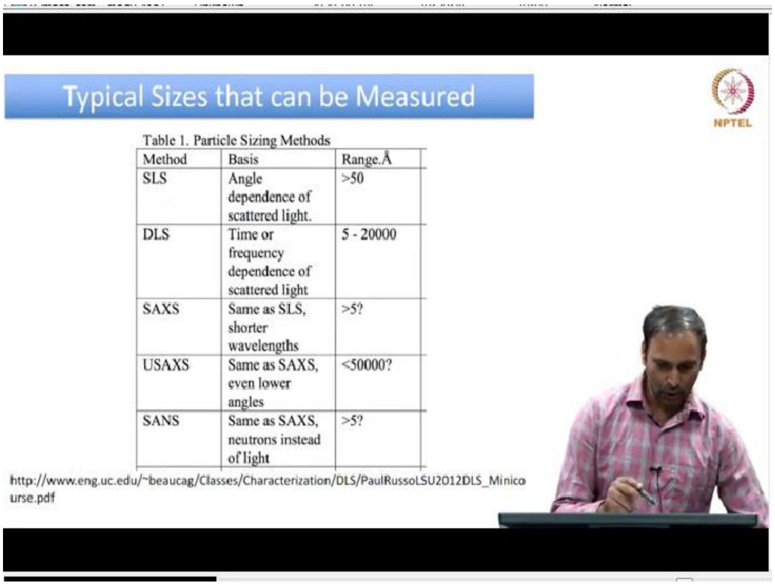

Now okay this is a there are different types of scattering experiment that people do we want to introduce these terms but maybe what I will do is I will come back here okay.

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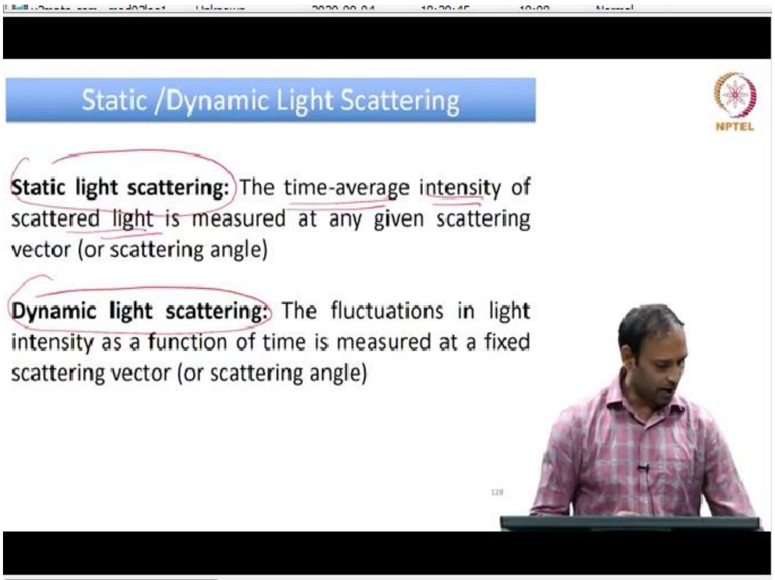

People do different kind of scattering experiments, one is what is called a static light scattering experiment, other one is what is called a dynamic light scattering okay. In static light scattering what is measured is the time average okay, time average intensity of the scattered light okay is what is measured okay.

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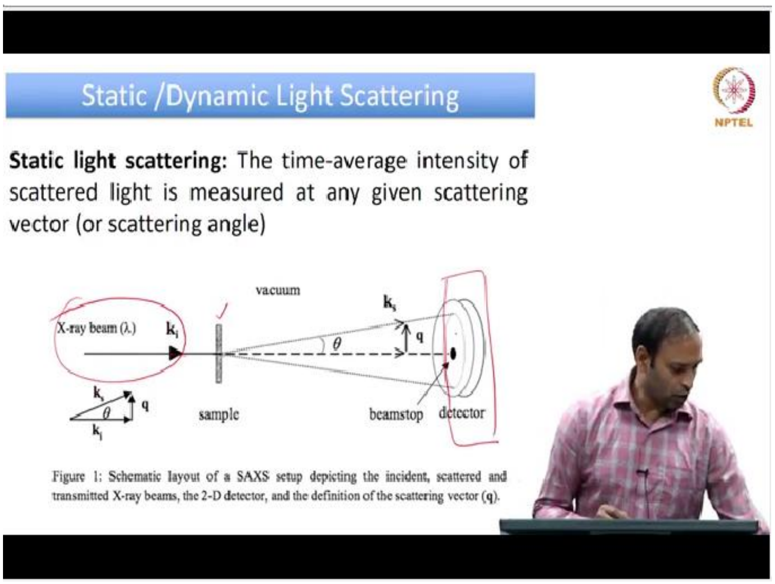

A typical experiment looks something like this you know I have a light source okay and I have a sample and this light beam is incident on the sample okay and the local heterogeneities or the non uniformities in the sample will make the light deviate or scatter light and that is actually collected on a screen okay and this screen is typically a camera okay.

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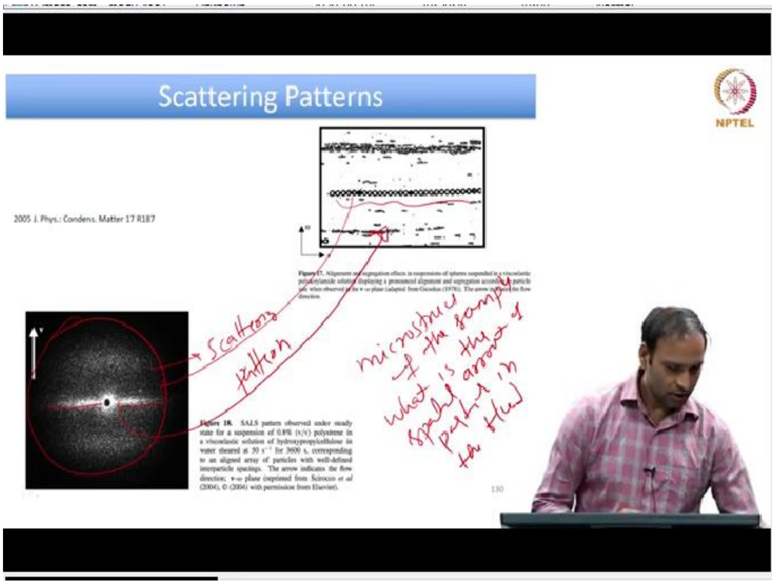

What you record is something called as a pattern like this okay, this is what is called a scattering pattern okay and what you see here is related to what is the microstructure of the sample or in other words what is the spatial arrangement of particles in the fluid okay, what you are seeing here is a case where particles have form chain right. Now if you have a case where the particles have formed chains you will get a scattering pattern which is kind of elongated in a particular direction.

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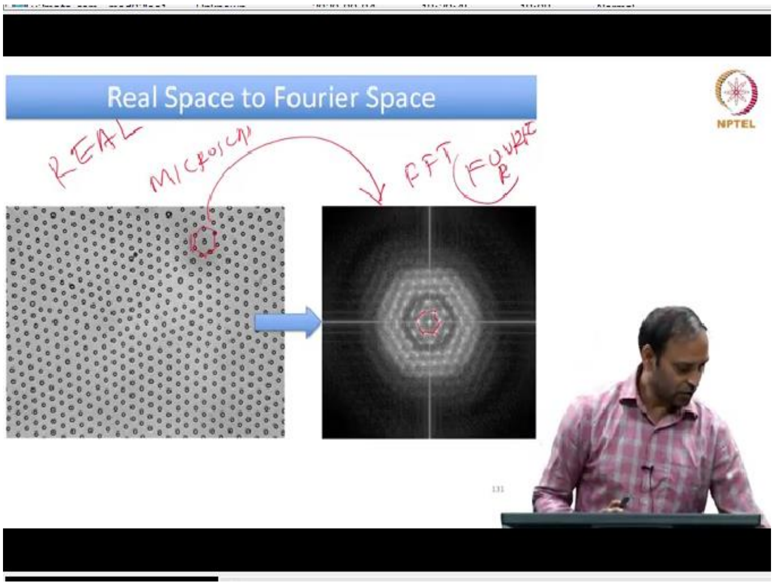

Or this is an optical microscopy image okay where the particles are nicely arranged right everything is a hexagonal pattern right it is a hexagonal pattern. Now this is a microscopy image okay by an optical microscope we have taken that converted that into a FFT pattern and what you again see is a hexagonal pattern right, can you see here okay in a way one way to think about this static light scattering experiment would be I am imaging microstructure but not in the real space in what is called as a Fourier space okay that is all that is there okay.

So, therefore in a typical static light scattering experiment what you do is you measure time average intensity of the scattered light okay and it is measured by fixing you know your screen or a camera at a particular location okay and depending upon the location of that okay whether it is very close to the beam, very closer sample or very far away from the sample okay. This theta will vary right.

Depending upon the theta you know the variation of the theta you can essentially obtain information about different length scale okay present in your system ok. Let me put it at that you know in that way at this point okay.

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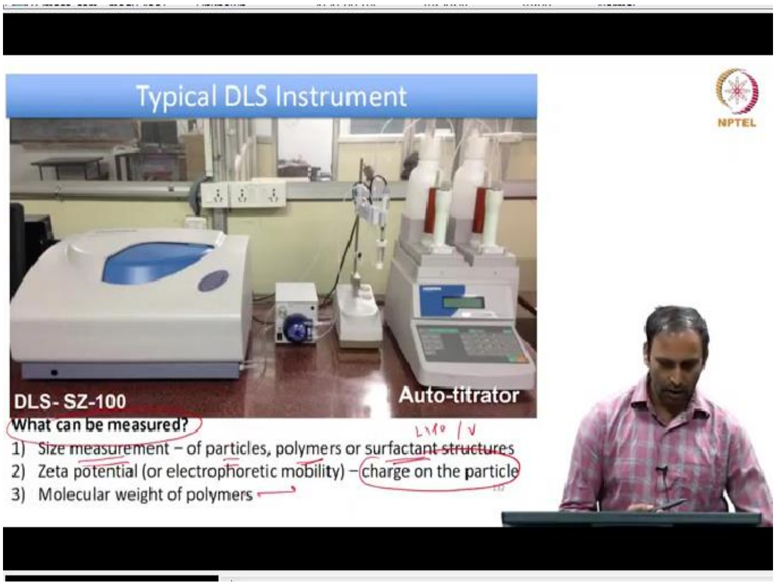

Now yeah so that is something about static light scattering okay in the dynamic light scattering what you do is what you measure is a fluctuations in the light intensity as a function of time is measured. In one case you measure the a time average intensity that is in static light scattering, in the dynamic light scattering what you measure is a fluctuation in the light intensity itself as a function of time okay.

That is the difference between the static light scattering and the dynamic light scatting okay. The instrument for dynamic light scattering it looks something like this is a one of the table top devices that is available and you can actually use this for a measurement of size of the particle okay or polymers or some surfactant structures I talked about this liposomes right or vesicles you can measure size of that. You can also use such an instrument for measuring charge in the particle, molecular weight of polymers there is a lot of okay.

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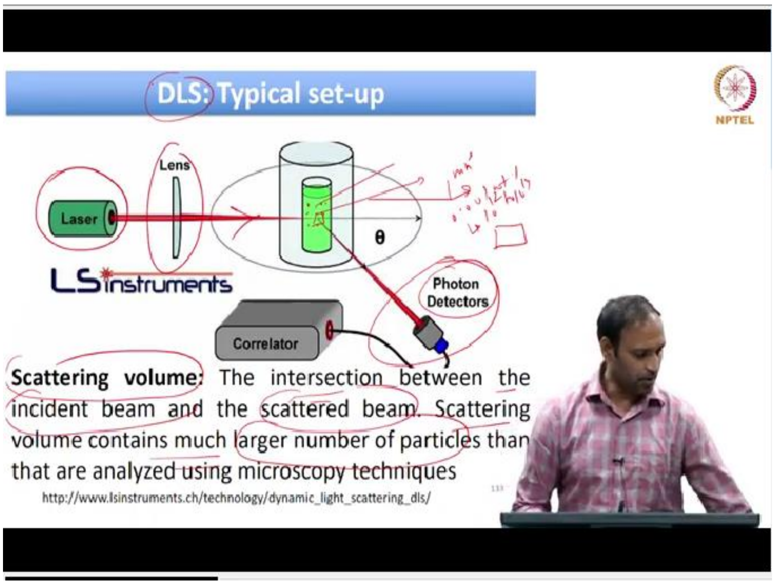

Within the instrument you know what essentially there is a laser source, there are set of lenses and these lenses as I said are useful in you know sending a collimated light right okay and it falls onto the sample okay and there is a detector okay, typically these detectors what they do is they are what are called as they are called as photon detectors okay, they essentially measure the number of photons okay scattered okay.

And that is your sample that has some particles okay, again I had mentioned about the scattering volume at some point the intersection between the incident beam this is your incident beam right and the scattered beam okay, that gives you some finite volume right and that contains the particle that you have in the fluid. Therefore the scattering volume contains okay a much larger I mentioned this point right.

If you look at the scattering volume so if even if it is like say you know of the order of say millimeter cube volume okay that millimeter cube volume will have really large number of particles okay, even if you take 0.001 weight percentage sample it turns out that number of particles in 1 ml would be as high as 10 power 12 to 10 power 14 particles okay. Therefore the scattering volume really contains a large number of particles than what can be analyzed by something like microscopy you know where you look at only a small section of your sample okay.

For example something like this right if I am going to analyze particle size from this okay of course they look monodispersed but then you know I will be limited to maybe few 100s of particles right. However, if you do scattering experiments the scattering volume will contain essentially large number of particles okay. Therefore you get a better average you know for the particle size when you do DLS experiments. **(Video Starts: 17:50)**

Maybe I will stop here, we will continue with you know talking about how does one use DLS for measuring particle size. **(Video Ends: 17:56)**

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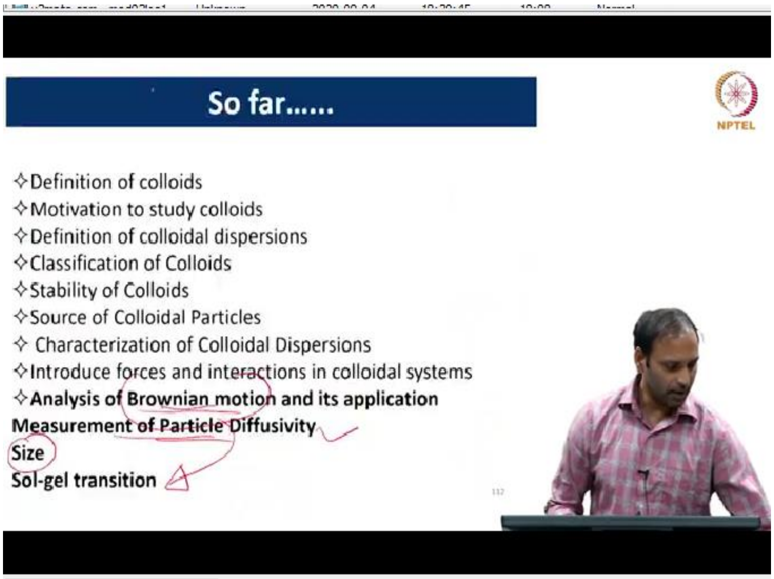

Plus we will also talk a little bit about using Brownian motion for looking at what is called as a sol gel transition okay, that is what we will try and do in the next class thanks.